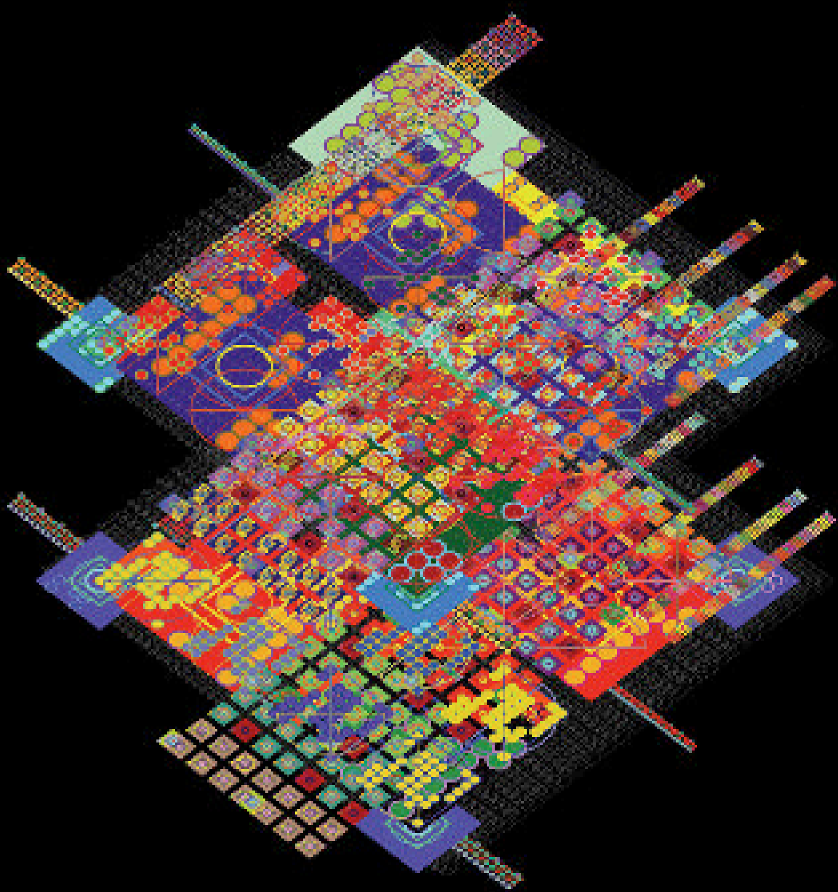
WHEN THE MACHINE MADE ART

The Troubled History of Computer Art

GRANT D. TAYLOR



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To Victoria and Vivienne

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Introduction

Unorthodox

The term "computer art" is rarely used in today's cultural discourse. To use the term is to impart a sense of nostalgia, to reminisce about a bygone era of pioneers and antiquated machines. For most, the term appears thoroughly unsuited if applied to contemporary forms of art. Art employing the latest digital technologies no longer relies on stand-alone computers, but is embedded in multiple devices, interacting globally with mobile and Web-based technologies. For this generation of art students, computer art is thoroughly passé, more a curious preform to the dynamic world of digital art. Students are seldom interested in the computer as a singular type of technology—a medium defined by a physical machine—but are absorbed in digital modalities across diverse social and geographical spaces.

Young contemporary artists who employ digital technologies in their practice rarely make reference to computers. For example, Wade Guyton, an abstractionist who uses Microsoft Word and inkjet printers, does not call himself a computer artist. Moreover, *New York Times* critics, who admire his work, are little concerned about his extensive use of computers in the art-making process.[1] This is a marked contrast from three decades ago when artists who utilized computers were labeled by critics—often pejoratively—as computer artists. For the present generation of artists, the computer, or more appropriately, the laptop, is one in an array of integrated, portable digital technologies that link their social and working life. With tablets and cell phones surpassing personal computers in Internet usage, and as slim digital devices resemble nothing like the room-sized mainframes and bulky desktop computers of previous decades, it now appears that the computer artist is finally extinct.

However, computer art is not yet that historical artifact, a fossil from which a new species of technologies can be said to have evolved. The term "computer art" can still be found in academia. The occasional conference, university graduate program, or college course still carries the term "computer art," which means some educators have resisted current trends of replacing it with the up-to-date descriptors, such as "digital art" or "media art."[2] The Computer Arts Society, formed in 1968 in the UK, remains steadfast, believing that the term has a historical significance that others designations lack. There remain defenders of the term too. Dominic McIver Lopes, one of those rare aestheticians who still employ the term, favors its use and asks audiences to "set aside the negative associations that cling to the name," those common misgivings that he says propel us toward preferring the term "digital art."[3] On the whole, however, "digital art" has become the term of choice, both in the art world and the academy. As influential theorist and curator Peter Weibel recently wrote, computer art is now "finally implemented as 'digital art.'"[4]

While the term "computer art" appears redundant in the face of rapid technological change, there are other reasons for its absence from our current lexicon. The negative associations that "cling"—to use Lopes' description—to computer art give us some clue to the deeper undercurrent of misgiving. As Douglas Kahn, a leading theorist of early digital music, rightly points out, when we speak of early computer art, it is often branded as "bad art."[5] For many artists of the period, the term both embodies a sense of rejection and reveals the essential contradiction in the art form itself. Pairing the noun "computer" with "art" has in effect built a label with an unending fission, a precarious reaction from joining two seemingly incompatible and oppositional worlds. This discomfort concerning the incongruous combination has in fact permeated all writing on the subject. For many of its detractors, computer art was simply a contradiction in terms; for even its most ardent exponents, the classifier was simply insufficient to describe the immense diversities within digital practice. In fact, ever since the birth of this neologism in 1963, to the decline of its use in the early 1990s, the oxymoronic overtones of the term "computer art" have troubled all who have used it. The term, unlike those within the narratives of modern art that were coined by a disparaging critic and later accepted by the art establishment ("Impressionist" and "Cubist" come to mind), has remained problematized and contested throughout its entire history.

In many ways, computer art has become synonymous with negative criticism itself. Yet the nature of computer art's criticism is complex and multileveled, often reflecting modes of traditional art criticism and at the same time being entirely divorced from it. Like its history, the criticism of computer art is unorthodox. For example, no single computer artwork has sustained public controversy, the engine that frequently drives criticism. There is no scandalous artwork like Édouard Manet's *Le déjeuner sur l'herbe* (1862–3), a painting that raised the ire of the French Academy and insulted public sensibilities, in the computer art movement. Likewise, no computer artwork has ever evoked the same sense of radical dislocation or bewilderment that met Pablo Picasso's *Les Demoiselles d'Avignon* (1907). Yet, if we collect all the denigrating judgments of computer art, we find that they rival those of, if not exceed, all previous art movements. If we examine responses to computer art by professional critics, rarely do they represent judicial appraisals, that detached and objective perspective we believe formal criticism requires. Many critics were simply uninformed, as will be revealed, which was particularly troubling since a knowledgeable position was valued above all else. Being conversant with the subject was crucial in placing the critic's words above mere opinion.

However, the first writers on computer art were not established art critics. They were practitioners of computing—most commonly scientists, technologists, and engineers who understood the complexities of this new technology. In addition, many of those who wrote on computer art were performing multiple functions: the art historian who organized historical facts and brought clarity to context, the critic who examined the value of the work, and the advocate who generated popular excitement. Not to say that these elements were in equal proportion: out of the three, judgment of aesthetic value remained the scarcest. There was no independent, disinterested perspective that we associate with art criticism. The first writers on computer art were deeply fascinated by the computer, becoming, as their writings show, emotionally invested. These disciplinary outsiders had the necessary technical expertise, yet lacked a deep understanding of art and modalities. In time, however, computer art would gain the attention of the mainstream critics. Art historians and art critics entered the fray, with some critics having notable reputations, such as John Canaday, Stuart Preston, Robert E. Mueller, and James Elkins. While these figures were widely known in the mainstream art world, there were other influential critics, including Jack Burnham, Jonathan Benthall, Gene Youngblood, Herbert W. Franke, and Jasia Reichardt, who would make their name in that difficult intersecting zone between art, science, and technology.

Computer art criticism was not limited to known and newly known writers either; its discursive space was much wider. The criticism of minimalist and conceptual art, which was contemporaneous with computer art, revolved around a small, some say elite, avant-garde cluster of celebrated critics who often employed esoteric language to describe the aesthetic or intellectual value of artwork. Conversely, computer art, with its interdisciplinary nature, had an even wider audience beyond that of science and technology. Computer art was part of the greater social sphere, driven in large part by the general public's interest in the future of this emergent technology. Computer art has never been deprived of an audience. As much cultural as technological, the computer was a unique historical artifact. While it was one of the most tangible symbols of the late twentieth century, the computer remained allusive and mysterious. The computer garnered wide public interest, and because of its perceived impact on the world, the reaction to it was often immediate and impassioned. Indeed, where computer art lacked consideration from the mainstream art world, it certainly made up for it with keen public interest. Consequently, if we stratify computer art's discursive space, we find that its reception and criticism is multi layered, with responses and reactions emanating from the mainstream art world; the fields of science and technology; the new creative space that emerged between art, science, and technology; and the larger public realm.

It is little wonder computer art's critical response was so diverse; it reflected the wide-ranging artistic and scientific disciplines in which computer art first gained attention. While responses to computer art can often be described as excitable, a celebratory and superficial reaction to the newness and promise of an emerging art form, the majority were negative. Almost any artistic endeavor associated with early computing elicited a negative, fearful, or indifferent response.

As early as 1956, musicians and poets exploring the vistas of a new technology were ambivalent: thrilled at forging new artistic paths and yet subdued by an undercurrent of misgiving from their cultural peers. While computer music was often greeted with interest as the latest novelty, the early computer experimentalist Lejaren Hiller felt that emerging from "many quarters" was a deepening "incredulity and indignation."[6] Joel Chadabe, another pioneering computer composer, felt that the critics and the traditional musicians "feared" the machine and its potentially harmful influence on the entire field.[7] In the early 1970s, Elliot Schwartz, in his listening guide to electronic music, best summed up the general reaction: "The notion of music 'created' by a computer always seems to arouse a surprising degree of hostility, usually on the part of people who find 20th century art increasingly 'dehumanized' and 'mechanical.'"[8]

Computer poetry fared little better. As Christopher Funkhouser has written, the literary world was underwhelmed by computer poetry.[9] Mirroring the critical responses of mainstream music, literary critics focused on the dehumanizing tendencies of the computer and the perceived ontological break between author and reader.[10] John Morris, writing in the *Michigan Quarterly Review* in 1967, praised the importance of the written poem as an essential "communication from a particular human being," and noted that if the difficulty of working with the computer discouraged those currently interested, then poems would happily remain "one last refuge for human beings."[11]

In the world of dance, also, the computer received what Jeanne Beaman described as a "curious but cool response."[12] Beaman, who in the early 1960s pioneered computer dance and choreography, explained in her introductory presentation to computer dance:

> Most of us do not even want a machine of any kind to succeed in conceiving any art form at all. The arts are usually presented as our last refuge from the onslaughts of our whole machine civilization with its attendant pressures towards squeezing us into the straitjacket of the organized man.[13]

The most scathing attacks were saved for the visual arts. The most common critical position is one that merely dismisses computer art as inconsequential. Viewing computer art as tediously repetitious, the critics' commentaries make clear their belief that it has no claims to the status of art. Even when computer art gained fashionable notoriety, the critics, such as John Canaday from the *New York Times*, spurned computer art exhibitions as “popular sideshows.”[14] Computer art was another example of the vulgarization of science, where besotted artists, dallying with the latest scientific and technological media, produced what was tantamount to science as kitsch. Because it emerged from the abstract sciences, the computer art form was viewed by many as an anachronistic project—akin to the early modernist fascination with pure science. In general, artists from the mainstream held a common disdain for computer art shows, seeing them as “science fiction grotesqueries masquerading as art.”[15]

Beyond the ontological debate over computer art’s claim to be art, the other major response centered on the matter of aesthetics. The first critics described computer art as bleak and soulless and bemoaned the arrival of this strange and powerful machine in art. Robert E. Mueller wrote in *Art in America* that the visual results from computers had been “exceedingly poor and uninspiring.”[16] According to Mueller, technologists lacked the necessary knowledge of art and its history, and their visual creations, which were mathematically inspired, bored the “sophisticated artistic mind to death.”[17] While many galleries showed computer art, these exhibitions were often “condescendingly reviewed,” as though the medium was “without serious intent or noble aspiration.”[18] Nearly every computer artist tells a similar story, a tale in which their computer art is accepted on its merits, only to be rejected once the curators discovered it was generated on a computer. Computer artists were regularly rebuked and insulted by gallery directors. Such was the stigma attached to computers that artists, such as Paul Brown, have used the expression “kiss of death” to describe the act of using computers in art.[19]

Indifferent as many critics and curators were, there were some responses to computer art that were considerably more severe. In fact, computer art has aroused the kind of extreme resentment that characterized many of the idolatry controversies scattered through the history of art. Beyond the sabotaging of computers, physical attacks have been made on artists for their involvement with such devices, and the careers of art curators have been significantly damaged by their participation in computer art exhibitions. Though it is commonly accepted that computer art was unpopular upon its arrival, many are unaware of the level of vitriol directed toward computer artists. In a case reaching the levels of harassment and personal attack, Grace Hertlein reported that she was called a "whore" and "traitor" by a fellow artist, who saw her choice of medium as morally questionable and as a complete rejection of authentic artistic traditions.[20]

While it did not encounter the extreme reactions that modern art received when it was first displayed (such as the American public's xenophobic reaction to the *Armory Show* of 1913 or the Nazi regimes' racial slogans and mockery at the *Degenerate Art* exhibition of 1937), computer art's negation was more enduring. The negative criticism lasted the entire duration of the movement, and computer art never found the widespread critical and cultural acceptance that modern art received. Computer art was different too in that it possessed an inordinate amount of self-deprecation, a kind of lack of confidence that meant exponents were unsure how to position the movement. Paradoxical as it sounds, supporters have been some of the strongest critics. In fact, a strange kind of defeatism or fatalism permeates much of the writing on computer art, producing a sense of the lost and forsakenness that affects the entire discourse.

Although exponents find the computer intriguing and significant, they often judge it a "disappointing instrument of representation."[21] In the 1990s, commentators believed the computer art of the 1960s and 1970s deserved little attention. As Michael Rush rightly points out, the first large survey of the field, Frank Popper's *Art of the Electronic Age* (1993), gives scant attention to computer art before the 1980s. Similarly, Rush, in his later survey, wrote that it was only at the end of the 1990s that the "aesthetic bar" was raised sufficiently enough for computer art to warrant attention.[22] More recently, scholars like Douglas Kahn assert that graphic arts in the first decade were less interesting—especially as it pertains to contemporary digital practice—than the work being completed in the fields of literature and music.[23]

In the last decade, however, the perception of early computer art has evolved. Writers no longer give a cursory treatment of the pioneering phase, but offer more detailed and nuanced accounts. Indeed, computer art, which was long considered "non-art" by traditionalists well into the 1990s, is now generally accepted as art. While traditional criteria for defining art have evolved, computer art's acceptance is largely due to the art-historical context recently provided by scholars. Interrelated with this new scholarship is a new audience who seeks to celebrate the history of digital media in the arts and honor those artists who were central in making it. In addition, aestheticians, with accumulative success, have built engaging theories of digital art that have assisted in deepening our understanding of digital practice. A small but committed market for digital art has also arisen, and collections, both private and public, have formed. The largest and most extensive collections are held at the V&A in London, the ZKM in Karlsruhe Germany, and the Anne and Michael Spalter Digital Art Collection in the United States. Offering much needed protection to these media-sensitive artworks, these collections have emerged as important research repositories, allowing future scholars access to rare digital artworks and their related documents.

Thanks to a decade of work by scholars and cultural critics, the summative accounts of the previous decades have given way to in-depth histories. Margit Rosen has described the rush of a new generation of scholars—Rosen being a prime example—who have "set out to find the protagonists and works of the pioneering era," collecting and cataloging key documents as they went.[24] These new narratives, which benefit from extensive research and coherent critical paradigms, have particular national focus.[25] While the historical vacuum is beginning to be filled, there still remains much research to be done, and, like all new research initiatives, questions have emerged. The difficulty of generating an appropriate methodology that encompasses the vastness and interdisciplinarity of digital arts also remains. Edward Shanken, a key art historian in the field, rightly points out that there is no clearly defined method for "analyzing the role of science and technology in the history of art."[26] And Shanken believes that, without approaches that adequately make sense of the interconnectedness of the fields, digital art will remain misunderstood by traditionalists and marginalized from the larger narrative of art. Charlie Gere, a cultural historian and leading voice in the field, also believes that digital art and its history have been "disregarded" and "woefully neglected by contemporary art galleries and institutions."[27] Lamentably, nearly all surveys of art since the 1960s fail to mention computer art. For many, it is hard to reconcile the fact that the digital computer, perhaps the greatest and most impactful invention of the twentieth century and a technology that fundamentally changed the economic and cultural fabric of the globe, is continually omitted from the history of art. Digital technologies, as Bruce Wands asserts, are so “firmly established” in “our daily lives” that their effect is profound at all levels of contemporary society.[28] In a ubiquitous digital culture—one with a severe knowledge gap—Gere advocates for a more forceful approach, believing that new research should elucidate, through argument, the cultural significance of computer-based arts. *When the Machine Made Art* heeds that call.

While recent scholarship has begun to uncover the rich history of digital arts, it is yet to answer the fundamental question of computer art’s rejection. Why was computer art so heavily maligned? Every narrative mentions it, but none explores the reasons for it. Importantly, computer art’s repudiation has meant that all critical or historical endeavors have met with a similar fate: first posited as insignificant and then relegated to the margins of art discourse. I would argue that a close examination of computer art’s criticism reveals a multiplicity of prejudices, all of which have affected the field of digital art and added to the discontent and frustration that Shanken, Gere, and others have expressed. However, exploring the criticism of computer art is not a straightforward matter. For computer art’s somewhat turbulent history is, like its criticism, thoroughly unorthodox.

Computer art has a fragmented and often capricious history. Previous historical accounts of computer art possess idiomatic elements that separate it from traditional art history. They tend to be aggrandizing in nature, seeking to justify and promote computer art. Often simplistic, celebratory, and utopian, these accounts neglect the basic precepts of art history research, such as the artwork’s physical dimension and completion date. The scant archival material available is fragmented and often difficult to access, though recent research projects are remedying this. One of the main problems, however, is that narratives of computer art give priority to technical interests over historical context. Mirroring the influence of science and engineering journals, computer art discourse is filled with technical explanation. Consequently, computer art requires a specialized technical knowledge of its viewer. This is probably why the first histories of computer art focus on technological change as a narrative structure. In this deterministic model, the emergence of a new technology or technique becomes a historical landmark. To use one often-repeated example, the pioneering phases of the 1960s and 1970s, the commercial software of the 1980s, and the multimedia of the 1990s become the usual configuration.

Herbert W. Franke, a key figure in computer art discourse and the first to write a historical account of computer art, believed that such a history was "dependent on the computers," and that nothing could be achieved beyond the state of progress within computer science itself.[29] While computer art was inextricably linked to the evolution of computer technology, the technical model of explanation is only one dimension in a possible spectrum of historical understandings. By using technology as the underlying logic, these histories fail to acknowledge the importance of cultural and ideological contexts in the emergence of computer art. Like technological determinism, this process removed the computer from its social and political reality and treated it as a self-forming technology in isolation.

As many interested art historians will admit, digital arts have remained difficult to assimilate into traditional art historiography. More so than others, computer art resists the linearity of art history. To research computer art is to probe several disciplines and their histories at once: the history of the computer as a visual medium, the history of computer graphics and its emergence as a global industry, and the history of computers in the creative and fine arts. This shared historical continuum is often convoluted and intertwined, making research difficult. For instance, the history of computer art and the history of graphics are indiscernible, especially in the first decade, as illustrated in Franke's dual-titled *Computer Graphics—Computer Art* (1971), which represents the first comprehensive account of computer art. The boundaries between the two, as we shall see, remained permeable and indistinct.

The expanding nature and convergence of digital technology have meant that computer art is essentially a diffuse practice. Hence, a plurality of theories emerged around computer art, resulting in a continual need to define the "computer." Defining its nature, crucial properties, and necessary conditions remained a central aspect of computer art discourse. Because the computer was a variegated technology, any concept associated with its explication had difficulty sustaining competing articulations. As such, computer art remained an elusive concept that frustrated and defied the powers of definition.

Another problem confronting researchers of computer art is initially defining which computer art form is under consideration. Since its inception, the term has been employed in a variety of contexts. As the computer became the new experimental medium, it was employed within a constellation of practices, including visual arts, film, choreography, literature, and music. The term "computer art" has over time denoted different artistic practices. In addition, the issue of definition was complicated by the fact that exponents of computer art included artists, scientists, engineers, technologists, and mathematicians. This has led commentators with vastly different perspectives to define computer art's essential character in relation to their artistic goals and disciplinary norms.

Similarly, the proliferating nature of digital technology meant new forms were perpetually surfacing and rapidly diversifying. As Dieter Daniels wrote regarding the growing complexity and intricacies of current digital media, it is "impossible to take in the whole picture."[30] No technology has ever unfurled its potential as swiftly as computers. In contrast to traditional tools, which retained their form and function for hundreds of years, the computer has changed dramatically in a short space of time. There was, as pioneering artist Mark Wilson suggests, a "bewildering variety of computational techniques" available to the artist.[31] Throughout the history of computer art, it seems that artists have often struggled with the morphology and tempo of digitalization. For the theorist and artist, it was difficult to follow the rapidly evolving nature of the technology and the sudden succession and redundancy of forms. Equally, the historian was faced with the difficulty of mapping these rapidly transforming and ever-expanding digital forms. This is perhaps why art historians have traditionally preferred subjects that evolved at a manageable pace.

Also, because computer art was an international phenomenon—best described as globally dispersed in advanced countries—it did not derive any cultural legitimacy from a nationalist art history, although some recent publications have focused on national developments.[32] Apart from having no national heritage, there was no centralized location or organizing body that could devise a coherent corpus of belief, in contrast to the myriad of other twentieth-century art movements that achieved this through a type of geographically linked metropolianism. With the exception of the Computer Art Society in London, there was no attempt by computer art practitioners to formally organize themselves socially and politically around a central idea.

But it is within this unconventional history that the key to computer art's alienation is found. An examination of its history shows a dizzying array of ideologies impacting and informing computer art. Within this discursive terrain, competing dogma between art and science shape and construct its reception and criticism. Born into a culture war, computer art becomes a site of contestation, a kind of pawn in a battle for cultural supremacy. Subsequently, to understand the criticism of computer art, we are required to illuminate those emerging theories, methods, and themes that provide the life force of computer art. These include cybernetics, information theory, artificial intelligence, artificial life, and the science of complexity, among others. As will be shown in later chapters, the interaction of these discourses within the fields of science and art causes contradiction and instability within the computer art movement. Yet, it is these theories, poorly understood by mainstream art critics, which provide theoretical depth to computer art. Through a deep examination of key computer-generated artworks, this book provides a model for interpretation in which an informed position, rather than an uninformed dogmatic approach, is able to lay bare the inherent value and theoretical implications of early digital art.

Beyond situating a set of visual practices within an art historical context, this book also exposes the wider debates surrounding computer art. Because the computer has its own cultural dynamics, quite beyond its rapid technological growth, it is necessary to consider computer art as part of the social history of computers. Nevertheless, it is important to never lose sight of the relationship of computer art to the art movements with which it shares a specific historical epoch, such as the Art and Technology movement, video art, conceptual art, geometric abstraction, and others. When cast into relief against those other movements, computer art's unique theoretical and cultural position becomes apparent.

My narrative begins in 1963, when the relatively cogent idea of computer art moves into the cultural domain and receives its first critical appraisal. The crisis of 1989 provides a point of departure, when the computer art project is engulfed in heated argument and the term "computer art" begins to, as Richard Wright observed that year, "drop out of usage."[33] Because the pictorial, static form of computer art received the most intense criticism and possessed the most turbulent and contested history, it remains the focus of this study. Written material on computer art has generally concentrated on the three major areas of production: computer-generated visual art, computer-generated music, and computer-generated animation. The dominant form—the one that was produced by the highest number of artists—remained computer-generated visual art. Other forms of computer art, such as animation and electronic music, did receive similar negative responses, but also found a modicum of commercial and institutional success.[34]

Ironically, the static works of computer art—the art form that received the most vociferous criticism—is the art form now most easily exhibited. For curators, presenting dynamic, time-based, or interactive computer art remains challenging, especially with older artworks that require obsolete technology. Computer art was both traditional, using the frame and established inks and grounds, and, by means of digital generation, new. If experimental new media art remains somewhat marginalized today, even if begrudgingly accepted in some major museums, static works are most familiar and assimilated into collections.

The structure of this book is chronological, showing the historical, rhetorical, and theoretical shifts in computer art discourse. The key objective of Chapter 1, "Future Crashes," is to map the discursive environment in which computer art first emerged. Beyond chronicling the notoriety and controversy of the first computer art exhibitions (held in the advanced industrialized nations of the United States, West Germany, and Japan), the chapter examines the rapid crystallization of computer art in military and corporate research laboratories, which form the first crucible of the art form. As Gustav Metzger stated in his reflection on the birth of computer art, the "true avant-garde" was the military.[35] I argue that computer art encapsulates much of the technocratic vision and the scientific pragmatism of the post-war period. Computer art, governed by technical utility and conceived through the logical philosophies of Western science and technology, is found to be largely underpinned by what many perceived as the rising cult of science. Computer art's relationship to science and its ideologies would remain close and enduring. However, this relationship precluded computer art from finding legitimacy in the art world. Shaped by military prerogatives and scientific ideals, computer art grew against the grain of fine art practices and its established traditions.

To illustrate how atypical and incongruent computer art was to mainstream visual art, one needs to examine those nascent art movements that share the same cultural field. Apart from being produced in research laboratories, many of which were military, computer art was disseminated by specialized computer science journals. Its self-sufficiency in the scientific realm differs from those art movements that closely resemble computer art, including the avant-garde Art and Technology movement and conceptual art movement. Although they share many characteristics, both theoretically and aesthetically, these art forms are able to situate themselves more comfortably within the fine art tradition. Moreover, computer art's idiosyncratic traits, such as its devotion to mathematics and its adoration of the machine, meant it was orientated more toward the unfamiliar philosophies of technoscience.

When computer art arrived on the fine art stage in 1965, the computer was already a compelling symbol, an artifact that had accumulated complex cultural meanings. The first exhibitions received an immediate and mostly negative response. The dominant humanist tradition within the art world contributed significantly to this anti-computer reaction. Many found the appearance of the computer in the sanctified realm of fine art as another unwelcome incursion by modern science. Following the mechanized atrocities of the two world wars, there was widespread disenchantment with the increasing rationalization of the post-industrial world. Combining the strong anthropomorphic ideals of Renaissance humanism with the eighteenth-century traditions of romantic protestation against the machine, this humanist reaction sought to admonish computer art for its dehumanizing and hyper-rationalizing tendencies. In addition to dismissing computer art as aesthetically inconsequential, the critics attacked computer art on an ethical level, branding the abstract compositions as cold and clinical. This was more a reflection on the medium than on the art. Computer art had extensive aesthetic similarities to the abstract work of the period, including conceptual avant-garde art and modernist hard-edged abstraction. Such a comparison helps to demonstrate that the reception, a type of anti-computer dogmatism, was more emotive than critical.

For the humanist, the artificial methodologies of computer-generated art alienated the human from the art experience. Computer art seemed a deliberate denial of human feelings of wonder and mystery through the cold calculation of instrumental rationality. For critics, it was concurrent with the rationalization of the world, a process by which all human activities are progressively exposed to increasing calculation and control by impersonal technological forces. Although this liberal sentiment would continue to haunt the reception of computer art, the most compelling criticism came from other quarters. In 1964, the same year that computer art first entered the cultural sphere, influential cultural theorists Jacques Ellul, Herbert Marcuse, and Marshall McLuhan produced publications that in different ways were critical of technology. The Cold War period saw the popularization of dystopian theories that posited technology as inherently predisposed toward domination. And computers were a central part of what the technocratic and scientific regimes used in prosecuting the Cold War.

Two significant ideological forces that mediate the anti-computer sentiment within the fine arts can be identified. The first is the humanist position that carries a heavy anthropocentric bias and has a general resistance to advanced technology. In many ways, the humanist of the 1960s can be said to have subscribed to the tenets of twentieth-century modernism, including the ideologies of progress, rationality, and teleology. All were products of Enlightenment thought. The second is an anti-humanist stance that emerged in the 1960s and promoted a measured skepticism toward technology and its perceived modes of control. Whereas humanism in the fine arts tradition was both liberal and conservative, attacking certain technologies for their dehumanizing dimension, the popular anti-humanist critique of technology attacked the rising technocracy rather than the technology itself. This 1960s anti-humanist response was a precursor of the postmodern critical position taken by many art critics in the 1970s and 1980s. The multiple strains of humanism and their oppositional attitude toward computer technology have had a negative impact upon the reception and criticism of computer art. Nonetheless, as explored in Chapter 3, there were humanist strains that provided a positive part of the growing mythology surrounding computer art.

This emotive response to computers was not just a knee-jerk reaction by angst-ridden humanists. The zealous technologists did little to allay fears that the machine would render the artist redundant. Following the 1950s discourse on artificial intelligence, many technologists explicitly promoted computer art within the "man versus machine" paradigm, which effectively positioned the computer as an oppositional force. Beyond touting the first renowned computer art piece as successful simulacra of a modern master, the rhetoric emerging from the technologists tended toward the final demystifying of art. For the technologist, mechanized creativity was simply a natural progression in the computer's bid to automate all human functions. On a more fundamental level, the scientists envisaged a machine to wipe away what they saw as the fallacious mysteries of art. In contrast, most art critics felt that art made by an autonomous machine undermined the integrity, function, and meaning of art and its history. The computer threatened to invade the territories of art. Like Charles Baudelaire in his reaction to photography, critics and artists were fearful that this could ultimately usurp and corrupt human creativity. Fearing the computer, mainstream artists felt that they were surrendering the privilege of creating art to a mere automaton.

The widely held view that the computer was encroaching on the sacred ground of human artistry was not the only problem facing computer art. The anti-computer sentiment was part of a larger controversy permeating cultural discourse, especially in the West. Late in the 1950s, C. P. Snow brought the perceived polarity of science and the humanities into sharp public focus with his notorious *Two Cultures* lecture. Because computer art was an amalgamation of art and science paradigms, it appeared to embody this cultural tension. The *Two Cultures* debate framed much of the early criticism and reception of computer art. Computer art writing is filled with rhetoric concerning the antagonism between art and science. Mostly, the technologists stared across the cultural divide to lambast the artist for being sluggish in taking up the newest technology, while the artists countered with claims that the scientist was a naïve and unwanted trespasser.

The competing ideologies of art and science would endure as a polarizing force in computer art. Because computer art was an unfamiliar and foreign phenomenon, emerging from a technocratic and militaristic world, the art establishment found it to be disconcerting. Equally, however, for the science sphere, computer art was a logical, yet trivial and aberrant offshoot of the fruitful symbiosis of science and technology. Subsequently, the computer art project rested precariously between the two major cultural discourses. While in many ways computer art was an attempt to bridge two divergent and opposing worlds, it was destined, through its scientific and technocratic heritage, to remain marginalized from the mainstream art world. Likewise, the scientific community would malign computer art because its artistic intentions were inconsequential and insignificant to the key project of science.

A child born to loveless parents, computer art nevertheless benefited from the new artists who came into the field in the 1970s and positioned computer art as a site of cultural conciliation. As happened with the Art and Technology movement in the United States, the polarities of the cultural field were to be united by the synthesis of knowledge and collaborative effort. Chapter 2, "Coded Aesthetics," continues the focus on the 1960s; however, the chapter also examines how early computer art was predominantly shaped by trends in post-industrial science and technology. Computer art shared primarily the assumptions, terminology, insights, concepts, and methods from a variety of technoscience paradigms. For instance, rather than having recourse to conventional aesthetic criteria, computer art found its first aesthetic tradition in the changing visuality of science. Especially in the first decade, the symbolic narratives of science and mathematics were far more influential than modernist paradigms. New electronic visual devices fostered growing interest in picturing the visible and invisible forces of nature. Scientists, with likeminded artists, became fascinated with the visual byproducts of scientific research. This caused a shift in which the bewitching patterns of nature—visualized by mechanical drawing instruments and other electronic technology—became a significant source of artistic creativity. This mixture of mathematical–mechanical patterning provided the first aesthetic foundation for computer art, along with its first mythology. Like computer art, the servo-mechanical drawing instruments from the natural and abstract sciences appeared to connect to the mysterious forces of nature. With the mathematical patterns of nature abstracted into computational form, computers appeared to generate strange geometric forms from some mysterious Platonic space. The technologists and scientists relished the mathematical grandeur of harmony, order, and symmetry—those elements that find continuity with ancient Pythagorean, Platonic, and Byzantine traditions. The mystic space of mathematics and the desire to discover the unseen realm of abstraction emerged as a key mythology in computer art.

The other factor that illustrates the trend toward the abstract sciences and that made computer art diverge considerably from the traditions of fine art is the desire for the mathematization of art. This quest puts computer art at odds with the sacrosanct assumptions of traditional fine art. Because the computational experience is predominantly an abstract one, the discourse of computer art is part of the primal dream of mathematics. Influenced by mathematical–logical formalism and the empiricist epistemology of natural sciences, the technologists and mathematicians envisaged the power of the computer as an experimental tool—an instrument to transform complex mathematical information into visual phenomena. Beyond making the abstract visible, there is a prolonged attempt to submit art to the powers of mathematics—to, in effect, demystify art. For many exponents of computer art, mathematical formalization could purge art of the taint of rhetoric and mystery. The Kantian doctrine of artistic creativity, which is the cornerstone of Romanticism, would come under relentless attack. Fine art was no longer the domain of the "artistic genius," those with "a talent for producing that for which no definite rule can be given," as Kant suggested.[36] Instead, scientists, armed with the ultra-reductive machine, attempted to debunk the notion of the genius—effectively claiming that talent is not innate, but could be programmed into a computer. The scientists and technologists found in the computer the possibility of a fully mechanized art, or, as Franke put it, the final "delegation of the aesthetic-creative processes to machines."[37]

The mathematicians and technologists put their faith in the emerging technoscience system-based paradigms of the day. Combining information theory and cybernetics with structural linguistics and behavioral psychology, technologists and mathematicians closely observed the production and reception of art. Beyond deciphering the mysteries of art, the technologists and mathematicians believed it was possible, through programmed aesthetic and stylistic rules, to automate aesthetic production and "program the beautiful," as Max Bense famously phrased it.[38]

"Virtual Renaissance," Chapter 3, covers the 1970s and traces the significant shifts that take place in the computer art movement during this decade. The most important occurs in praxis. Artists, once adverse to computers, began enthusiastically exploring the computer as an art-making device. Over time, artists filled the space originally taken by scientists and technologists, developing the *esprit de corps* of a relatively coherent group. In trying to avoid antagonistic collaborations, a central factor leading to the disintegration of the Art and Technology movement, a number of artists learned the intricacies of computing. In the shadow of Art and Technology's decline, a new breed of computer artist emerged—the artist-programmer. With the influx of trained artists, new mythologies and narratives emerged that brought new-found optimism and reassurance. One of the key icons to emerge from this period, which provided a recurring theme, was the Renaissance figure of Leonardo da Vinci. The Renaissance master encapsulated the new artist-programmer paradigm and the dream of unified learning that was such a powerful desire within the 1960s *Two Cultures* debate. This new discourse sustained computer art during a period when other technological art forms fell from favor. An emerging mythology was not, however, the only cause of computer art's relative success through the 1970s. Apart from the new publications and journals (of which *Leonardo* was the focal) that emerged in the early 1970s, one of the key invigorating and sustaining features was the growing number of women in the field of computer art. Having to overcome the masculine world of computing, women emerged as authorities in both criticism and practice. In addition, the global increase in computer literacy and the ever-expanding computer industry facilitated the influx of artists to the field. After a period of mistrust concerning computers, artists began feeling a new sense of ease around the computer, which, through its ubiquitousness and expanding role, would clearly play a significant part in modern life, and thus in art.

The appearance of the artist brought new humanistic tendencies to the once impenetrably cool and utilitarian computer art form. The nascent artist-programmer paradigm shifts the emphasis away from mathematically inspired abstraction toward such traditional fine art genres as landscape and self-portraiture. There was a direct attempt to humanize the machine. Moreover, the new understandings of programming, which revolved around intuition and heuristics, allowed the artist freedom to interact with the computer in an open-ended and responsive manner, which contrasts to the self-generating nature of previous work. Using the computer as a mechanical generator of vast amounts of visual form, the artist explored the diverse potential within a computer art system. However, while there was an emergent subjectivity in 1970s computer art, the quest to make "deep inroads" into the mysteries of art, as Jack Burnham wrote, remained a defining characteristic.[39]

Despite their impact upon the field and the diversity of technique emerging from their influence, artists became highly critical of computer art, as did commentators and critics. Computer art's renaissance is perhaps more virtual than real. Chapter 3 concludes by exploring how, and on what grounds, representatives from science and art attacked computer art. Both critics and exponents made scathing assessments of computer art during the 1970s. For them, the abstract and natural sciences could not provide an adequate aesthetic foundation. Artists were quick to lay blame at the feet of the scientists and technologists who, without real claim, arrogantly called themselves artists. As the criticism of computer art was predominantly formed from the dissent between the cultural fields and their competing agendas, the first stage of computer art was dismissed as unimpressive and inconsequential. To measure computer art's qualified failure, the chapter concludes with an examination of the relative success of video art. While they both emerged in a similar techno cultural environment, video art was legitimized almost immediately through a combination of critical, institutional, and counter-cultural support. Crowned the new "avant-garde" with festivals and retrospectives, video rapidly became an art "genre," while computer art remained marginalized, languishing in a state of malcontent.

Chapter 4, entitled "Frontier Exploration," explores the first half of the 1980s when computer art again attracted new interest and popularity. Computer art and its discourse underwent significant change through the expanding nature of digital technology and the cultural popularity of emerging technoscience paradigms. One of the most notable changes in computer art discourse was the re-emphasis on Neo-Platonism and mathematical mysticism. Computer artists became the "pioneers" of a new digital world. Beginning with the computer artists of the 1970s and materializing in its strongest form in the early 1980s, the computer was increasingly imagined as a mythic space, an abstract frontier for artists to endlessly explore. This growing metaphysical overtone was the result of a number of factors. One was the impact of, and cultural interest in, the science of complexity. Chaos theory and fractal geometry became popular metaphors for a raft of social phenomena. These theories had a direct impact on the consciousness of the computer artists, who imagined themselves as discoverers exploring the mysterious territories between order and chaos.

Technoscience themes continued to shape, sustain, and develop computer art. However, the ever-evolving nature of computer technology defied any singular conceptualization. With first the development and then the refinement of the graphics interface, the computer invited a whole new kind of practice. The personal computer, with its new user-friendly interface of windows, icons, and later the mouse and pointer systems, revolutionized computing and brought a raft of potential applications to visually orientated fields, such as desktop publishing, industrial design, and entertainment. This precipitated a shift away from the province of the specialist—the orthodox artist-programmer—toward the uninitiated practitioner or user. Commercial software development resulted in a number of art and design applications. These applications embedded the traditional art-making metaphors and processes of drawing and painting into a real-time interactive interface. Thus, the new breed of computer artist was not required to learn programming or understand the complexities of the machine. With the refinement and commercialization of special input devices, such as the joystick, stylus, and light pen, artists began to work directly upon screen-based imagery. Beyond the computer interface, there was a new convergence of electronic and digital media. Multimedia allowed artists to incorporate a number of sensory modes into interactive and performative events. These technological developments resulted in two significant outcomes for computer art. First, static imagery appeared outdated in the face of new dynamic and interactive digital techniques. Second, the off-the-shelf commercial software packages effectively divided the existing computer art project into two camps. The first of these, the purists, who represented the artist-programmers, saw themselves as working with the essential algorithmic nature of the medium. The second group, the commercial software users, treated the computer as a mere tool—a means to an artistic end. So began the rhetorical debate that centered on the mind/body dualism in which one group privileged the analytical and cerebral while the other valued traditional artistic standards such as intuition, craft, and manual dexterity. As the decade proceeded, the gulf between the two groups widened, resulting in a raft of criticism concerning the project of computer art. “Computer art” as a term became a site of contestation between rival groups as they attempted to assign and control its meaning. Apart from analyzing the general ambivalence surrounding computer art, the chapter concludes by demonstrating the increasing de-rationalization of the computer art object and the move away from the idealization of mathematics as the normative aesthetic and theoretical paradigm.

Chapter 5, entitled "Critical Impact," explores the mounting crisis and widespread discontent that developed at the close of the 1980s. This resulted in the fragmentation of computer art into vastly contrasting conceptualizations in 1989. Key to this division was a series of journal articles written in 1989 that recorded the changing discursive space and resulting schism. More significantly, these articles provided the first instances of critical discourse in the realm of computer art. Richard Lucas' *Delphi Study*, conducted in 1986, which systematically gauges the thinking of theorists and practitioners at the time, confirmed a distinctive shift toward contemporary art and its dominant critical discourse. Those computer artists who used the computer as a tool began theorizing digital technology through postmodern critical modes. Following trends in art critical discourse in the early 1980s, they significantly reoriented computer art discourse toward the social-critical. For the first time, the thinking of Walter Benjamin, Michel Foucault, Jacques Derrida, Roland Barthes, Jean Baudrillard, and Jean-François Lyotard were discussed in relation to computer art. The intention of the new postmodern computer art commentators was to fill the critical and theoretical void that had plagued computer art since its inception. They saw the lack of criticality as the most pressing problem of computer art. The first objective of this new critical stance was the negation of the term "computer art" and the need to identify, and if necessary recast, the history of computer art. For the postmodernists, the important aspect of the computer was that it disrupted the agenda of modernism. So, in a complete turnaround from previous criticism by both humanists and anti-humanists, the computer was increasingly perceived as a technology of rupture rather than an embodiment of the Enlightenment vision.

Postmodernists tended to align computer technology with the history of photographic technology. Viewed through the new photographic digitalizing software, computer art became increasingly photogenic. Postmodernist critics also attacked the discourse of computer art for being apolitical and inherently conservative.

Programmers tended not to be driven by anti-authoritarian imperatives or any kind of political radicalism. They were far too devoted to the machine and its potential. While the postmodernists attempted to formulate a homogenous and unified critical position, computer art as a practice proved ideologically diverse. Whereas postmodernists devalued the mainstays of modernism—ideals of uniqueness, authorial genius, and formal purity—many computer artists advocated a return to modernist principles, in particular formalism. Many of the commentators reinforced the close allegiance computer art shared with the discourses of science and technology. They stressed the importance of existing scientific paradigms and methodologies. Computer art, on the whole, was incompatible with much of the postmodernist project because computer art originated from and was heavily invested in the modernist paradigm. I argue that critical postmodernism, or the model employed to theorize contemporary photography, is an ill-fitting paradigm for the critique of computer art in the 1980s. There were inherent contradictions in employing the intellectual discourse of postmodernism in the critique of computer art. After all, an arc of twentieth-century continental theorists and philosophers who represented the critical foundation of the postmodern position were skeptical of the promise of science and technology.

While the application of postmodernism to computer art was modish in character, it did bring political consciousness and contextual understanding to computer art. The influence of postmodernism and critical theory, in general, provided a theoretical foundation for digital art and new media in the 1990s. Nevertheless, postmodernism certainly did not take over as the dominant paradigm from which computer art could be understood. The technoscience paradigm of artificial life that emerged with the synthesis between biology and information in the 1980s had an enduring impact on computer art. While the biological metaphor was implicit in the work of the 1970s, by the 1980s, with fractal and genetic algorithms, the metaphor became fully active. The biological metaphors of generativity and emergence became crucial to those art forms that emerged in the wake of computer art's decline, such as "generative art" and "algorithmic art." Similarly, facing the expanding digital art field, many computer artist-programmers rearticulated the essential aspects of the computer as central to the art's meaning. Like the postmodernists, they also abandoned the term "computer artists" for a myriad of other designations, such as "proceduralists," "dataists," and finally the "algorists."

In the epilogue "Aftermath," the fate of computer art in the 1990s is evaluated. From 1989 onward, the term became increasingly moribund as a lexicon of other more defining terms took its place. These include "algorithmic art," "generative art," "random art," "software art," "system art," and many others. This concluding section demonstrates how the history of computer art—the so-called pioneering phase—acts as a prehistory for the now dominant discourses of digital art. Also noted is the way the postmodern understanding of technology began to prevail within digital and new media discourse. By the 1990s—through the central idea of virtuality—immersion, cyberspace, interactivity, and telepresence began to take center stage. These discourses are found to be replete with theory from continental philosophy. However, computer art does not fade away under the domination of new media theory. Much of its philosophy, central tenets, and history are nonetheless embedded in other discourses. Beyond being crucial in the evolution of art toward new media, computer art, through its pioneering artists, laid the foundation for digital art culture. In addition, the early computer artists were the first to institute the innovative digital and media art programs that are so widespread today. Many of the pioneering artists, once courageous in their attempt to carve out an art practice with what was an exceedingly difficult technology, have built enduring careers. As digital technology has now become culturally integrated, the memories of chastisement and ridicule have begun to fade. A new focus, one deprived of old prejudices, has begun the process of revaluating these computer-generated artworks, finding them to be acutely important to the history of art.

CHAPTER ONE

Future crashes

In 1964, Toronto art critic Arnold Rockman joined with computer scientist Leslie Mezei to write the first recognizable piece of computer art criticism. Appearing in *Canadian Art* and entitled "The Electronic Computer as an Artist," this seminal article possessed all of the basic elements of art criticism: historical context, stylistic analysis, and, most importantly, evaluative judgment. Still, these elements were limited in scope. The article, which was largely an introduction for unfamiliar readers, outlined recent achievements and prognosticated the future of this promising technology in the arts. While the article was notable for its attempt at formal criticism, the authors' tone was distinctive, for its tenor was one of admonishment.

As with all co-authored writing, it is difficult—if not impossible—to entangle the prose, correctly identifying each author's attitude. In this case, the authors were from two different disciplines, with one from the humanities and the other from the sciences. On a pragmatic level, the article required two sets of knowledge and expertise. Rockman would provide the art-history analysis and critic's eye, and Mezei would supply the technical explanation and recent trends in computing. It remains entirely fitting that the first article on computer art required an interdisciplinary union, and this combined method would embody those tensions that would plague the movement. In their attempt to make sense of an emerging field, both artist and scientist were fully reliant on each other's knowledge, thus recognizing the deficiencies and inherent duality of computer art. Yet whatever viewpoint each brought to the article, there was an agreement that visual artists were severely lacking, while the scientist, acting as a foil to the reticent artist, was the real avant-garde of computing.

Rockman and Mezei believed visual artists were blind to the power of the computer, believing the "lukewarm response" and lack of interest from painters and sculptors was perhaps "a result of ignorance."[1] Undeniably, visual artists were slow to recognize the computer's potential. While many musicians and poets embraced the new technology as early as 1956, it would be a number of years later before technologists intentionally created visually aesthetic designs, and longer still before trained artists embraced digital computing. As Rockman and Mezei understood, the artist had no role in the development of the newest creative medium; rather, the scientist—or more particularly the technologist—had become the vanguard of computer-generated imagery.[2] The authors were not alone in identifying apathy, for other technologists felt somewhat perplexed by the reticence shown by the art community. Some even felt that artists lacked the necessary insight to appreciate the implications of the computer, and that they, the scientists and technologists, were the only ones capable of exploring the mesmerizing vistas unleashed by computer technology. Mezei and Rockman simply believed that artists regarded the "machine as their enemy."[3] Later, Jonathan Benthall, who trained as a social anthropologist, stated, using a more sexualized metaphor, that the computer had become for the artist a "creature of great sexual attractiveness whose actual anatomy remains elusive, frigid and unexplored."[4]

Beyond the reference to the growing epistemological divide between art and science, what is left out of the article is perhaps most revealing. Two award-winning computer artworks, entitled *Splatter Pattern* and *Stain Glass Window* (each published a year before in the journal *Computers and Automation*), were not attributed to an artist or a research laboratory, as all of the others featured in the article had been. Only months before, in May 1964, Mezei had given the first lecture on computer art at the fourth meeting of the Computing and Data Processing Society of Canada, which formed the basis for "Artistic Design by Computers," an article printed in the 1964 August edition of *Computers and Automation*. In his timeline of recent events, he mentions *Splatter Pattern* again, though not by name but by the process in which it was made.[5] This image, which graced the front cover of *Computers and Automation*, was the first computer art to be judged as the best out of that year's submissions. Interestingly, the U.S. Military was responsible for the computer program that generated the artwork.

A military laboratory producing the first recognized award-winning piece of computer art in the United States is certainly unorthodox. In fact, there is no similar example in the history of art. The uncomfortable fact of computer art's origins has prompted many commentators and proponents to situate the emergence of computer art a number of years after 1963, effectively bypassing its military beginnings. The reason why Rockman and Mezei failed to mention it may indicate a sensitivity that others in the arts acutely felt.

The trade journal *Computers and Automation* (later to become *Computers and People*) facilitated the birth of computer art through its "Computer Art Contest" of 1963. Submissions were invited for any artistic drawing or design made by a computer. That year, the first and second prizes went to the United States Army Ballistic Research Laboratories (BRL) in Aberdeen, Maryland, the same laboratory that had started the computer industry in the United States during World War II. The army-sponsored revolution in computing at BRL had produced the famous ENIAC, which was followed by the ORDVAC, EDVAC, and the BRLESC 1, which in 1962–3 most likely had a role in producing the first examples of computer art. The prize-winning art piece *Splatter Pattern*, which was printed on an early printer called a "dataplotter," was a design analogue of the radial and tangential distortions of a camera lens (Figure 1.1). In 1964, the same laboratory won first prize for an image produced from the plotted trajectories of a ricocheting projectile (Figure 1.2). However, as mathematical visualizations of natural phenomena, these authorless images were not produced for aesthetic reasons. As the captions accompanying the artwork communicate, the artworks were, as Rockman and Mezei rightly assert, "merely an aesthetic by-product" of utilitarian pursuits.[6]

Notwithstanding, the images—deemed "beautiful" by *Computers and Automation*'s editor Edmund C. Berkeley—were published as "art." Three years before, in 1960, William Fetter, a Boeing employee, had coined the term "computer graphics" to describe computer-generated imagery. Berkeley, through *Computers and Automation*, contributed to the general currency of the term "computer art" and, in consequence, propelled these new creations toward the discourse of art.

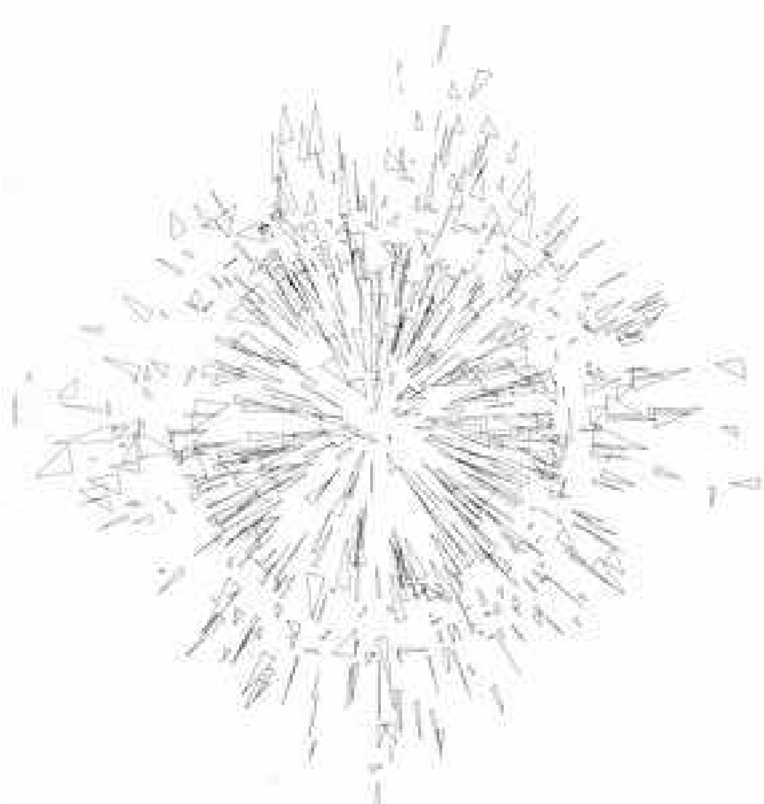

FIGURE 1.1 *United States Army Ballistic Research Laboratories,* Splatter Pattern, *1963. Computer-generated, graphed on an Electronic Associates, Inc. Dataplotter. From Computers and Automation (August 1963). Courtesy of the U.S. Army Research Laboratory.*

While these images, automated and functional as they were, were not construed as objects in the tradition of Marcel Duchamp's *Readymades*, neither were the technologists anti-art in the Duchampian sense. Rather, they perceived their machine-made product through the narrow lens of conventional pattern-making and novel design. Nevertheless, the fact remains that technologists working for government-funded military agencies created the first computer-generated imagery deemed to be fine art objects. An analysis of the entries in *Computers and Automation* dating from

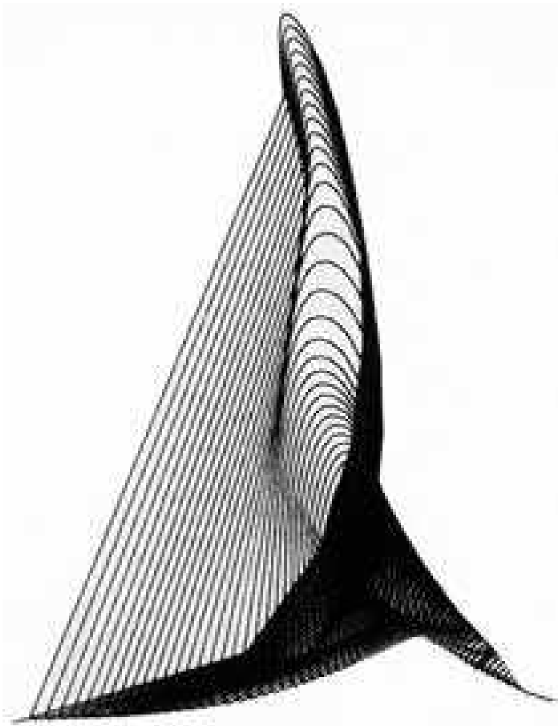

FIGURE 1.2 *United States Army Ballistic Research Laboratories,* Trajectories of a Ricocheting Projectile, *1964. Computer-generated, graphed on an Electronic Associates, Inc. Dataplotter. Courtesy of the U.S. Army Research Laboratory.*

1963 to 1965 reveals that large research laboratories associated with the military or otherwise dominated computer art production. These included the Westernhouse Electric Corporation, Bettis Atomic Power Laboratory, California Computer Products, Inc., and Calcomp Plotter. Indeed, the military link would persist, in not only the development of computer technology but also the funding of computer art exhibitions, including in 1968 when the U.S. Air Force partly funded computer art's first international exhibition, *Cybernetic Serendipity*. Within the sciences, there would be little surprise if a government-funded laboratory won a competition; however, to the art community it appeared particularly objectionable.

Fortunately for the artistic community, the publication was a specialist trade journal, popular to a small but growing group of technologists involved in the computer industry.

As an industry-related special interest journal, *Computers and Automation* played an important role in popularizing the idea of computer art. Through the competition, the journal attracted works from all over the world. From 1965, technologists from Canada, Germany, London, Italy, and Japan published their work in the journal. By 1970, artists from France, Holland, and Sweden were also publishing in the journal. In this respect, the contest was the first of its kind—self-consciously global—and the only forum in the world that published and discussed computer art as a self-contained category. The journal had a crucial role in connecting the growing number of interested technologists and artists. From 1968, the journal published the names and addresses of practitioners as a way to encourage interaction and communication. In addition, the journal was the first medium in which computer artwork was sold. The journal published advertising for Compro, a computer printing company from New Jersey that sold award-winning prints.

The appearance of *Computers and Automation* reveals that computer art and its growing discourse was active among technologists some years before the first exhibitions. Technologists perceived computer art in the context of the flourishing computer industry, which had been expanding significantly through the early 1960s. Computer art was an extension of the computer industry rather than a natural outgrowth of the arts. Although it had developed independently of criticism, the computer art project was self-sufficient. Within the scope of the periodical, computer art had a small but growing audience. It was attracting international practitioners and diversifying through competitions and mail-order art catalogs. In many ways, computer art was the by-product of computer science's self-confidence, rather than an invention of some technologically inspired artistic movement. Like the computer hobbyists of the period, individuals who would shape personal computing in the 1970s, the computer art practitioners perceived what they were doing as amateur rather than professional, happenstance rather than ideological.

However, computer art was not to remain within the bounds of the insular world of computer engineering for long. In April 1965, the first public exhibition of computer art took place in New York. The

New York Times art critic Stuart Preston opened with: "The wave of the future crashes significantly at the Howard Wise Gallery."[7] On display were "computer-generated pictures" produced by A. Michael Noll and Béla Julesz, two technologists from the Bell Telephone Laboratories, which, at the time, was one of the most innovative scientific organizations in the world. Research scientists at Bell Labs also supplied computer-generated music for an ambient backdrop to the art. Only months earlier, at the Technische Hohschule in Stuttgart, West Germany, Noll had joined with fellow mathematicians Frieder Nake and Georg Nees to produce the first exhibition in Europe. This temporal congruence was as much due to exchange of research and development between two technologically advanced countries as it was about the need to reveal the invention and novelty of recent computer research. Initially, the technologists did not intend to create fine art. Nevertheless, Julesz was enthusiastic when he found it possible to make the electronic computer "produce patterns of some originality and interest," while Noll came to computer-generated imagery by accident when a colleague's microfilm plotter erred and produced an unusual linear design, an abstract configuration that held a certain aesthetic quality.[8] To the mathematician's surprise, the press, television, and art colleges began to take interest in what Nake had perceived as "everyday and business."[9] As Nake recounted, "A great time started for a young mathematician who had become an artist."[10]

Previously, computer art had remained within the confines of the technocratic periodical *Computers and Automation*. Once exhibited at the Howard Wise Gallery, however, it was effectively nudged into the orthodox art world. Well known for its receptivity to the latest technologically based art, the Howard Wise Gallery was a suitable place for this experimental art. However, this was no ordinary exposition of work created by artists working with new media. Apart from being organized by scientists and sponsored by the telecommunications giant AT&T, the exhibition was showing art generated by a machine. Emerging from the technical sphere, computerized art was inevitably set on a collision course with the art community and its well-established paradigms of art production and meaning.

From the onset, problems besieged the exhibition. Julesz was not pleased with the use of the term "art" in the title of the exhibition because the images were stimuli for psychological investigations into visual perception. Julesz' ambivalence was the first in an ongoing debate within the computer graphics community about the categorization of computer-generated imagery as art. On the other hand, Noll was quite comfortable in identifying his works as "art" because his production was made "solely for their aesthetic or artistic effects."[11] A compromise was reached by titling the exhibition *Computer-Generated Pictures*.

One of the key artworks from the exhibition—the first ever digital artwork to be granted copyright status—was Noll's *Gaussian-Quadratic* (Figure 1.3). It was in the summer of 1962 that A. Michael Noll sent a memo to his colleagues at Bell Labs explaining he had

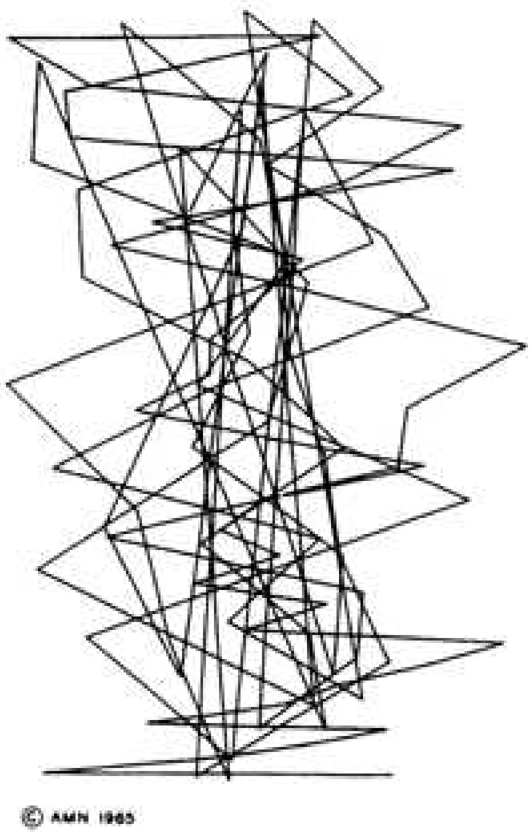

FIGURE 1.3 *A. Michael Noll,* Gaussian-Quadratic*, 1962–3. IBM 7090, Stromberg-Carlson S-C 4020 microfilm plotter. © 1965 A. Michael Noll.*

generated a “series of interesting and novel patterns” on the IBM 7090.[12] In an attempt to avoid debate or provoke the displeasure of his employer, he called his creations “patterns” rather than “art.”[13] This more innocuous term, however, did not hide the importance this simple memo held for the history of art. One particular abstract pattern in this series held a certain allure for Noll. Investigating the visual effects of programmed randomness, Noll had produced *Gaussian-Quadratic*, the mathematical title stemmed from the line segments having a Gaussian curve distribution. Noll felt that this particular abstract design possessed a resemblance to the Cubist infrastructure of Picasso’s *Ma Jolie*, one of his favorite paintings in the Museum of Modern Art collection.

In actuality, much of the ambivalence over whether or not to call the work “art” was associated with the initial response by AT&T, the parent company of Bell Telephone Laboratories. While *Gaussian-Quadratic* is celebrated as the first copyrighted piece of computer art, in effect the first accepted creative act in which the artist has the legal right to control reproduction, the impetus for seeking legal status was a result of Bell Labs’ uneasiness with the art-making activities of some of its researchers. Essentially, the research institution forced the scientists to gain copyright as a way to disassociate the work from the scientific research undertaken at Bell Labs. As Noll outlines some years later:

> Although the research management staff at Bell Labs was very supportive of the Howard Wise Gallery exhibit, the legal and public relations folks at AT&T became worried that the Bell Telephone companies that supported Bell Labs would not view computer art as serious scientific research. Hence an effort was made by AT&T to halt the exhibit, but it was too late, since financial commitments had already been made by Wise. Accordingly, Bela and I were told to restrict publicity, and, in an attempt to foster such restriction, Bell Labs gave Bela and me permission to copyright all the pictures in our own names.[14]

However, when Noll attempted to register the copyright for *Gaussian-Quadratic* with the Copyright Office at the Library of Congress, they refused. Their refusal was on the grounds that a “machine had generated the work.”[15] Noll patiently explained that a human being had written the program that incorporated randomness and order.

They again declined to register the work, stating that randomness was not acceptable. The copyright was finally accepted when Noll explained that although the numbers generated by the program "appeared 'random' to humans, the algorithm generating them was perfectly mathematical and not random at all."[16] Nevertheless, by registering the copyright, Noll took the position of creative artist, which was a designation he continually shunned. Many artists and critics, as the technologists admitted, came to resent this blurring of the boundaries between art and science.

The initial reaction to the Howard Wise exhibition from artists and critics alike was hostile. But not all of the reviews were written with disdain. Noll believed that Stuart Preston's *New York Times* article has some positives. However, on a close reading of the article, the tone of the piece expressed a reservation and discernible regret that future art would be "entrusted to the *deus ex machina*."[17] Perhaps an age had arrived in which the artist would become subsidiary to the machine—a mere idiot servant to an art-making robot. Although the exhibition was a significant landmark, and it generated a certain amount of technical interest, the criticism ranged from "cool indifference to open derision."[18] Preston described the imagery as "bleak."[19] The reviewer in *Time* magazine noted that the pictures on display not only resembled "the notch patterns found on IBM cards" but also had "about the same amount of aesthetic appeal."[20] The *New York Herald Tribune* denounced the works as "cold and soulless," a criticism that would continue to haunt future computer art.[21] Most artists, as Goodman noted, believed the medium had not proved itself "accessible or refined enough to venture into."[22] While the Howard Wise Gallery was the premier commercial venue for presenting art and technology, receiving much press and attention, none of the work sold.[23] Noll admitted in retrospect that the public and media's response was "disappointing."[24]

This response was not confined to the United States. Tellingly, computer art received a uniform response across the world, which was both apathetic and dismissive. In West Germany, the artistic community responded with distrust on seeing the first examples of computer art; they were "nervous, hostile, furious," as Nake recollected.[25] The critical response to the first computer art exhibition in 1965 in Stuttgart, West Germany, was effectively the same as that in the United States. Even in Japan, the artistic community was apprehensive. Haruki Tsuchiya observed that artists who were not computer professionals were extremely suspicious of computer art.[26]

When computer art moved from the relative safety of the technocratic domain to the intensive critical environment of the art world, it created inevitable frisson. The general antagonism between the scientific and artistic communities, what Goodman called the "uneasy liaison," pervaded the early commentary on the emerging art form.[27] Over the following five years, these hostilities were played out in science-based publications, which tended to depict the technologist as a zealous scientist forging new artistic paths, while the artist, characterized as defiant and lacking fortitude, languished in the doldrums of technological ignorance, as first witnessed in the Rockman and Mezei article. Herbert W. Franke, the first to write a full history of the computer art movement, recognized that the computer, as an art maker, had raised and exposed many problems, and only members of the scientific community, the commentator believed, had the language, awareness, and skill to approach the new form.[28] Those who presented themselves as art pundits, as Franke outlined, increasingly needed to give way to "scientists, mathematicians, and technicians who, becoming involved in the discussions … injected new energy into the field."[29] In response, the artist and critic felt that the scientist was trespassing on their ground; they saw the scientist's work as dull and lifeless, evidence of aesthetic ineptitude. The aesthetician Robert E. Mueller concluded his 1967 book *The Science of Art* with this exact sentiment:

> The fact that computer specialists and scientists who work in the visual realm have little or no detectable knowledge of the tradition of artistic visual work makes most of their work entirely without artistic meaning and completely sterile visually. … If they insist on working in the direction of purely design orders, it is not easy to see how they can make anything of more meaning than natural orders like snowflakes.[30]

Once placed in historical context, the reasons for this mounting antagonism become clearer. The technologies, employed to create this so-called art, originated from the military and industrial laboratories. The scientist and technologist were introducing the ultra-rational and now semi-autonomous computer into a domain broadly dominated by romantic and existential humanism, which held artistic genius and human intuition to be the cornerstones of creativity. Moreover, the first exhibition took place not in a provincial gallery, but in New York City, the center of the avant-garde art world. Whether they liked it or not, New York critics were forced to reconcile with this new art form.

The critics' unease and suspicion must be understood through the frame of pre-existing ideologies that inform the development of the modern digital computer, concepts that enviably form the basis of the new art form. The figures who became the very first practitioners of computer art—the technologists—were imbued with a particular type of technocratic spirit, a twentieth-century mindset that is characterized by a firm belief in the technical powers of rationality, efficiency, and order. The technocratic spirit finds its roots in the mechanical efficiencies of Taylorism and Fordism that emerged early in the century. While a technocratic spirit can be identified in early twentieth-century art (for example, in the dogmatic techno-inspired yearnings in manifestos of the Italian Futurists, or in the utopian rhetoric of the Constructivists and their desire to engineer a new world order), computer art in North America was philosophically tied to those often esoteric theories, such as cybernetics and information theory, that informed American science and technology.

Even more deeply ingrained within the technologists was the belief in the pre-eminence of science. The ideology of scientism that spread among American intellectuals in the post-war years held that scientific method constitutes the most authoritative worldview. Following the wars, science came to be organized in the manner of the industrial corporation. Big Science, as it began to be termed, employed the model of research organization that proved so successful during the wars. Understood primarily in military terms, science and technology were viewed as strategic national resources. Universities would be brought into the orbit of the military-industrial complex, transforming much of the academic research into an industrialized type of knowledge production. These large, well-funded, multi disciplinary research laboratories, and the scientists and technologists that formed them, would capture the public's imagination, becoming visionaries—the ingenious builders of tomorrow.

Perhaps the most evocative and influential figure to the technologists of North America was the father of modern computing, John von Neumann, a Hungarian-born mathematician who dominated intellectual life in the fields of science and technology following World War II. During the war, von Neumann was an adviser on American government projects that developed strategic instruments for the war effort, including the infamous Manhattan Project. Neumann's scientific defense work included work on the high-speed computing machine ENIAC, which was developed by the Ballistic Research Laboratories, the same military laboratory that would win the prize for best computer artwork. Through the war, technoscience experts, such as von Neumann, were increasingly associated with the military as well as with the powerful private corporations that serviced it. As intellectual figures, they fostered and embodied the technological optimism and belief in technological mastery that permeated the period. In popular wartime imagery, the scientist and the engineer appeared as heroic figures, building the advanced technology that would win the war. In post-war writing, the scientist was presented, according to historians Andrew Jamison and Ron Eyerman, "as a man apart, a great man of thought and ideas, more a magician than a technician."[31]

The prestige of the technologist expanded in many circles during the Cold War period, as military laboratories emerged as world leaders in computing technology. The Defense Advanced Research Projects Agency (DARPA), which funded the majority of the growth in computer science, became the foremost sponsor of research into artificial intelligence. The Vietnam War and NASA increased the need for computing power, which resulted in significant growth and prosperity for the computer industry, including the burgeoning use of computers in business. As a consequence, IBM produced most of the world's computers. Almost exclusively, IBM machines generated the computer art of the 1960s.

However, this technocratic spirit that developed early in the century and gathered pace over the course of the world wars was not universally held, especially for those in the humanities. The memories of atomic clouds rising over Hiroshima and Nagasaki resonated deeply within intellectual and artistic circles. In the immediate post-war period, some intellectuals and artists were swept up in a wave of existential humanism, inspired by Sartre and others. Pessimism and collective despondency toward technology spread, with some commentators increasingly demonizing the implicit desires of science and technology. Social critics were reacting not only against the atrocities of two world wars, but also against the perceived loss of human qualities in a society increasingly under the sway of technological logic. In 1952, the American social critic and humanist Lewis Mumford lamented man's "worship of the machine."[32] According to Mumford, the scientific revolution had brought about a paradoxical effect of mechanizing humanity. "We have created a topsy-turvy world," Mumford mourns, in which machines became "autonomous" while men became "servile and mechanical."[33] People, as Mumford described, are so involved in the process of mechanization that "a large part of our fantasies are no longer self-begotten: they have no reality, no viability, until they are harnessed to the machine."[34] For Mumford, machines in industrialized society had alienated human beings and disconnected them from nature. In similar fashion, the influential Canadian media critic Marshall McLuhan "mourned the effects of the mechanistic way of modern life."[35] McLuhan similarly observed that America's technological society "vitiated family life and the free human expression of thought and feelings."[36]

The age of technological enthusiasm that initially dominated post-war America began to decline through the 1960s. Large parts of society rejected the rationality and hegemony of military production and technocratic modes of thought. Instead of sentimentalizing America's key role in the age of science and technology, the writers and philosophers of the 1960s counterculture probed the depth and extent of a society dominated by technology. In the same year that computer art began to be popularized, influential writers published a critical response to post-industrial technology. In 1964, for example, Herbert Marcuse argued in *One-Dimensional Man* that systems of production in modern capitalist and socialist societies repress the spirit and constrain the freedom of individuals.[37] The same year also marks Jacques Ellul's influential publication *The Technological Society*, which argues that modern societies, regardless of ideology, are subjugated by "technical phenomenon."[38] By being a type of slave to technique, Ellul believed, man was reduced to a technical animal. Likewise, Marshall McLuhan, who was widely read in North America, published in 1964 *Understanding Media*, a book that argued that technology was a force that appeared to reduce society to the "sex organs of the machine world."[39]

Stemming from their academic training and traditions, art critic Jack Burnham noted that "many art critics considered themselves 'humanists' with strong feelings concerning the encroachments of technology on nature and cultural traditions."[40] For those who lamented the cruel mechanized dystopia of the world wars, or the epic destruction made possible by the atomic age, a computerized form of art would appear particularly repugnant, even contemptible. As the cultural critique of technology spread in the early 1960s, paralleling the intensification of the Cold War and the escalation of the Vietnam War, the computer became a highly visible and threatening symbol of a social order increasingly dehumanized by technology. Nake, who was politically active in the late 1960s, acutely felt the growing perception of the computer as the Cold War technology *par excellence*. Dissatisfied with the direction of computer technology and feeling the pressure of his politically engaged peers, he eventually renounced computer art in 1971.[41]

However, it was not just the appearance of this new powerful and once secretive machine that was the problem at the Howard Wise exhibition; it was the encroachment of science into the world of art. In all the critics' responses, there is a palpable fear that computer art and its scientific creators would destabilize the basic categories and cultural positioning of art. Scientists were perceived as overconfident, presumptuous, and even boastful, while their reductionist techniques of reducing art to code appeared to lack all artistic sensibility. For many humanists, such an exhibition was another example of the progressivist march of science and its applied realm: technology. As the early criticism demonstrates, computer art exhibitions were spaces where scientists and technologists were making bold incursion into lands once clearly demarcated and culturally divided. For the cultural warriors, computer art was more an act of war than a birth of a new medium.

As the first technologists began to experiment with the computer as a possible art-making device, the cultural rift between science and the humanities was becoming a public debate. In 1959, with the publication of his lecture *The Two Cultures*, C. P. Snow brought the polarity between the humanities and science and the associated epistemological tension into sharp focus.[42] The English social critic blamed the widening gulf as a major impediment to solving some of Western society's intractable problems. However, Snow's most pointed criticism was aimed at the artistic-literary tradition, which he characterized as antiquated and increasingly obsolete, especially considering the enormous debt twentieth-century society owed to science and technology. Most provocatively, Snow, a trained physicist, announced that "scientists have the future in their bones," while "traditional culture" wished that "the future did not exist."[43] For Snow, literary intellectuals were "natural Luddites" who had little understanding and appreciation for advanced science and technology. Computer art became a cipher for Snow's rigid cultural divide. The first historian of computer art, Herbert W. Franke, who was a scientist himself, mirrored Snow's argument. For Franke, the rejection of the computer by the arts was "caused by a lack of understanding and even a distinct rejection of the technical side of modern life."[44] Rockman and Mezei's article, as mentioned above, characterized the scientist and technologist as optimistic, progressive, and future-orientated, effectively ascending over the languid, ignorant, and narrow-minded visual art community.

The impact of Snow's lecture and subsequent publications, including his 1965 response to critics of his perceived cultural dichotomy, *The Two Cultures: A Second Look*, was extensive. A myriad of publications followed in which the rupture in cultural discourse was reinforced or rejected. Nevertheless, Snow's generalizations became the framework from which the debate was contested. Simplistic stereotypes were offered: science is concerned with objectivity; art with subjectivity. Science was commonly considered a process of uncovering the deep structures of nature through rational, provable means. Appearing in opposition to science, art was concerned with the subconscious, intuition, and chance.

György Kepes, the Hungarian émigré artist who would have such a wide-ranging impact on art and design education in the United States, first at the Illinois Institute of Technology under the leadership of László Moholy-Nagy then later as the founder of Center for Advanced Visual Studies at MIT, had experienced this particular culture war firsthand. He wrote in 1965 that in "no other area of contemporary civilization are claims and counter-claims made with such vehemence, such offensive and defensive rigidity."[45] During the 1950s, Kepes believed that culture had in fact bifurcated, resulting in intense suspicion of any scientific endeavor in the arts. As a way to overcome the art world's reticence toward science, Kepes wrote *The New Landscape in Art and Science* (1956). But on its release, the publication was poorly received by his contemporaries. Some art magazines refused to review the book because, as critic and artist Douglas Davis wrote, "art and science are unmixable entities."[46] By the 1960s, Kepes had become increasingly disenchanted with what he perceived as insularity and biases of artists. He believed that artists, lacking any real orientation to the contemporary world, closed themselves off to the wider world by forming small intimate circles. In doing so, artists missed the "vital connections with contemporary intellectual and technological reality."[47] Kepes, despondent at the art world's intractability, felt that any real collaboration between the disciplines was "improbable."[48]

Although Snow's essay reinforced simmering prejudices, the central tenet behind the *Two Cultures* lecture was to remedy the perceived social and intellectual disjuncture. The history to the perception of difference between science and art, often located in the rise of modernism and the will to demarcate in absolute terms each domain, was congruous with the history that attempts to unify the two cultures.[49] In *The Two Cultures: A Second Look*, Snow optimistically suggested that a "third culture" would emerge and close the gulf between the scientists and literary intellectuals. This resulted in a number of publications on the possible emergence of a third culture, where professionals, with a growing awareness and wider spectrum of knowledge, would breach the gap between the two.[50] In contrast, only a few social commentators argued for the further separation and bifurcation of culture or that the conflicts between art and science cannot be overcome.[51] Through the 1960s, a significant amount of literature from the arts and sciences prescribed various ways to reconcile the two cultural monoliths. They ranged from reforming pedagogical practices to heightening interdisciplinary engagement. Many, however, simply looked to define the commonalities between art and science.

From the outset, computer art was promoted as a possible model for cultural convergence. Mirroring Snow's dichotomy, Franke wrote, "One of the most important effects of computer art is that it actively encourages the bringing together of the two cultures—the technical, and the humanistic and literary."[52] In the coming decades, computer art discourse would be infused with the belief that its practice somehow overcame the internecine elements within the cultural divide—that somehow the project was the ultimate synthesis of science, technology, and art.

Where Snow's critique perhaps fails is in its lack of acknowledgment of the use of science and technology by European artists. In the early 1950s, Hungarian-born artist Victor Vasarely emphasized the need for a creative synthesis between art and science. Following Vasarely's quasi-scientific approaches to making art and abandoning traditional handmade methods of production, like-minded artists began forming in Western Europe and South America. Intense experimentation with new media and production methods followed the first major post-war kinetic exhibition, *Le Mouvement*, in 1955.

The first large group was Zero, which Otto Piene and Heinz Mack founded in Düsseldorf in 1957. Beyond the idea of starting anew, which was implied in the name, the aim of the group was to employ the latest technologies with a romantic and intuitive approach. Other groups with similar tendencies, but who found Zero too romantic and idealistic, gathered under the label New Tendency (*Novelle Tendence*), a movement that would influence many sectors of European art. This broader movement emerged from an exhibition in 1961 held by Groupe de Recherche d'Art Visuel (GRAV), which was organized by Matko Mestrovic and others, in Zagreb, Yugoslavia. Individuals in GRAV, who wrote a *Charter of Foundation*, advocated a scientific approach to new materials. Overall, the members of New Tendency shared a cool scientific tone.

The artists who had formed these groups emerged from European and Latin American academies. Commonly, they wanted to make a science of art by systematically analyzing perception and putting to use the new materials and mechanical instruments that gave modern science its unique dynamism. For the science-orientated artist, the practice of subjective interpretation was replaced by the techniques of observation and scientific-styled investigations. Through their research and experimentation, they attempted to invent new forms of visualization that revealed a new awareness of perception, a field previously considered the exclusive domain of science. As a historical precedence, the use of empirical methodology of science would become a crucial feature of computer art.

Although these new pseudoscience movements gained substantial popularity, Nouvelle Tendence was not, as Douglas Davis stated, "universally admired."[53] As Lea Vergine wrote, critics saw the artwork as a "profane, technological and para-scientific exercise."[54] In the early 1960s, the shift toward science waned, with many groups folding. Davis cites 1963 as the beginning of the end for the "group renaissance."[55] GRAV called a meeting in Paris, which was attended by more than 30 artists, all related to

Novelle Tendence. Although the meeting was "noisy, vigorous, and optimistic," the following years saw each group falter.[56] Vergine says that technologically inspired art had "started out in the scientific laboratory and ended up in the boutique: the stoical longing for the golden proportion had given way to Biedermeier."[57] When the exhibition *The Responsive Eye* was held in New York in 1965, which was computer art's inaugural year, it was quite clear to the European artists "that the game was over."[58]

The Art and Technology movement in the United States emerged some years after the decline of New Tendency in Europe. Douglas Davis mused: "The torch carried so long by the Europeans passed now—for a brief time, at least—to the Americans, who seized upon esoteric materials and methods with a zest approaching the uncritical."[59] As the statement concedes, differences arose between the movements. The United States' Art and Technology movement was far "more self-conscious" and formalized than its European counterparts.[60] Following the *Two Cultures* debate, there was a conscious effort to join cultural disparities by forming cooperatives and fostering a climate conducive to collaboration. These alliances were encouraged to deal directly with large private and government institutions. In Europe, the artist held a more autonomous position, embarking on research within artist collectives, rather than collaborations funded by the government, the military, or corporations.

In the late 1960s, significant cultural resources were dedicated to joining art and technology. Even established art historians, such as Jack Burnham, championed the potential union of art and technology.[61] Between 1966 and 1972, several large-scale exhibitions took place internationally, including at prominent galleries in the United States, such as the Museum of Modern Art, Los Angeles County Museum of Art, Corcoran Gallery, and Walker Art Center. The most significant exhibition was *The Machine: As Seen at the End of the Mechanical Age*, which sought to historicize the intersection between art and technology. Curated by Swedish art historian K. G. Pontus Hulten, the exhibition represented an extensive survey, including the art of some 100 artists. Drawings by Leonardo da Vinci, experimental media since 1950, and contemporary works commissioned and overseen by EAT were included. The other major exhibition to have international exposure was *Cybernetic Serendipity*. Curated by Jasia Reichardt, it used cybernetic theory as the overarching theme to explore nascent computer and electronic technologies. Universally, these large-scale exhibitions exploited an assortment of different technologies and media to focus attention on the transformative powers of science and technology.

Yet the romance with science and technology in the United States can be traced even earlier in the 1960s. Although spasmodic at first, groups like USCO (or The Us Company), which formed in 1962 in Garnerville, New York, toured widely with multimedia performances and environments. The group saw technology as a means of bringing people together in a type of modern tribalism, an idea taken from McLuhan. In McLuhan-styled rhetoric, the artists wrote in the *Kunst Licht Kunst* catalog: "We are all one, beating the tribal drum of our new electronic environment."[62]

The real escalation in interest took place in October 1966 when avant-garde artist Robert Rauchenberg joined with Billy Klüver, a Swedish physicist working at Bell Laboratories, to stage a series of unique collaborative performances between artists and engineers at New York's 69th Regiment Armory. Because the venue had housed the famed 1913 Armory Show that brought modern art to the United States, the event was viewed auspiciously. *The Nine Evenings: Theatre and Engineering* involved the collaboration of 40 engineers and 10 avant-garde artists. Together they created an elaborate theatre, dance, and musical performance. It was an enormous undertaking, with 3,000 hours of engineering time required. The event was soon followed by the founding of Experiments in Art and Technology (EAT) by Klüver and Rauschenberg. EAT was established to promote collaborative work between artists and engineers. The opening meeting, held early in 1967 at Rauschenberg's loft in Manhattan, was attended by a variety of artists and scientists, including representatives from AT&T and IBM. Klüver believed that beyond improving the status and respectability of artists in society, art could become a vehicle to change the direction of technology. EAT and the other organizations supposed that through collaboration they could direct and control the forces of cultural change in an ethical and just way.

Other well-known avant-garde artists, like John Cage, also sought to remove those cultural barriers that pushed artist and engineer apart. He voiced a common feeling among a small group of artists, all open to advanced technology, that they could transform the social order. As Edward Shanken has written, Cage tried to counteract what he perceived as the "deleterious effects of technology—such as the destructiveness of war and industrial pollution—by appropriating it for beneficial aesthetic purposes which would infiltrate engineering and reform industry."[63] Technology and capitalist industry were joined together as an ideological front. The shared belief was that the technocracy could be countered by the revolutionary figure of the artist, who was the only one capable of humanizing technology.

Although computer art predated the Art and Technology movement in the United States, its popularity was inevitably linked to the expanded movement. The desire for cultural unity and the humanization of technology provide immediate similarities. Computer technology was often an intrinsic part of the Art and Technology exhibitions, as, for example, in Jack Burnham's 1970s *Software* exhibition. Although the computer became an important functional and symbolic technology within the movement, the computer art project often had divergent aims and characteristics. For example, in Art and Technology exhibits, the computer functioned within the museum space on an experiential and metaphorical level: the actual computer was part of the artwork. Within these exhibitions, the computer was taken out of its original functional context; in contrast, computer art exhibitions often only displayed the static images in isolation from the computer, which remained in the university or commercial laboratories. Whereas Art and Technology artists examined the aesthetic visual possibilities of science and technology, computer artists focused on production value of the apparatus itself. Art and Technology had no discernible relationship with any single technology, whereas computer art privileged the computer above all other media—it was the practical and spiritual core of the movement. But what set Art and Technology apart from computer art was the moral questioning of the processes and outcomes of science and technology. Trained as engineers and scientists, the first computer artists had no desire to look deeply at the social implications of the computer; rather they preferred to isolate the computer from its social setting and investigate the computer as a revolutionary image maker.

For Art and Technology organizations like EAT, computer art remained, as Franke asserts, "only of peripheral concern."[64] EAT and the avant-garde artists who supported it were interested in large speculative and experimental projects involving the latest technologies. By the late 1960s, the majority of computer art being produced was image-based, and most common was the plotter-drawn static image, what many today call the computer-generated print. This format brought it closer to the traditional arts than the large-scale, electronic media artworks of EAT. From the beginning, technologists have attempted to conform to their understanding of what constituted art—as something that was flat, portable, and could be hung on a wall. This type of media mimicry, of course, was not new. The inventors of photography, Nicéphore Niépce, Louis Daguerre, and William Fox Talbot, also adapted the photographic image to the pictorial framing traditions of painting. As a result of this remediation, small-scale plotter and photographic images made up the first exhibitions in both New York and West Germany in 1965. Although the scientists were seen as mere amateurs dabbling in the visual arts, they soon produced images with striking similarities to artistic movements of the day.

Of all the art movements of the 1960s, conceptual art is the one most aligned with computer art. In *Art of the Electronic Age*, Popper places one of the origins of computer art in the rise of conceptual art; he cites Christine Tamblyn's article "Computer Art as conceptual art," which argued that because "computers were designed to augment mental process, as opposed to being visual or manual aids," they were more suited to mental conceptualization.[65] One could conclude that computer art became a category in its own right before conceptual art. Conceptual art was only formalized by critics and practitioners in the late 1960s. Henry Flynt's conception of "concept art" varied in many ways from LeWitt's later definition of "conceptual art," which solidified in meaning through the 1967 essay "Paragraphs on conceptual art." By the late 1960s, computer art had already been exhibited, and its discourse, interdisciplinary as it was, was well established. Nevertheless, the idea and term "concept art," like "computer art," was first employed in written form in 1963, and both were broadly transcultural and system-orientated.[66] As early as 1962, Umberto Eco had coined the term "programmed art" to describe the new formalized trends in European art. "Programmed art" was often used as a blanket term for optical art and gestalt art and located its genealogy in modernist art practices. For art critic Guido Ballo, programmed art's heritage existed in the rigors of Neo-Plastic abstraction and constructivism. Like conceptual art in Europe and America, computer art appealed to the same concepts of objectivity and the will to detach the art object from the idea.

Aesthetically, the idioms of conceptual and computer art were often identical. In the same year as Noll exhibited his computer series at the Howard Wise Gallery, Sol LeWitt, one of the dominant exponents and theorizers of conceptual art, also began completing serial-based work. Seriality relied on the application of organizational schemes or systems that engender a number of possible visual sequences. Similarly, systems and algorithmic procedures, along with the production of different visual sequences, provided the basis for the computer-generated artworks exhibited at the Howard Wise Gallery. Within LeWitt's pseudoscientific methodology, there was a central place for mathematics. The conceptual artist viewed mathematics as a technique to both configure the object and avoid subjectivity. Both conceptual and minimalist art employed simple mathematical structures widely. Donald Judd, for example, employed mathematical calculations or principles of seriality rather than subjective judgments when creating his sculptural form. Empirical in nature, his process sought to obviate signs of personal decision by making mathematical sequence correspond with compositional arrangement.

Another major corollary between computer and conceptual art was the importance of the algorithmic procedure. The algorithm remained the foundational tenet of computer art. Here, LeWitt outlines his conceptual schema and methodology:

> To work with a plan that is pre-set is one way of avoiding subjectivity. It also obviates the necessity for designing each work in turn. The plan would design the work. Some plans would require millions of variations, and some a limited number, but both are finite. Other plans imply infinity. In each case however, the artist would select the basic form and rules that would govern the solution to the problem. After that the fewer decisions made in the course of completing the work, the better. This eliminates the arbitrary, the capricious, and the subjective as much as possible.[67]

Selecting the "basic form and rules that would govern the solution to the problem," as LeWitt wrote above, describes perfectly the algorithm procedure. Moreover, the algorithmic idea is behind his famous phrase: "The idea becomes a machine that makes the art."[68] LeWitt's first *Wall Drawings* produced a predetermined drawing system for generating lines. A prearranged sequence provided each work with its particular self-propelling mechanism, which served as a structuring device. As LeWitt stipulates, "art is about not making choices. It's in making an initial choice of, say, a system, and letting the system do the work."[69] It meant that all of the "planning and decisions are made beforehand and the execution is a perfunctory affair."[70] Producing a system that was prefigured, visually unpredictable, and autonomous was entirely consistent with the aims of computer art.

Another commonality between conceptual and computer art was the suppression of authorial presence. Conceptual artists decoupled the relationship between the art object and artist by mitigating all personal signs of invention. The artist became detached from the idea of personalized draftsmanship by installing a predetermined system—a type of instruction for another to follow. That way there was, as LeWitt states, no "dependence on the skill of the artist as a craftsman."[71] Effectively any person could carry out the instructions. The same process was at work in computer art, where artists devised a predetermined drawing algorithm for the computer automaton to carry out the instruction. The human agent initiated the conceptual form, and a machine actuated it. Likewise, the computer artwork lacked any autographic mark, trace of spontaneity, or artistic authenticity. The plotter arm would replace the human arm in the production process.

The parallel use of permutation series, mathematical, and generative systems has meant that the computer and conceptual artist have produced strikingly similar works. This correlation is evidenced in the early 1970s work of Manfred Mohr and LeWitt. Approximately a year after Mohr completed his *Cubic Limit* works (Figure 1.4), LeWitt exhibited his *Variations of Incomplete Open Cubes* (Figure 1.5). LeWitt's art was described by Donald Kuspit as having "the look of thought," while Mohr's works were perceived by computer art critics as "stimulants for the mind."[72] Both are serial projects, sharing mechanistic rationalism, clinical detachment, and the use of algorithmic generative processes. Both art objects emerge from the seemingly infinite possibilities contained in the construction and deconstruction of the cube. Although Mohr's

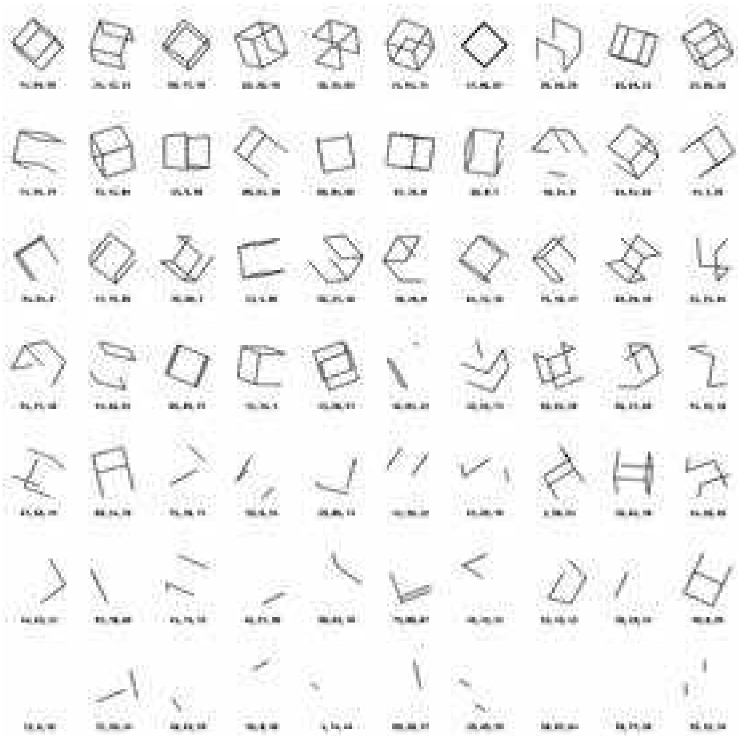

FIGURE 1.4 *Manfred Mohr, P-154-C, 1973. Plotter drawing on paper, 23.6 × 23.6 in. Courtesy of the artist.*

work was conceptual, paralleling and prefiguring much of LeWitt's cubic work, Mohr did not gain the attention of art historians and critics, such as Rosalind Krauss, Lucy Lippard, or Donald Kuspit, who all wrote on LeWitt's cubic work. It appears that although Mohr's work was exploring the current theoretical ground of contemporary art, the critics prejudged such work on the grounds of its computational basis.

When one compares computer art and conceptual art from the late 1960s period, their aesthetics are exceedingly similar, even without reference to their similar methodologies. In LeWitt's words, conceptual art was "emotionally dry" and looked "hard and industrial."[73] Computer art evoked similar descriptions from critics. While conceptualism emptied art of its subjective content, bringing

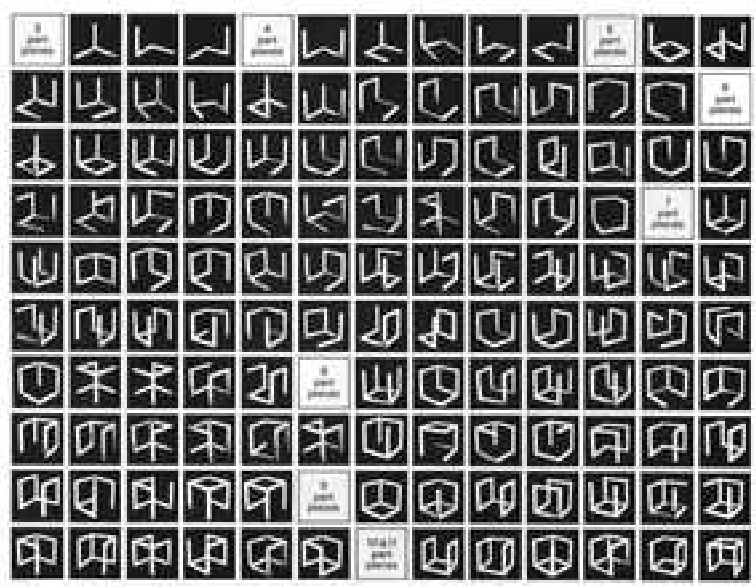

FIGURE 1.5 *Sol LeWitt,* Variations of Incomplete Open Cubes *(photographic component), 1974. 11.75 × 16.5 in. © 2013 The LeWitt Estate/ Artists Rights Society (ARS), New York. Image courtesy of the Wadsworth Atheneum Museum of Art, Hartford, CT.*

about austere aesthetics, in the 1960s, mainstream art was still influenced by the reductive logic of late modernism. In movements such as minimalism and hard-edge abstraction, the art was often characterized by impersonal order, regularities, repetitions, and rigorous standardization. During the 1960s, as critic and art historian Don Denny records:

> there came to prominence a kind of painting and sculpture which shows geometric organization; inorganic, constructive relationship of parts; arrangements derived from arbitrary, predetermined methods. Edges are firm, surfaces smooth, areas discrete, colour systems drastically minimized or schematized. The most immediate psychic tone of these works is one of detachment, calculation, an impersonal and impenetrable coolness.[74]

For Denny, the art implied an "alliance with, or comparability to, the appearances of scientific technology."[75] The "spirit of planning," the "rational contrivance," and "fine calibration," to use the critic's descriptions of abstract paintings, corresponded directly to the methods and general aesthetics of computer art.[76] Therefore, it appeared contradictory and a little unjust when art critics condemned the geometric shapes and basic linear designs of computer art. On an aesthetic level, as previously demonstrated, the work shared all the reductive characteristics of conceptual art and hard-edged geometric painting of the era. Of course, most of the critics were not judging the aesthetics, rather they were castigating the machine that produced them. Douglas Davis felt a similar sentiment at work in the critical response to the larger-scale Art and Technology exhibitions. "It seems clear," as Davis wrote in 1975, "that the moral fervour implicit in the attacks on technology by many social and literary critics are not based in aesthetic disgust alone."[77] When the critic from the *New York Herald Tribune* described the work in the Howard Wise exhibition as "cold and soulless," he was imagining the machine more than the art. There was little attempt to adequately interpret the work, to provide a deeper understanding and appreciation for this new form. Quick to judge, the critics asserted a type of dogmatic judgment based on their prejudice toward the computer. It lacked a sophisticated treatment of art, a considered insight that good criticism often possesses. Admittedly, computer art was rudimentary, similar in its simplicity to perspective systems in the early Renaissance or the first grainy photographs of the nineteenth century, yet a fair critical response would have been sensitive to the incredible difficulties of employing computers to make art. It could be said in defense of the art critics that they were ignorant, as many were, of the challenges the new medium posed. Critics were simply ill-prepared for the advent of computer art.

On another level, the independent use of the computer and its allied electronic devices in place of conventional art materials, or the rejection of the representational methods of the past, would seem to correlate to the wider rejection of modernist convention circulating through 1960s art theory. As Rosalind Krauss observed, "More than a rejection or dissolution of the past, avant-garde originality is conceived as a literal origin, a beginning from ground zero, a birth."[78] Computer art could have been celebrated by the art theorists and critics as a birth of a radically new movement with an alternative medium. Yet, for all its congruence with mainstream and avant-garde movements, computer art was shunned. As demonstrated, this alienation was not based on the questionable abstract aesthetics, but on the conscious or unconscious estrangement felt toward the computer itself, which was shared by both mainstream critic and traditional artist alike.

However, there were inherent differences between computer art and the avant-garde movements of the day. One of the defining features of 1960s computer art is the technologist as practitioner. Because computer art emerged from the sciences, the technologist was not familiar with the language of avant-garde discourse, let alone the terminology of the larger field of visual arts. The different approaches and styles of writing are clearly apparent in the criticism and commentary on computer art. Even though it would have been possible to theorize computer art in conceptual terms, there was no attempt to do so. Indeed, computer enthusiasts took little from contemporary art theory, and when they spoke of art it was directed toward early modernist abstraction. Nor did the technologists seek to declare or occupy a position, or formulate a manifesto of any type. They did not possess the revolutionary aspect or the intellectual rigor of the avant-garde. In the very beginning, computer art had none of the self-critical reflexivity that defines the conceptual art movement. Conceptual art was a meta-critical and self-reflexive venture, which focused critical attention upon all facets of the art world, including the notion of the artist within a cultural and historical context, the reimagining of the exhibition and museum space, and the denunciation of the art market and its capitalist structures. While computer art did implicitly question the status of the art object, the movement was not self-consciously ideological.

Although the 1960s was a decade of tremendous social upheaval and cultural change, the radical politics that permeated the period did not infiltrate or affect the idiom of computer art. The practitioners of computer art were far less political than their counterparts in the Art and Technology movement. As Shanken showed, there was far more "common ground" between Art and Technology and conceptual art.[79] The computer artist shared none of the grand visions and ideological underpinnings of Klüzer, Cage, and Rauschenberg. Computer artists did not attempt to liberate culture from repressive and alienating technologies. As Jasia

Reichardt observed in 1968, computer art was far removed from those "polemic preoccupations" that concerned art.[80]

Even when computer and conceptual art seemed to be almost identical in appearance, as in the LeWitt and Mohr examples, there were a number of essential differences. In LeWitt's work, the tension of the work arises from the relationship between the idea and its physical realization. For Mohr, in contrast, it resides in the potential of the computer algorithm and its power to generate vast amounts of signs. Beyond the central philosophical differences, there were several instrumental distinctions. In addition, Mohr focused on the exploration of one media, while LeWitt's project involved a variety of media, such as text, diagram, sculpture, and photography.

The most substantial difference, however, is the dissociation by LeWitt and most other conceptual artists with the reductivism and rationalism of mathematics. As LeWitt stipulated, conceptual art does not have "much to do with mathematics, philosophy, or any other mental discipline."[81] In his writings, the artist carefully maneuvers his notion of conceptual art away from any suggestion of intellectual rationality by stipulating that "conceptual art is not necessarily logical."[82] He went on to emphasize that conceptual artists are "mystics rather than rationalists. They leap to conclusions that logic cannot reach."[83] There was a deliberate effort on the part of LeWitt to distance the artistic practice from scientific methods, whereas Mohr's computational technique was rigorous, logical, and highly reductive. Additionally, LeWitt dismissed randomness, a process central to the practice of computer art. The conceptual artist explored his idea thoroughly, so that "arbitrary or chance decisions would be kept to a minimum."[84] In contrast, computer art, through its preoccupation with pseudorandom behavior, had a multifaceted open-endedness not shared with most conceptual art. Whereas LeWitt's work shows absolute clarity, comprehensibility, and self-containment, Mohr's work is seemingly complex, fluid, and open-ended, as if part of an ongoing search. The art idea is ever evolving, the algorithm ever changing. Ironically, this indeterminacy and flux became part of the postmodern art critic vocabulary; and yet, computer art again remained marginalized and without serious critical consideration.

Although the technologists did seem to break with traditional categories of painting and sculpture by utilizing the most complex media of the time, they did not abandon traditional media in order to question its use. In conceptual art, the artist remained central in the conception and often production of the material artwork, while the computer artist ceded generation and production entirely to an electronic machine. The computer artist had gone one step too far by creating a further distance between artificer and artifact, which threatened to sever the link between art and artist altogether. The idea became embodied in a machine, and that machine was crucial in the realization and conceptualization of art. Furthermore, one could say that the technologists still held the modernist belief in the self-contained art object: illustrated in the need to materialize and exhibit an artifact. Noll, who was the first to use the computer for aesthetic purposes, attempted to mimic modernist aesthetics. Far from conceptual art's anti-aesthetics, computer art never abandoned its preoccupation with notions of abstract beauty. Computer art's lack of aesthetics, which critics continually pointed to, was more about the limitations of the medium, rather than a will to deconstruct the concept of beauty. Like the modernists, Noll was trying to locate the boundaries, both aesthetic and epistemological, of computer imagery rather than questioning the medium's production. The technologists were concerned with making discoveries not for art, but for science, especially the burgeoning computer sciences and its expanding subfield of computer graphics.

What becomes discernible in computer art criticism is certain anti-computer sentiment. The perception of the computer, which had emerged as a compelling symbol, changed in the decade prior to the first exhibition. Through an uneasy mass media, as sociologist Irene Travis observed in 1970, the "awe-and-wonder" assessment that had characterized the public response in the 1950s gave way to a more general "anti-computer spirit" in the following decade.[85] What had been a symbol of great hope in the cultural imagination became an object of profound fear. This was motivated not only by the anxiety that the computer would take the place of the worker, which had been dramatized in the 1956 Hollywood movie *Desk Set*, but also by the alarm that the computer could become the seamless instrument of governmental control. Through the 1950s, the computer became the principal technological metaphor of the period reflecting the human mind as no previous machine had. A cognitive revolution began to emerge around the theoretical work of Alan Turing which precipitated a new conception of the human being as a machine. In 1950, Alan Turing posed the question, "Can machines think?" in his seminal paper "Computing Machinery and Intelligence," published in the journal *Mind*. Turing wrote about the possibility for machine intelligences through a simple analogy between the human brain and the electronic computer. Turing claimed that by the dawn of the new millennia computing machines would be capable of imitating human intelligence perfectly. The decade would see the first artificial intelligence conference and the extensive use of the "human-as-machine" and "computer-as-brain" metaphor in advertising. This process meant a steady anthropomorphizing of the computer. Before the computer took its current name it was known generally as the "electronic" or "mechanical" brain, as it was in Edmund C. Berkeley's *Giant Brains or Machines That Think* (1949). As the computer became a surrogate for human intelligence and the faculty of memory was metaphorically conceded to machine, the computer appeared to be a wholly new species of technology. It appeared, as historian Theodore Roszak wrote, to flirt with the "mysteries of the mind itself."[86]

One of the most significant introductions of the computer to mass culture was the televised presidential election between Stevenson and Eisenhower in November 1952. On live television the famed UNIVAC computer was to tabulate and predict results. The three reporters, Walter Cronkite, Charles Collingwood, and Art Draper, conversed with the machine as if it was a prophet or oracle, even though the machine exhibited no human characteristics. Cronkite introduced the machine as the "miracle of the modern age, the electronic brain." While Collingwood asked waggishly, "Can you say something UNIVAC? Have you got anything to say to the television audience?" When it came time to televise the predictions, the programmer hesitated, as the result was contradicting the current political predictions. Fearing the embarrassment from a wayward result, the hierarchy or the computer manufacturer ordered the programmer to falsify the results in order for them to fall in line with the political experts. Eventually, the Eisenhower landslide that the computer had predicted beforehand eventuated, which meant an admission from Collingwood and the programmer that the computer had been correct all along. The very next day, headlines varied from "Machine Makes Monkey Out of Man" to "Big Electronic Gadget Proves Smarter Than Men." Through this publicity stunt, the UNIVAC became an overnight sensation and grew to be synonymous with computing. "When the news got out," historian Jeffrey Young explains, "the powers of the invincible, omniscient, and mysterious computer reached mythical status. UNIVAC instantly became a household name."[87]

Sociologist R. S. Lee, writing in 1970, noticed that during the 1960s there was a "secondary undercurrent of uneasiness" that related to the notion that the computer was now capable of autonomous cognition.[88] The specter of machine intelligence and the deeper fear that machines would someday enslave its creators began to haunt the public consciousness. Stanley Kubrick's 1968 film adaptation of Arthur C. Clarke's *2001: A Space Odyssey* is a prime example of this fear. In the narrative, the controlling computer on Discovery One spaceship, called HAL 9000, malfunctions despite its claims to be infallible. The computer endeavors to cover up the error by killing the witnesses to its humiliation. A battle between man and machine eventuates, which sees the survivor escape HAL's marauding vengeance. The human eventually triumphs by disabling the errant computer. Ironically, the first recording of computer-generated music, *Music from Mathematics* (1962), created by John R. Pierce and Max Mathews at Bell Labs, contained the song "Daisy Bell," which became the famous last utterance of the film's disobedient and murderous computer.

At the close of the 1960s, the computer had become, as the sociologist Irene Taviss suggested, a "symbol for all that is good and all that is evil in modern society."[89] The computer's capacity to engage in operations approximate to "human reasoning" had "generated much popular agitation—ranging from awe and admiration to fear and resentment."[90] In the 1960s, the use of the computer increased. Although the computer was not yet ubiquitous in business and government, its indirect influence was increasingly felt. The high degree of emotional reaction to computers seemed to relate to the challenge machines seemed to present to humans. Commentators in the mass media often took great delight when a computer made an error. No other machine's failure elicited the same reaction. When a computer makes a mistake, Taviss wrote, "man is reassured that this machine is as fallible as he is."[91] The public took great interest and pride when the world chess champion beat the world's most advanced computer.[92] This sentiment is still strong today. The art critics covering the Howard Wise exhibition also appeared to take pleasure in vilifying the computer for its primitive results, positing that human creation was beyond the reach of machines.

As the 1960s advanced, the computer as a pervasive mechanism replaced the autonomous super-brain myth of the 1950s. The computer was now both the corrupter of human minds and the mechanism of central government organization. As Frederic Withington suggested in his 1969 sociological study, the computer symbolized "impersonality, conformity to preestablished patterns, reduction to a number, and impossibility of changing the status quo."[93] The computer now became an agent of stagnation and colossal inertia inherent in modern organization. From this perspective, it is not principally a useful tool or an important labor-saving device, but a machine that imposes its own logic on society. The popular image of the computer was an immaculately clean room filled with streamlined computational machines and their various peripheral devices. Standing dutifully by was a collection of dark-suited human programmers and operators, often ominously called the "priesthood." In the popular imagination, the priesthood were seen to deify the computer as some kind of superhuman instrument, which led many to view them as slaves to the new system-based order. For many, the computer had no emotions, no personality, and therefore no cultural knowledge or adequate frame of reference.

These trends in public consciousness give us some clues to the reception of computer art by critics, artists, and the wider public. The power of the computer seemed to be accelerating at an imperceptible rate. And it appeared that technologists would begin to digitize human attributes beyond just mental functions. Human creativity appeared to be at risk. Perhaps the best indication of this social anxiety comes in the form of the science fiction of the era. A number of books were published that dealt with the loss of creativity to technological forms.[94] In 1958, Dennis Gabor, the Nobel Prize–winning physicist and inventor of holography, voiced this concern: "I sincerely hope that machines will never replace the creative artist, but in good conscience, I cannot say that they never could."[95] This sentiment of anxiety about the future impact of computing on the creative fields was widely felt, even by those in science.

It appears that critics were most concerned about the promises technologists were making regarding artificial or mechanized creativity. In the first writings on computer art, there was a great deal of celebratory bravado over the computer's potential to usurp artistic endeavor. Even before the industrial revolution, people within society reacted with trepidation whenever a machine embodied those characteristics that were believed to be exclusively human. Creativity was a cherished attribute. The artist had been traditionally associated with creation first through Ancient mythology and later Christian cosmology. As the art historian Rhys Carpenter wrote, “The artist’s greatest and most necessary illusion is the illusion he is creating. Rob him of that belief and you have shorn him of his power.”[96] The ideological power of art stems from the mystification of the process of making. With a Kantian understanding of genius, modernism in the twentieth century recast this mythology by building on the belief that art is the only “properly autonomous and self-determining mode of production.”[97] The computer appeared to undermine the ontology of art and efface the identity of the artist by reducing him or her to a mere servant of the machine.

The computer appeared to undermine the act of creation, once the exclusive domain of humans. Inherent in the computer art dream was the redundancy of the artist. This was implicitly put forward in the title of the first essays on computer art, for example, the co-authored “The Electronic Computer as Artist” (1964) and Pierce’s article “Portrait of a Machine as a Young Artist” (1965). The Howard Wise exhibition showed that the artist had become redundant in the physical production of the work, as Duchamp’s *Readymades* had done earlier in the century. Stuart Preston, the critic for the *New York Times*, appeared forlorn at the prospect of science and technology in control of the future to the point that they would allow “any kind of painting to be computer-generated.”[98] For the technologist, it appeared as a natural progression: increasingly efficient generations of automatons, widely employed in other fields, would be used in art production. In any case, from the technologists’ perspective they were designing machines to extend, multiply, and heighten human mental and physical abilities. However, computer automation, via the plotter, made the artist’s hand absent and craftsmanship irrelevant. While the new machines had expanded the capacity of our mind, now the computer, with its superior precision and systematized dexterity, replaced the drawing body.

The specter of usurpation informed the reception and criticism of early computer art. As computer artworks found their way into galleries and museums, the subject of creativity became increasingly contested. Noll claimed that science and computing were forcing us to “re-examine our preconceptions about creativity and machines.”[99] He went on to argue that, “if creativity is restricted to mean the production of the unconventional or the unpredicted, then the computer should instead be portrayed as a creative medium—an active and creative collaborator with the artist."[100] While some scientists believed that the computer could handle some elements of creativity, there existed considerable skepticism among scientists and artists about the claims that were being made. In 1966, at a computer conference held at the University of Waterloo, two statements were made by technologists that trumpeted the prospect of machine creativity, which according to Reichardt appeared "unnecessarily boastful and heroic."[101] According to Reichardt, who epitomized the dominant sentiment within the art's community, the machine did not possess the prime forces of creativity—imagination, intuition, and emotion. Later, in the 1970s, computing conferences circulated provocative press releases, such as "Computers Are Creating Art Which Is Indistinguishable From the Man-Made Product," which ultimately raised the ire of the conservative *New York Times* art critic John Canaday.[102]

Artists and critics were uneasy with the claim of computer creativity. Despite this, the technologists framed their computer art research in the "man versus machine" rhetoric that had permeated artificial intelligence discourse. Turing's "Imitation Game," now commonly referred to as the "Turing Test," objectively tested the intelligence of a system, machine or otherwise. In the spirit of post-war behavioral psychology, the test measured success by the number of human subjects fooled by his machine. The first examples of computer art worked on the same premise, albeit to simulate or actuate human creativity, rather than intelligence. A number of technologists employed the simulating power of the computer to recreate well-known artworks. The German mathematician and computer art pioneer Frieder Nake programmed the statistical laws of the early modernist painter Paul Klee. But the technologist who did the most to simulate human creativity was A. Michael Noll, the famed engineer at Bell Labs.[103] Most famous of his trials was the Mondrian Experiment, and in many ways this experiment symbolically placed the machine's creative power above that of the artist. While the experiment promoted the computer as a complement to the artist's powers, it implicitly framed the machine as a future competitor to the artist. Those technologists who first theorized the computer art form were quick to associate the computer's capabilities with the human mental faculty of creativity. Noll called it a "totally new kind of creative medium."[104]

In 1965, Noll produced the computer-generated artwork entitled *Computer Composition with Lines* (Figure 1.6), which won first prize in the *Computers and Automation* annual competition. Noll stipulated in the periodical that the motivation for the type of pattern and design came from Mondrian's *Composition in Line* (1916/17) (Figure 1.7). The marks made on the computer-generated picture were placed according to a pseudorandom number generator "with statistics chosen to approximate the bar density, lengths, and widths

FIGURE 1.6 *A. Michael Noll.* Computer Composition with Lines, *1965. IBM 7094, general dynamics SC-4020 microfilm plotter. © 1965 A. Michael Noll.*

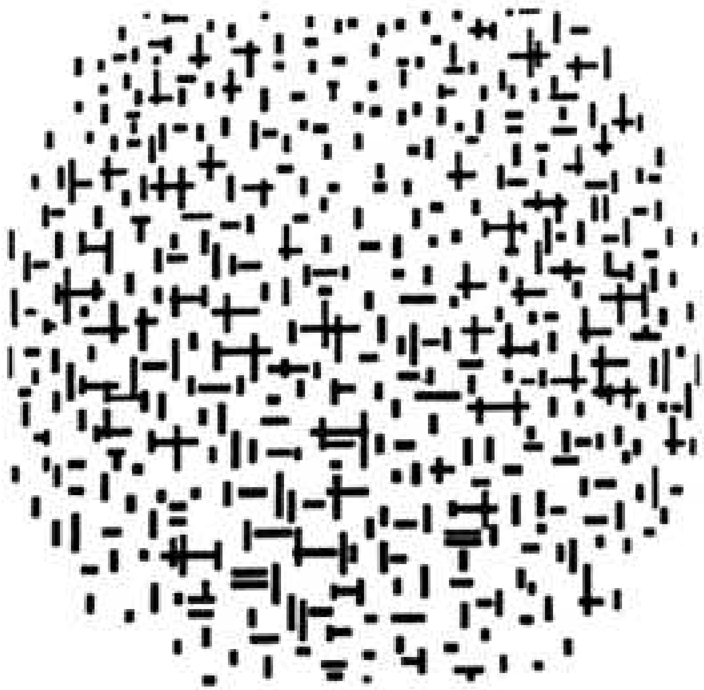

FIGURE 1.7 *Piet Mondrian,* Composition in Line, *1916/17. © 2013 Mondrian/Holtzman Trust c/o HCR International USA.*

in the Mondrian painting."[105] Because the computer had simulated Mondrian's schema so successfully, Noll felt an experiment, contrasting and comparing the two, could reveal some interesting findings.

The experiment, an approximation of Turing's original experiment of 1950, existed somewhere between applied visual psychology and experimental aesthetics and would be the first of many completed by scientists and technologists in the 1960s. Noll's test involved taking xerographic copies of the two artworks and presenting them to 100 subjects who worked at Bell Labs. The sample taken was representative of a scientific research laboratory, although the subjects had wide-ranging educational backgrounds. The questioner asked which picture they preferred and which picture they thought Mondrian had produced.[106] The results showed that 59 percent of the subjects preferred the computer-generated artwork and only 28 percent were able to identify correctly the picture produced by Mondrian.[107] As Noll recorded, the subjects described the computer-generated picture as being "neater" and more "varied," "imaginative," "soothing," and "abstract" than the Mondrian.[108] Noll concluded that in general these "people seemed to associate the randomness of the computer-generated picture with human creativity whereas the orderly bar placement of the Mondrian painting seemed to them machinelike."[109]

The psychological experiment was widely publicized in art and science journals and remains a key anecdote in the history of computer art. The art historian Meyer Schapiro was among those interested by Noll's results. Schapiro was interested in how Noll's simulations gave insight into the random element within Mondrian's compositions.[110]

Noll recognized the inherent weaknesses with such a subjective experiment. The reduction in size of the Mondrian to a xerographic reproduction would undoubtedly degrade the aesthetic quality. Also noted was the fact that a larger proportion of the subjects with technical training would identify the computer picture because of their fluency with computers. As Noll admitted, if artists and subjects from a nontechnical environment had been similarly tested, the "result might have been different."[111] Furthermore, as Noll declared, Mondrian apparently placed the vertical and horizontal strokes in a deliberate and orderly manner. Essentially, the test was an aesthetic exercise to establish which pattern was preferred—an arbitrary task where the subjects selected between randomness and order. Yet, although Noll was careful not to detract from Mondrian's artistic abilities, he did seem to boast that the computer had somehow usurped the role of the great Dutch artist, who was one of the "most influential masters of painting."[112]

Noll's experiment, and the ensuing interest, was a result of it being framed within the machine versus man paradigm. Noll continually stated that the programmer-artist working with the computer produced a pattern that was preferable "over the pattern of one of Mondrian's paintings."[113] The second question asked the subject to identify the pattern most likely produced by the human hand of the artist. Noll must have suspected that the subjects would choose the more ordered pattern due to the common association between precision and machine production. While Noll pursued randomness, it must be said that the modernist artist, beyond wanting to create certain emotive connotations, sought to create order as a way to elicit a feeling of perfect equilibrium. Although Noll said that the "experiment was designed solely to compare two patterns that differed in elements of order and randomness," the questions asked revealed that the pattern generated by the computer was in fact more humanlike due to the random nature of the marks.[114] What the test intended to illustrate was that although both patterns were conceived by humans, the central feature of the computer-generated picture, which was decided by a programmed random algorithm, simulated human creativeness successfully. The computer could feign creativity and feign it with such skill that one could come to admire the humanness of the machine-positioned lines.

In 1959, C. P. Snow stated that he felt it was "bizarre" that so "very little of twentieth-century science has been assimilated into twentieth-century art."[115] In a matter of five years, however, an art form emerged that incorporated the most advanced instrumentation and theoretical practice of twentieth-century science and technology. In doing so, science proclaimed its intention to take the technological power of the post-industrial age into a world traditionally resistant to such progressivism. The advent of computer art illustrates the shifting ground between the scientist and artist. In 1956, György Kepes lamented that "the artist and the scientist are almost never the same person."[116] In the 1960s, at the height of the *Two Cultures* debate, technologists attempted to blur the boundaries either in the name of conciliation or, as Franke suggested, for the "sheer pleasure" of manipulating "structures in conformity with aesthetic notions."[117] Visual creativity and aesthetic objects were no longer the artist's exclusive domain. Comfortable in taking the title, even when their main source of income derived from science work, the scientist and technologist redefined the definition of artist. In many ways, Rockman and Mezei were correct in asserting that technologists were the avant-garde of digital forms of art. A. Michael Noll and a host of other engineers at Bell Labs (such as Kenneth Knowlton and Leon Harmon) were prolifically inventive, exhibiting a creativity once only reserved for artists. Receiving considerable attention, their images would be exhibited internationally. Of course, traditionalists resented this.

In many ways, however, this was not a deliberate attempt by the scientists to affront the artists, though the scientists' boasting was seen as insensitive, often it was just a matter of celebrating the seemingly limitless possibility of the computer or taking advantage of the expanding nature of the visual arts. In addition, if technology had steadily reduced the need for specialized skill in a variety of industries, it was only logical that it would reduce the physical skill required in art. The scientist felt that the computer could offer real knowledge and extend the artist's powers in new and exciting ways.

Nevertheless, artist and humanist critics reacted by either ignoring the phenomenon or dogmatically criticizing it on an aesthetic level. They simply countered the technologists' claims by pointing out the fact that computer art was aesthetically simplistic, banal, and unoriginal, even when this was proved not to be the case. These criticisms did not deter the technologists from advancing the computer art project. The technologists were not satisfied simply to successfully invent a machine that autonomously produced drawings after a few simple instructions or trumping humanly produced works of art by presenting visual art simulacra; they were increasingly excited about the prospect of submitting art to the combined power of mathematics and computing.

The next chapter, "Coded Aesthetics," demonstrates how thoroughly science shaped computer art in the 1960s and how, for the first time, it developed a machine that could assist in the empirical study of art. Here was an instrument that could expose, in mathematical terms, the structure of art and the nature of aesthetics. The new "experimental aesthetics," as it became known, resulted in a scientific analysis of the statistical properties of artistic material. The abstracting power of mathematics coupled with the latest technoscience discourses represented a new and powerful tool to probe the primordial secrets of art. The technologist could vanquish the mysteries of art. While the computer had challenged the position of the artist, abstract science threatened to lay bare the very nature of art. For the humanist artist and critic, this mathematization of art was dangerously reductive and potentially dehumanizing.

CHAPTER TWO

Coded aesthetics

Because mathematics permeates every layer of its abstract and material form, the computer shares a privileged relationship with it. In fact, so intrinsic is mathematics to the computer that computer art is arguably the most mathematically imbued art form in the history of art. While other art forms throughout history have shared a functional and spiritual relationship to mathematics, computer art's bond is all-inclusive. Admittedly, there have been periods where the interrelationship of mathematics and art has been high. The Renaissance's mathematization of pictorial space is perhaps the most commonly theorized. In the twentieth century, op art, conceptual art, and geometric abstraction have been mathematically oriented. The Russian avant-garde was especially influenced by discoveries in multidimensional mathematics. As opposed to op art, which does not directly produce images with the aid of mathematical formulas or apparatus, computer art, which is produced by different sorts of empirical calculation, has a mathematical basis. The art produced conforms to the canons of mathematics and logic; it needs to be completed, consistent, and adhere to the stringent conditions of computability. Although not linked to pure mathematics, the art form is best defined as the building up of patterns from ever-changing relations, rhythms, and proportions of abstract geometric form. Computer art simulates the real by mathematically modeling it, rather than imitating it through a copying process based on human perception.

In the past, commentators have been quick to link computer art's aesthetic to early forms of modernist abstraction, such as constructivism. Although these movements are undoubtedly influential, the connection is often overemphasized, especially when one considers the more applicable and relevant trends within twentieth-century science. To locate computer art's aesthetic foundation, one needs to look beyond the aesthetic tradition of early modernism to the deep reveries within the mathematical consciousness of Western science. That elemental wonder of nature's structure and patterns, which is quintessential to the abstract and life sciences, provides the first aesthetic impulse for computer art. Moreover, the heritage of computer art is firmly rooted in the analog mechanical instruments and drawing machines that were utilized to measure and map natural phenomena. The very claim that computer-generated images could be defined as art has its roots in the popularity of scientific visualization.

The development of twentieth-century electronic technology encouraged a new responsiveness to beauty in nature. Following World War II, a "new landscape," as György Kepes described it, emerged out of modern science and technology. It provided for the first time totally new sensations from magnified electronic images, expanding our sensory experiences of time and space, and thus altering human perception forever.[1] With new mechanical instruments, researchers could describe nature in precise mathematical terms by mapping the complex orders and disorders of natural phenomena, whether visible or not. Science was becoming increasingly visual. During this period, there was a renewed appreciation of the aesthetical nature of visual data collected through the course of scientific experimentation. Historically, scientists have placed great aesthetic value on those images derived from nature, botanical and anatomical drawing being the most common. In the nineteenth century, however, there was a surge of interest in visualizing abstract language. This period witnessed mathematicians progressively composing pictures to visualize and understand geometric forms. The art historian and critic James Elkins called these images of science, which had been neglected by art history but were semantically rich in information, "nonart."[2] As will be shown by its history, computer art successfully made that transition from "nonart" to "art" through a series of precedents that saw scientists developing a growing aesthetic sensibility.

During the twentieth century, a small number of scientists viewed the products of their scientific pursuits as aesthetic forms.

Following the lead of others, such as the nineteenth-century German chemists Wilhelm Oswald and Ferdinand Runge, scientists such as Adolf Portmann and Horst Reumuth regarded the visual material produced through scientific processes as aesthetic objects. The nineteenth-century biologist Ernst Haeckel, also providing precedent, believed that there was significant value in celebrating the art forms of nature. Early in the new century, the German art critic and historian Franz Roh began to posit scientific imagery as art. In his landmark book *Photo-Eye*, first published in 1929, Roh exhibited images by nonprofessional photographers, which included photographs of medical diagnostics, astronomy, aerial imagery, and natural objects. The author stipulated the importance of these "outsiders" in gathering images of nature from various realms of scientific research and bringing their aesthetic qualities to light.[3] For Roh, the worth of photography existed in the "aesthetic value of nature itself," not the personal expression of the artist.[4] This shift in perceptions of what constitutes an aesthetic object underpinned the view that computer images had claims to being art, which eventually led to military and commercial laboratories entering the products of their research into computer art contests.

Laying the foundations for computer art's aesthetic claims, the American mathematician and artist Ben Laposky made the first systematic attempt to dissolve the boundary between art and science objects. In the early 1950s, Laposky photographed thousands of elegant analogue waveforms from a cathode ray oscilloscope he had modified (Figure 2.1). Laposky called his creations *Electronic Abstractions* or *Oscillons*. For Herbert W. Franke, Laposky's work was the first major initiative into graphic generation by way of electronic and computational machines. Consequently, those who have written on computer art have placed Laposky in the unique position of being the first computer artist. However, positioning Laposky as the first computer artist because of the technological precedent he set is problematic. The title does appear anachronistic. "Computer art," as a term, entered circulation a decade after Laposky's exhibition. While the term "computer" became part of public vocabulary in the early 1950s, computers are not mentioned in Laposky's original catalog. Rather, Laposky understood his practice through the paradigm of electronics, not computers. Furthermore, in the 1970s, Laposky would associate his work more closely with kinetic and op art rather than computer art. Beyond

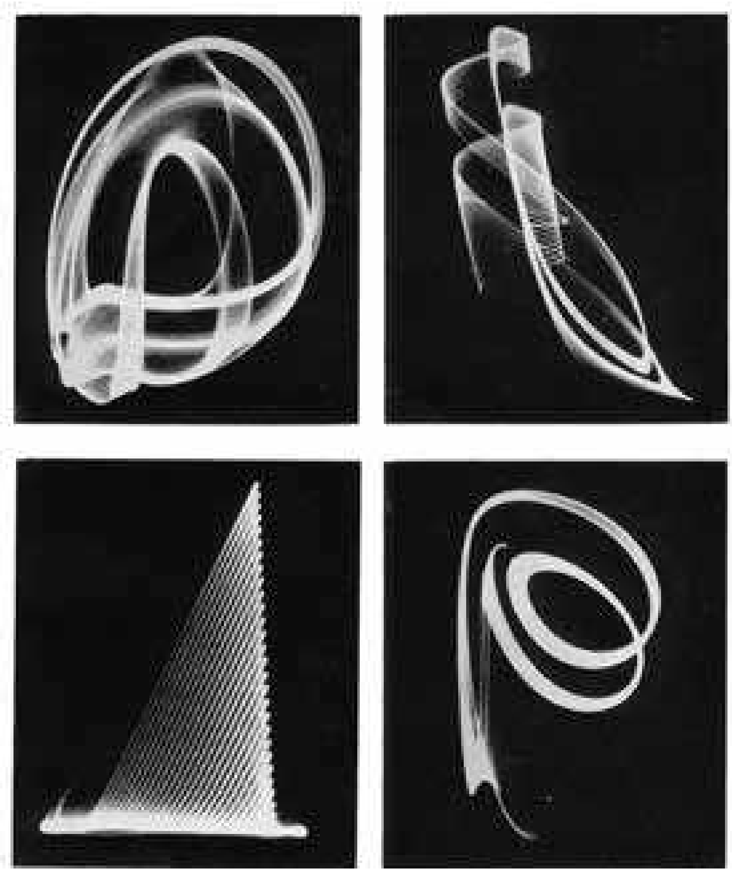

FIGURE 2.1 *Ben Laposky,* Oscillons *34, 26, 14, 47, 1953. Courtesy of Sanford Museum and Planetarium, Cherokee, Iowa.*

demonstrating the relationship between science and art, Laposky's electronic compositions were meant to reveal the potential of this new technique for design.

Although there are certain problems in retrospectively claiming Laposky's work as the first example of computer art, one cannot ignore the importance of the mathematician as an antecedent and as a link between analog and digital devices. Like early computer artists, Laposky redirected a utilitarian device from the domain of science—electrical engineering in Laposky's case—to art. Because

Laposky's art was cross-disciplinary, there was significant interest in the art form, which resulted in regional and international exhibitions. Incredibly, Laposky exhibited 188 times. The work was shown in more than 100 cities in 37 U.S. states and 16 countries. This international popularity mirrored computer art's initial interdisciplinary success and illustrates the widespread interest in experimental technologies that occurred outside the bounds of mainstream art.

What many commentators overlook in Laposky's practice, which is present in the computer art tradition, is the enduring desire to invoke the pattern and form of nature. In Laposky's case, he makes unseen natural phenomena both visible and tangible as an art form. These images become the visual manifestations of the basic invisible aspects of nature—the movement of electrons and energy fields. The oscilloscope, which can measure all kinds of phenomena, reconstructs waveform or measures voltage waves. Sensors convert these natural forces into electric signals that can be observed and studied. This utilitarian measuring device became a means of capturing nature's underlying and concealed forms and patterns. It is similar to the photograph in many ways, especially in its mechanical ability to allow nature to register its own image. Recalling the pioneer photographer William Henry Fox Talbot's metaphor in *The Pencil of Nature* (1844), Laposky writes, "The electronic beam within the cathode ray tube is actually the pencil or brush by which these traces are formed."[5]

The important visual characteristic which surfaced in preceding computer art was Laposky's curvilinear patterns. Within the abstract and natural sciences, the complex sine wave or Lissajous figure had become renowned for its aesthetic aura. This popular visual pattern was named after the nineteenth-century French physicist Jules Lissajous, who developed an optical method for studying vibrations. The physicist had created translucent images on a screen from the reflected vibrations of a tuning fork. There was a long history in physics in generating complex curvilinear designs from mechanical pendulums. Mechanical pendulums and electronic systems allowed the figure to be translated mathematically, allowing for the improved study of symmetrical and asymmetrical motion and force.

Laposky's *Oscillons* originated from a search for different mathematical forms. In the late 1930s, Laposky attempted to find a mathematical source for nonfigurative art through mathematical magic number squares. Laposky was also influenced by the serial rhythms developed by the mathematician, artist, and theorist Joseph Schillinger. Influential amongst computer artists, Schillinger's *The Mathematical Basis of the Arts* (1948) formalized the concept that a machine could generate art, once it had been codified into mathematical language. In the twentieth century, the Lissajous figure became popular as a schema for design, effectively making a shift from the purely scientific to the cultural. Many experimented with harmonograph tracing machines, pendulum pattern makers, and other analog devices. Since 1951, Ivan Moscovich experimented with different mechanisms for drawing mathematical curves and Lissajous figures. The aesthetic curvilinear effects produced by analog drawing machines and electronic oscilloscopes parallel early computer art. In fact, analog-mechanical works were shown alongside computer art in *Cybernetic Serendipity*. Because mathematically conceived figuration was easily mechanized, mathematical schemas such as sine curves were a simple way of producing visually complex results.

Some of the most admired computer art completed in the 1960s contained the harmonious mathematical properties of the Lissajous figure. In the United States, curvilinear designs dominated. The application of parametric equations to produce a complex Lissajous figure can be located in *Plexus*, a work by Kerry Strand and Larry Jenkins (Figure 2.2), both engineers who worked for Calcomp (California Computer Products, Inc.), the leading plotter manufacturer.[6] Maughan S. Mason, a technologist working for IBM, had previously found inspiration in pendulum motion and produced *Christmas Wreath—Computer Style* (Figure 2.3) by transforming linear configuration through a recursive mathematical function. Rare amongst early computer artists, he signed his work.

A description of the mathematical schemata was paramount to computer art's success. Indeed, the critic John Canaday, reviewing a computer art exhibition in 1970, believed that computer art, which for him carried banal titles that described what the abstraction echoed in the natural world, should carry the mathematical equations from which the works were generated.[7] In the early years of *Computers and Automation*'s coverage, the descriptions of mathematical equations were included in the publication, along with the computer and plotter model used. This demonstrates the scientific

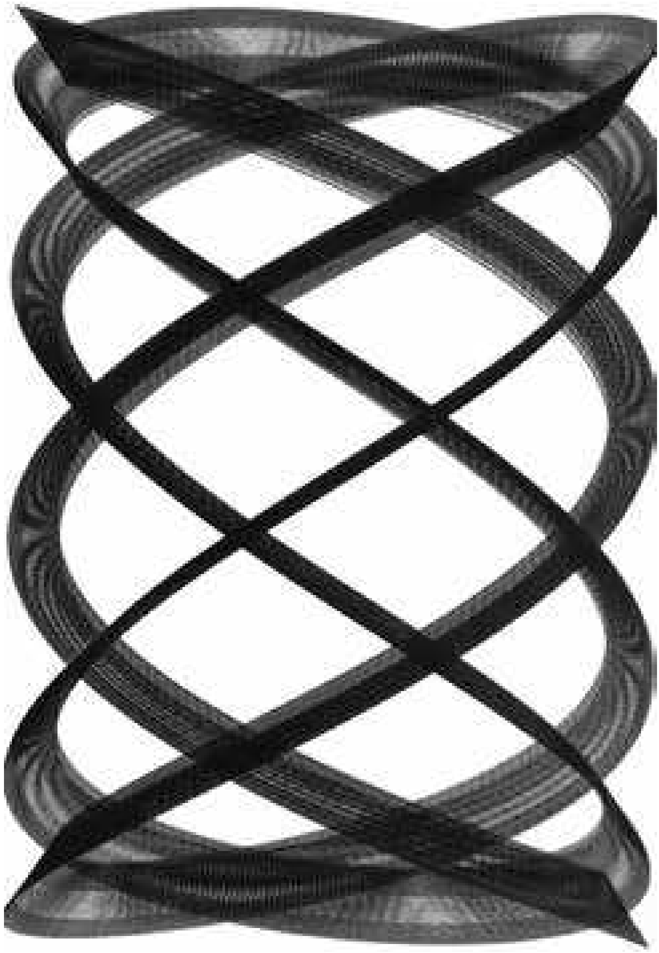

FIGURE 2.2 *Kerry Strand and Larry Jenkins,* Plexus, *1968. Color coordination and plotting techniques by Gary Craigmile. Courtesy of Kerry Strand.*

imperatives of the venture and the importance of mathematics in the appreciation of computer art. Much of the work was dominated by geometric patterns and figures generated by iterative and recursive procedures. There was a prevalence of moiré patterns or effects; however, unlike the op artists, the computer artists superimposed geometric patterns or shapes in a slightly different alignment until

FIGURE 2.3 *Maughan S. Mason,* Christmas Wreath—Computer Style, *1968. Courtesy Maughan S. Mason family.*

an abstract figure appeared. Repeating a basic Platonic shape and slightly altering the dimensions incrementally could generate a strange organic shape. The spatial form thus generated mirrored the accretionary growth of shells and horns. D'Arcy Thompson, who gave mathematical descriptions to a myriad of organic forms in his famous work *Growth and Form* (1917), influenced many scientists and computer artists.

For the early computer artists, simple iterative mathematical procedures seemed to echo the structures and forms of nature. Symmetry, which is an invariable characteristic of growth in living and nonliving systems, was easily amenable to algorithmic procedures. The interest in complicated spiral geometry, which has a long history in Western science and art, again finds expression in computer art. Kerry Strand's *The Snail* (Figure 2.4) generates a biomorphic figure by having an elliptical shape recur. In John Canaday's review, he singles out *The Snail* for analysis. After lambasting the engineer for the simple-minded title, he states that the "diagram"—deliberately distinguishing it as science rather than art—possessed a striking complexity and mathematical purity that only the computer, with its mechanical precision, could obtain. Indeed, while many dismissed computer art as overly simplistic, mere artless line drawings, many of the early examples were

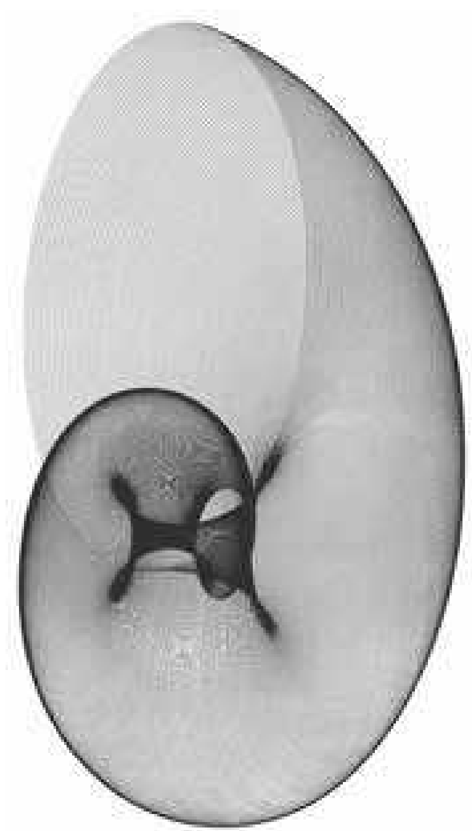

FIGURE 2.4 *Kerry Strand,* The Snail, *1968. Courtesy of the artist.*

executed with the highest visual complexity, producing subtle linear effects unattainable by the human hand.

With the development of the plotter, these mathematic-inspired visualizations seemed to exhibit great visual power, far in excess of the linkages and templates of the traditional drafting room. The plotter, coupled with the computer, gave an extreme form of exactitude and precision that exceeded any handmade craft. With the automatism of the machine and the programmatic powers of mathematics, the figures appeared to emerge from some inexplicable abstract world, something that mildly interested Canaday in his review. Because of the computer's ability to produce unexpected results from highly complex and stochastic programs, many computer artists complained that they failed to recognize their own output, which gave the machine a mysterious and transcendental quality. The moment would arise when the artist-programmer no longer retained a precise understanding of their own algorithm. This meant that there was always a dislocation from the final output—hence the technologist would name the work after what it resembled in the natural world. This was especially the case in the 1960s when the program was installed by punch card. The final image was visible only when it was plotted in the final stage of production. Many of the technologists talked of the excitement when the program took on a life of its own as the image emerged *ex nihilo*. They continually talked about the thrill of finding or discovering unsuspected possibilities. Says Manfred Mohr:

> Even though my work process is rational and systematic, its results can be unpredictable. Like a journey, only the starting point and a hypothetical destination [are] known. What happens during the journey is often unexpected and surprising.[8]

The abstract world of mathematics combined with the autonomous nature of the machine distanced the practitioners increasingly from their art. In instances where graphics are used to visualize something without direct reference to the external world—such as an abstract system of pure mathematics—imagery tended to gain the status of a real, tangible object.

Computer-generated images were not mere expressions of abstract theoretical descriptions, but were visual analogs of an algorithmic event, an idea that was lost on critics such as Canaday. This animated existence invested the image with an *élan vital*. Laposky initiated this conceptual transition by viewing electronic waveforms as art object rather than as scientific representation. As entities or real objects, they are no longer empirical data, rather formations that have their own phenomenological presence and identity. The electronic analog display allows for direct real-time manipulation of composition and form. The forms are viewed as visual analogs of natural events—kinematic entities that are somehow natural in their analogous relationships, and yet wholly synthetic as mechanized visualizations. The *Oscillons* appear delicate and too meticulous to have been executed by the human hand. Yet they do not appear mechanistic either and lack the perfect regularity or symmetry that we associate with geometric visualization. In reality, the image shows no suggestion of craftsmanship, no bush marks, and no straight lines. As a machine, the electronic oscilloscope is overtly organic from the pulsing electrons emitted from the anode to the phosphor on the screen that fluoresces. The images are viewed in terms of their phenomenological effect of light and pattern. Although they are synthetic, they appear to occur naturally—as if the forms have been summoned by human agency, but not created by it. From the very beginning, Laposky noticed that many of the *Oscillons* have an "almost sculptural quality" within the highly contrasted, nonilluminated background of an oscilloscope screen.[9] Likewise, Laposky described figures as "images of luminescent … moving masses suspended in space."[10] The mythic space of the computer becomes important to the computer art of the 1980s, and later to new media art in the 1990s as virtuality is conceptualized. Indeed, *The Snail* and other curvilinear figures completed by technologists became precursors to the later 1980s computer art of William Latham and others who abstracted nature's morphogenetic process and created strange biomorphic forms (see Chapter 5).

Like those Platonists who view scientific explanation akin to mathematical proof—as something one discovers rather than invents—many of the computer artists viewed their figures as objects discovered rather than human constructs. Mathematical Platonism proclaims the belief in an archaic reality, a mathematical realm that exists independently of the human mind. Philip J. Davis and Reuben Hersh suggest that if you are a Platonist in mathematics, you see yourself more as an "empirical scientist like a geologist, you do not invent anything, because it is all there already. All he can do is discover."[11] The naming of the work after what it corresponded to in the natural world, the most common practice of scientists and technologists in the early years, also indicates the tendency for this type of Platonic objectification. As Roman Verostko, one of the celebrated computer artists of the late 1980s, wrote:

> None of the works are made with intentional representation in mind. Rather, each work presents one more adventure into a world of forms that have never been seen before. This art does not re-present some sort of subject or object. Just as a botanist might label a newly discovered flower so also I label this or that newly made form or series of forms. Titles are therefore arbitrary and often derived from evocative qualities associated with the work.[12]

As covered in later chapters, the Platonic tradition of discovering form within the unseen and untouched realm of abstraction is a key mythology within computer art, and critics failed to recognize this new conceptualization of the art object. The surprise of an unexpected form springing into life permeates the writings of computer artists. For most, the forms seemed to emerge mysteriously and emanate from some extraneous source hidden in the depths of the machine. Such artists were unable to locate the source of this form and were equally mystified when they saw themselves as having contributed nothing consciously toward it. Consequently, the form was imbued with a strength and irrefragability that belies the form's fully conscious beginnings.

The admiration of complex pattern and symmetry has a long tradition in both Western and Middle Eastern art. The first person to qualify the mathematical origins of visual and structural pattern—the Ancient Greek philosopher Pythagoras—believed the world was beautiful because there was a certain measure, proportion, order, and harmony between all elements. Computer art's complex order structures have been consistently compared to classical music, and the exemplar of Pythagorean tradition—geometrical pattern—is the main feature of 1960s computer art. Computer artworks were frequently based on the golden section, Fibonacci numbers, and many other emblematic Pythagorean premises. Generally, however, the early technologists were interested in producing complex, aesthetically pleasing figures through simple mathematical functions and parameters rather than mathematical equations per se. The scientists and technologists explored ideas that they were familiar with, such as spatial arrangement, periodicities, combinatorics, transformations, and symmetry. They enjoyed the simplicity, intricacy, and purity of the geometric form that they were able to produce. The work *Verifying Star* (Figure 2.5), which is a Platonic shape repeated or superimposed to produce a self-contained geometric figure, was admired for the visual effect of its geometry and how it captured the often invisible, inner beauty of nature.

More so than the American technologists, the mathematicians in Europe were committed to the theorizing power of mathematics, in particular the mathematical-logical formalism developed early in the century. The mathematicians were influenced in varying degrees by logical positivists: the school of philosophy that emerged in central Europe between the two world wars. Logical positivism

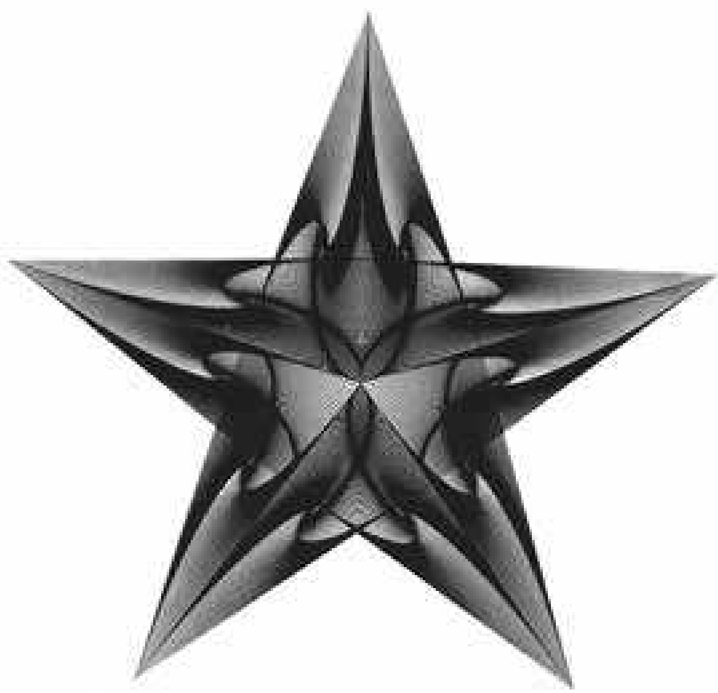

FIGURE 2.5 *Donald K. Robbins,* Verifying Star, *1967. Courtesy of Sandia National Laboratories.*

originated from the early work of philosopher Ludwig Wittgenstein and was developed by Alfred Ayer and others. Searching for truth in the foundations of language, logical positivism gave rise to the development of linguistic theory by Noam Chomsky and influenced the emergence of computational theory. It attempted to develop a philosophy of science by combining the resources of modern mathematical logic with the empiricist epistemology of natural sciences. This school of thought, with its research into formal systems, played a significant role in the theory of artificial intelligence. As logical empiricists, the mathematicians were interested in the power of the computer as an experimental tool. Like the American technologists, the Europeans employed the computer to transform complex mathematical information into visual phenomena. Indeed, much of the pioneering work visualized and recorded complex mathematical relations. Visualizing mathematical behavior would provide a new kind of analysis for approaching mathematical problems: the branch became known as "visual mathematics." Scientists felt that the visual faculty surpassed all other senses in its capacity to discover complex relationships. In Frieder Nake's *Matrix Multiplication Series 31* (Figure 2.6), for example, symbolic schemata were used in the production of an aesthetic visualization. This work visualizes the mathematical behavior and principles of a number series. For Franke, these methods of picture production break with the traditional process of building an image from visual structures, because the input data is merely computing operands.

In contrast to the figurative work in the United States and Japan, the Western Europeans were committed to visual abstraction. They—most notably Franke—tended to situate the inclination toward abstraction within the rediscovery of constructivism. In 1971, Reichardt felt that computer art was the last stance of abstract art after modernism's initial movement toward the abstract early in the century. Future commentators of computer art would continually draw on the constructivist legacy. Many computer artists saw themselves as neo-constructivists, and commentators continually noted the influence of the early European vanguard movements of constructivism, de Stijl, and Bauhaus. In fact, a majority of artists made the connection between their practice and early European abstraction. For Dietrich, computer artists were a generation who rediscovered constructivism after World War II.

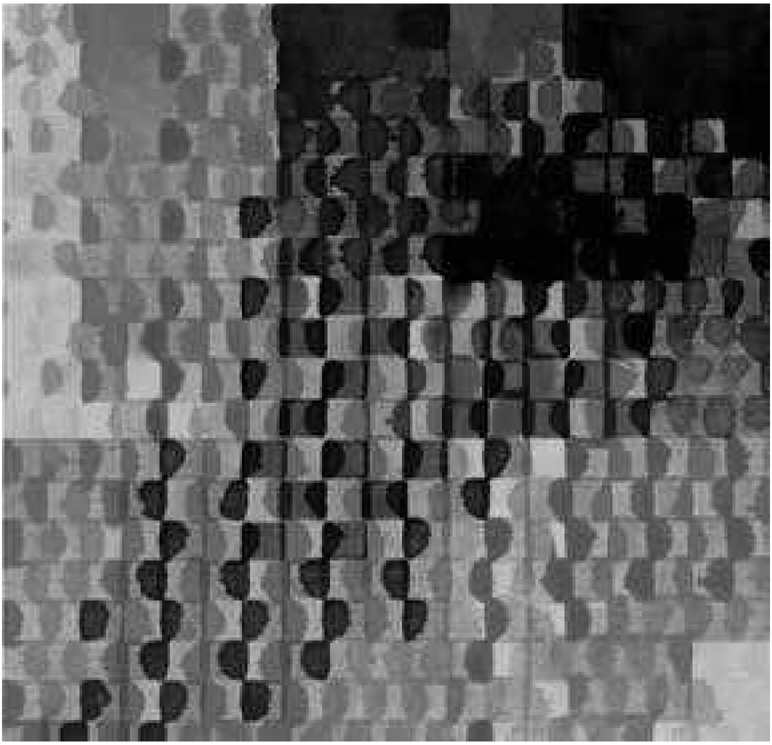

FIGURE 2.6 *Frieder Nake,* Matrix Multiplication Series 31 *(part), 1967. China ink on paper. Courtesy of the artist.*

For Franke, "constructivist tendencies" permeated computer art in its "rejection of the personal element," its "crystal-clear, objective presentation," and its "maximum precision."[13] The visual elements such as lines and planes, which constituted the visual aesthetic of constructivism, were easily amenable to computation. As Dietrich suggests, computer artists arranged "form and color logically and voluntarily restricted themselves to a few well-defined image elements."[14] The constructivist machine aesthetic is evident in Auro Lecci's computer-generated artwork *Slant One* (Figure 2.7), which is a basic geometric pattern characterized by qualities of exactitude, impersonality, and a clear formal order. Though the lines were generated by random numbers, its overall aesthetic is constructivist in form and sensitivity.

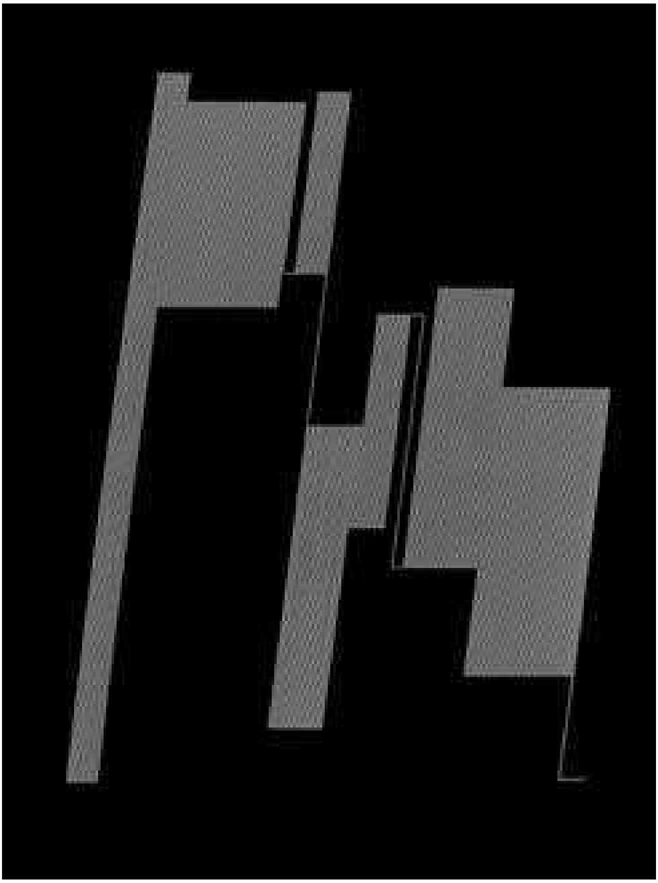

FIGURE 2.7 *Auro Lecci,* Slant One, *1969. Computer-generated artwork at the IBM Center at the University of Pisa. Courtesy of the artist.*

The new computer artists also shared with the constructivists the utilitarian doctrine for extending the formal language of abstract art into practical design. The modernist schools of criticism, such as constructivism, Bauhaus, and the de Stijl Group, analyzed compositions in terms of design elements and principles. These formal and reductive methodologies were reexamined by mathematicians working with the computer. Corresponding to the age of efficient industrialization, these modernist groups also were interested in producing art mechanically as a way to increase functionality and avoid embellishment and artistic idiosyncrasies. Like the Bauhaus artists, the early computer artist gave importance to utility and technological production over *l'art pour l'art*.

However, in the rush to proclaim constructivism as a key antecedent of computer art, a number of dissimilarities have been often overlooked. As theorist and historian Nicholas Lambert rightly points out, computer art was "heavily constrained by the available graphics technology"; the simple lines and abstract shapes were not a "self-imposed artistic limitation," but represented a "boundary to image structure."[15] Conveniently, it could be argued that technology imposed a limiting logic and unity on computer art that happened to correspond to constructivist sensibilities. However, computer art's heritage mirrored some of the programmatic concerns of constructivism. While computer art shared similarities in utility, technique, and aesthetics, it is more difficult to locate computer art in the social-historical dimension of abstract modernism. Moreover, the computer art movement fostered a mythology that was quite divergent from the utopianism of early abstraction.

One must remember that the New Tendency groups of Europe and South America claimed a constructivist heritage. They were, however, far closer to the visions of constructivism than computer art. Like the constructivists, who believed that industrial technology could shape a new world, the New Tendency groups were convinced that their new research could also be associated with a new vision for life. Resembling the historical avant-garde movements of the early modernist period, the New Tendency proposed a comparable myth that a new technically augmented society needed to materialize. The computer artists, at least in America, did not share the constructivists' ideological and aesthetical convictions; instead, they were directly engaged in the abstract scientific philosophies of the era. Computer art shared an innate relationship with the abstract sciences. While constructivists employed rudimentary mathematical relations, the computer artist engaged in higher-order mathematics, an aspiration that brought them in line with the experimental research agenda of computer science. In addition, the technologists of North America did not always share the constructivist tendencies of their European counterparts. Computer art was not homogenous. Figuration, at certain moments, dominated the work of the American technologists, which did not correspond to the constructivist pictorial tradition of pure abstraction. Furthermore, the focus on mechanical automatism, pseudo randomness, mathematical visualization, and coded aesthetics gave computer art its own unique methodologies. What becomes apparent is that commentators followed the modernist convention of historicizing new artistic trends by showing how they had evolved from past forms. Computer art, which at the time was an incommensurable object, was given legitimacy through its connections to the modernist movement and was thus authenticated within the history of art. In the future, conceptual art and the history of photography would also be employed to legitimize the claims of computer art.

Although mathematics provided the premise for the technologists' aesthetic creations in North America, offering a way to break down, as Charles Csuri believed, the artistic bias, the Europeans, especially West Germans, perceived mathematics as a far more powerful tool. Upheld as the only way for a field of study to attain the rank of a science, mathematics became for them a means to lift art to the level of science. The greatest exponent of this view was Franke, who believed that the computer could demystify art through abstract mathematical methods:

> The demystification of art is one of the most far-reaching effects of the use of computers in the arts. No sooner is it recognized that the creation of art can be formalized, programmed and subjected to mathematical treatment, than all those secrets that used to enshroud art vanish.[16]

For Franke, computer art would become another milestone in the "evolution toward the mathematization of art."[17] The desire to effectively purge art of its taint of rhetoric and mystery through abstract science was a weighty assertion, an incursion the art world would naturally resist.

For Franke, this mystery had made art a "substitute for faith," which falsely positioned art beyond the bounds of science.[18] Discovering the riddle of art or describing art scientifically represented the first impulses of many technologists. In the United States, Noll's Mondrian Experiment had begun to question the belief that creativity is "the personal and somewhat mysterious domain of man."[19] By placing art under the scrutiny of empirical method, the computer was the first instrument with the power to reveal these qualities. The West Germans desired a project that established a set of abstract references, elements, and principles of design in order to describe and analyze artworks. As an empiricist school of criticism, it attempted to make aesthetic and artistic analysis in a scientific manner. Its methods were those of science, such as modes of observation, analysis, proposal, and testing hypotheses. Like the formal systems before them, they described artworks by reducing them to their essential elements, analyzing the relations among these elements, and interpreting and judging them on these descriptions. Like the formalist and empiricist criticism, the system claimed to be universally applicable to art, devoid of subjective interpretation and value-free.

For the West German mathematicians, it was immediately recognized that to interpolate the machine in the artistic process opened essential questions regarding the creative act as the genesis for a work of art and the possibility of objective evaluation of the artwork without human involvement. The technologists felt that the fundamental problems of art, whether aesthetic or structural, were technical in nature. Furthermore, like many thinkers before them, they believed beauty was in essence a mathematical phenomenon that could, as Franke suggested, come under the "province of an exact science of art."[20]

In 1948, Joseph Schillinger, the famed music theorist and composer, had anticipated a time when machines might be "constructed for the automatic production, reproduction, and variation of works of art."[21] Importantly, these machines, called the *artomaton*, could automatically analyze and test the aesthetic quality of works of art. Around the same period, other influential discourses such as cybernetics and information theory were taking shape. Soon, scientists felt there was no limit to the descriptive and explicatory powers of the computer.

Like the Europeans, the Japanese believed that the computer had the potential to vanquish the mystery of art. The Japanese artist Hiroshi Kawano thought scientists, with the aid of the computer, had the ability to formulate the "algorithm of art."[22] Like Franke, Kawano believed that the computer, combined with the new sciences of cybernetics and information theory, would eventually reveal the underlying logic of art. Thus, for Kawano, the computer artist should be a "scientist of art" searching for its hidden rules.[23] Franke felt that once the "laws of aesthetics have been ascertained statistically" they could be "embodied" in computer programs.[24] Likewise, once art was deciphered, Kawano believed that the programmer could codify the artistic process and then "teach" it to the computer.[25] Therefore, Kawano felt that the computer artist never produced the work of art; rather the computer, programmed with "artificial creativity," produced an entity he called the "art computer."[26] For Kawano the "art computer," which was an "experimental product of scientific aesthetics," located the computer in the artist's former place: at the center of artistic generation.[27] The autonomous computer then would have the power to judge its own aesthetic qualities, totally divorced from human sentiment and tradition.

The will to discover the structure of art through formalized and abstract systems corresponded to the intellectual sensibility of the era. As Robert E. Mueller described, McLuhan believed that the "dismembering of language, which scientists are doing for the purpose of putting ideas into the retrieval system of computers, may have a salutary effect on art and science by giving us a new look at the inner roots of ideas we thought were indestructible."[28] Computer technologists felt that they could elucidate the patterns and structure of art, as others had done within the natural science disciplines. The technologists believed that there was a connectedness between each sphere of art: in its reception, art making, and evaluation. Exploring the connectivity and circuitry of the human experience, within the natural and artificial environment, was the broad project of cybernetics.

Cybernetics and information theory, both emerging from the post-war climate, were two highly influential discourses in computer art, but being mostly an esoteric technoscience concept, it was alien to mainstream art. Calling on many of the discoveries made by Claude Shannon in information theory, the American mathematician Norbert Wiener proposed a general theory of science that incorporated the control and communications in animal and machine.[29] The first scientist to bring about this new logical formation of information was Shannon, who wrote the first mathematical theory of communication. While Shannon concentrated mainly on applications of information theory to communication engineering, psychologists Warren McCulloch and Walter Pitts developed mathematical models of the nervous system and effectively applied informational theory to physiology. In a series of papers from 1945 to 1952, McCulloch and Pitts formulated the mathematical theory of the mind, pointing to the similarity in abstract function between the human brain and the computing device. McCulloch and Pitts endeavored to show how the physical sciences of mathematics helped to explain biological functioning of the brain. Other scientists studied the possibilities of intelligently controlled machinery as models for human behavior. Norbert Wiener believed there was a unity among all these investigations. In 1948, Wiener incorporated this vision under the name "cybernetics." He described this combinatory field as based on the essential unity of the set of problems concerning the interrelationship between communication, control, and statistical mechanics, whether in biological or mechanical form. In the 1960s, cybernetics became a paradigm for a variety of biological, mechanical, and cultural processes across a number of humanist disciplines. Suddenly, discourses such as the visual arts, which had been relatively impervious to science, began showing the theoretical effects of abstract system-based science.

Although there were artists like Roy Ascott who conceptualized their practice in terms of cybernetic theory without making overt links to digital technology, it was logical for computer art to be understood through cybernetic metaphors, because the computer was the prime experimental instrument and in many ways the material embodiment of cybernetics. One of the central features of cybernetics was the insistence that organisms and machines were not essentially different in effect. This meant that scientists using cybernetics could derive general models of control processes from living systems and apply them to the construction of machines. The idea of cybernetics in the arts made its most visible entrance through the visionary curator and writer Jasia Reichardt. The first international exhibition to include computer art, *Cybernetic Serendipity: The Computer and the Arts*, highlighted cybernetics as its incorporative theme. The 1968 exhibition, which has become a seminal moment in digital art's history, took two years of painstaking organization. The exhibition complemented other exhibitions of the period, such as Jack Burnham's *Software*, which centered on the idea of the world as information, logic, and system, rather than energy or material constitution. Beyond curating the seminal *Software* exhibition in 1970, Jack Burnham, through his book *Beyond Modern Sculpture* and his article "Real Time Systems," signaled a shift away from an object-oriented world toward a systems-oriented world.[30] Burnham believed that this "system aesthetics" had become a major paradigm in the arts. In *Art into Ideas*, Robert C. Morgan credited Burnham's system aesthetics as having clarified the "feeling that art had transversed from the object to the idea, from a material definition of art to that of a system of thought."[31] The overarching idea was that art was another form of information—one that could be systemized and mentally or mechanically processed. The artist Robert Mallary also popularized cybernetics in the seminal essay "Computer Sculpture: Six Levels of Cybernetics," which communicated a model of cybernetics that imagined the computer as an autonomous organism.[32]

Including visual arts, poetry, music, dance, film, and animation, the *Cybernetic Serendipity* exhibition employed the general theme of cybernetics to explore the connection between creativity and technology.[33] Many of the works in the exhibition reflected the brave new world of technology-based art, such as robotics, electronic music, multimedia installations, and the like. However, the graphic component of computer art, with its recourse to experimental aesthetics, had a deeper aim, which was to probe the pictorial tradition by producing a mathematical theory of art. The computer, Franke recognized, could place the "whole field of aesthetics as well as artistic practice onto new foundations."[34] Influenced by the models from cybernetics and information theory, many sought to understand artistic production, reception, and criticism in terms of feedback loops or communication cycles. Building on previous formal theory that evaluated art statistically, mathematicians and physical scientists began moving toward contemporary psychological approaches in the examination of visual knowledge and aesthetics. The influential American scientist John R. Pierce, in his book *Symbols, Signals, and Noise* (1961), stated that art was clearly a communication phenomenon, and Abraham Moles, in *Information Theory and Esthetic Perception* (1966), sought to make the communication in art into a science. The new experimental methods developed through information theory, psychology, and aesthetics had an enduring effect on computer art, yet were not easily assimilated by humanist critics. The new modes of visual research emanating from cybernetics and information theory required specialized knowledge of both science and technology that went far beyond the parameters of most art theorists and critics.

The desire to generate new formal aesthetic systems and laws permeated computer art in West Germany. While in America the computer had been met with focused pragmatism, in West Germany it was considered the perfect tool to investigate and establish new theories of aesthetics and question the very idea of "beauty and art."[35] Whereas the North American technologists employed the computer to capture "routine processes of artistic creation," they did not "introduce a progressive element" into art, which for Franke was the "trend towards theorizing."[36] The Europeans felt that the pragmatism in the United States meant that programming and technical possibilities dominated the subject of computer graphics at the expense of theoretical considerations, which was confirmed by Otto Piene, one of the founders of Zero, who came to the United States in 1964 to teach at the University of Pennsylvania. Otto stated that Americans "make things, as opposed to merely thinking about them."[37] Indeed, it was some time before the possibility of formal systems presented itself to the American commentators. One of the earliest articles about this in the United States, "Artistic Design by Computers" (1964) by Leslie Mezei, outlined the possibility for formulating general laws of aesthetics that could aid in artistic design.[38] Mezei called attention to American mathematician George D. Birkhoff's *Aesthetic Measure* (1933), a text also influential to the West Germans, as a possible starting point, but the article had little effect on the American technologists. Although there was discussion about the application of the computer to design, the art produced in the United States in the late 1960s did not engage at any depth with the new formal aesthetic theories. Their Western European counterparts, however, constructed entire formal theories with the possibility for building art systems that generated and evaluated works of art.

Germany had a well-established tradition in formal aesthetics or "exact aesthetics," as it was known. For Franke, these formalized models could provide the theoretical foundation for computer art. As Franke noted, "the setting of stylistic laws in an algorithmic form is a precondition for the generation of computer art" and "each of its products may serve as a preliminary study for investigations in the science of art."[39] They believed that the programmed computer could "make aesthetic distinctions, choices, and assessments," and "organize and compose art of a superior quality automatically."[40] The quest to generate "aesthetic structures" or, in the case of the computer, to "program the beautiful" was an idea first proposed in 1965 by the German philosopher, mathematician, and semiotician Max Bense.[41]

Through the 1960s, Max Bense with Abraham Moles established new foundations for aesthetics through information theory. Influenced by Birkhoff's numerically orientated aesthetic measure, which considered the values of order and complexity, Bense developed a more general theory that incorporated Weaver's and Shannon's mathematical theory of communication. Calling the theory "information aesthetics," Bense's model became influential in several disciplines and in research centers across central Europe. With a number of like-minded semioticians, Bense co-founded the Stuttgart School at the Technische Universitat, which became one of the major European centers for research into aesthetics. Importantly, this site, through Bense's suggestion, held Europe's first computer art exhibition. Bense's vision remains the foundation for Franco-German digital art to this day.

As one of the founding fathers of computational aesthetics, Bense was a major philosophical inspiration for computer artists. Bense also had a more direct influence on popularizing computer art: he suggested the idea for a large-scale international computer art exhibition to Jasia Reichardt, which resulted in *Cybernetic Serendipity*. For Franke, Bense had anticipated the principles of computer art in his work *Aesthetica* (1965), a project where Bense theorized the ability to "Program the Beautiful." Two students—Georg Nees, who studied with Bense, and Frieder Nake, who attended Bense's lectures—became pioneers of computer art in Western Europe. Utilizing Bense's theoretical model of informational aesthetics, the mathematicians embodied many of his concepts. Bense's information aesthetics gave rules for computing complexity and order for a specific image. Through both statistical analysis and aesthetic laws, mathematicians constructed models of art by simulating art objects. Nake, like Noll, saw the advantages of programming stylistic laws. Nake went on to simulate paintings by Paul Klee and Hans Hartung (Figure 2.8). Nake was so committed to this type of investigation that he believed it was necessary to abandon art for a decade and focus on the aesthetic fundamentals of visual perception.[42]

For computer artists, the most important area of Bense's semiotics was his theory of "generative aesthetics." He coined the terms "artificial art" and "generative aesthetics" in his main work *Aesthetica* (1965). Artificial art was introduced by Bense to distinguish mechanically produced art from art deriving solely from

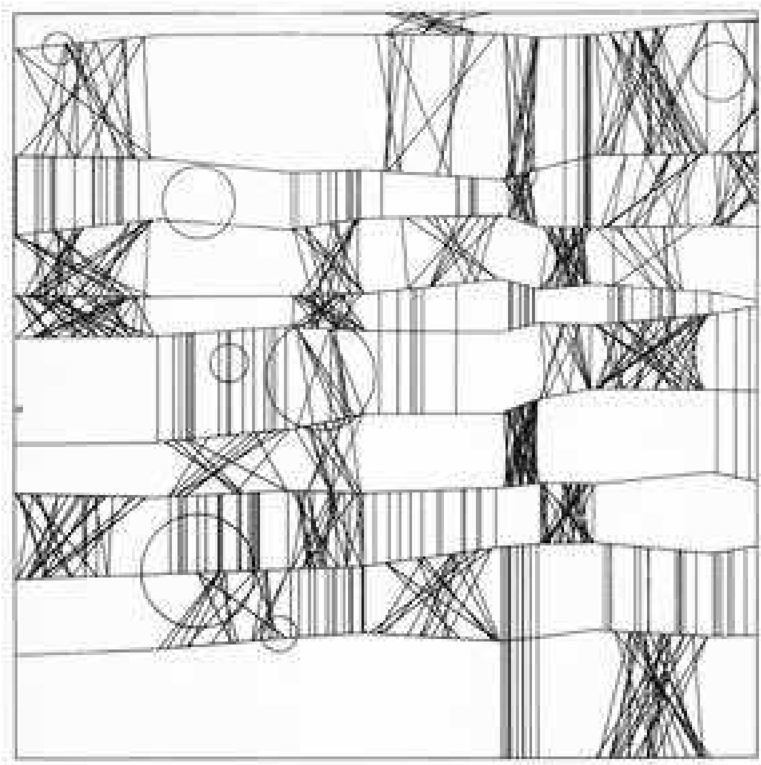

FIGURE 2.8 *Frieder Nake,* 13/9/65 Nr. 2 *(also known as* Homage à Paul Klee*), 1965. China ink on paper. Courtesy of the artist.*

human productivity, or "natural art" as he called it. Bense considered computer art to be the prime example of "artificial art." For the West Germans, it was not just a matter of completing experiments in graphic design, determining the aesthetic norms, or investigating applied visual psychology; there was a desire to see if the computer could generate aesthetic properties. In principle, would it be possible to frame programs with general laws of aesthetics to bring about an optical aesthetic effect? Nake conceived of the computer as a "Universal Picture Generator" capable of creating every possible picture out of a blend of available picture elements.[43] Through Bense's theories, the idea of the computer as an entire system of art making emerged. The computer was not merely a tool, which characterized the attitude in the United States, but was a machine that embodied the rule and formula of art. Out of this research, mathematicians and technologists constructed a series of art-producing programs with inbuilt graphic parameters, such as pseudo randomness, that became the model for many art and graphic systems of the future.

One main disjuncture between computer art and abstract modernism is the emphasis placed on the mysterious qualities of mechanical chance. Computer artists were more fascinated by the possibilities of producing vast amounts of geometric form by building a simple coded mechanism for chance. This shift was taking place at the time when the relationship between order and disorder became increasingly relevant in both scientific and artistic realms. Writing before the emergence of computer art, Umberto Eco saw in European optical art the innate potential of mathematical randomness.[44]

One of the most celebrated features of the computer technique was the ability to have, as Japanese artist Tsuchiya suggested, "systems and randomness at the same time."[45] Tsuchiya imagined the "secrets of wonderful works" in the balance of order and randomness.[46] The American computer scientist John R. Pierce, writing in *Playboy*, would call it the "artistic utterances of mechanical chance."[47] But it was Meyer Schapiro who was the only art historian and critic to recognize the potential of digital chance in formal analysis, using Noll's Mondrian Experiment to probe order and randomness in Mondrian's abstract composition.[48]

Early in the computer's development, Allan Turing in his 1950 *Computing Machinery and Intelligence* recognized that an interesting variant in a digital computer was the random element. From the very beginning, computer artists sought to create chance procedures that would result in new unexpected data. The random chance factor allows the computer to make unpredictable and arbitrary selections without subjective involvement, an attribute not possible in human. This interest in random behavior, what Franke called the "generative impulse," was a transcultural phenomenon and became a key factor in computer art discourse. The computer works by Nake, Nees, and Noll that emerged in the first year all utilized programs that generated random results. Randomness was even a large part of the analog art phenomenon of Laposky's *Electronic Abstractions*.

The search for random behavior is an enduring trait of human behavior. For many, chance somehow revealed the unfathomable convulsions of nature. Most often, the use of randomizers in societies was to ensure fairness, to prevent dissension, and to attain divine direction. The methods for generating chance or randomization were diverse from casting animal bones to tossing many-sided die. The use of chance mechanism to solicit divine direction—called divination—was to guarantee the elimination of human interference, so that the will of the deity could be discerned. Since antiquity, the subject of probability had long been a field of interest within mathematics. Mathematicians called a series of random behaviors “stochastic,” from the Greek word *stochos*, meaning “to guess.” For much of its history, the field of probability analyzed mostly numerical and statistical data; but in the nineteenth century, mathematicians began visualizing random behavior. In the 1866 edition of *The Logic of Chance*, the English logician John Venn attempted a visual illustration of randomness by building a randomly generated graph (Figure 2.9). Each step of his random path was taken by allowing random movement in any of eight directions. The direction of movement at each step along the path was determined by using the digits in the decimal expansion of pi (π), a sequence of digits that Venn believed random. Striking for Venn was that a small number of fixed rules produced an unpredictable amount of complexity. Venn’s graph exhibits similarities in pattern and structure to Manfred Mohr’s computer-generated *P018 Random Walk*, completed just under a century later (Figure 2.10). During the 1950s, theorists noticed that linguistic rules have the effect of opening up new realms of activity. Generative grammars were seen as immensely powerful in their capacity to generate sentences. The rules leave a system essentially open and incomplete, always capable of novelty. Increasingly, computer art would be conceptualized through the generative structures in language.

Of course, the use of a randomizer in art was not new. Random behavior had always had an affinity with the unknown. The idea of chance happenings was popular in the work of the Dadaists, who were attempting to overcome the ideologies of rational order. Although artists like Hans Arp incorporated random and arbitrary effects into their collages, Dadaists’ chance mechanism was significantly different from mechanical chance, which had an element of precision and determinism. Because the computer is a determined system, the random number generators do not generate numbers that are random, making true chance unattainable. The

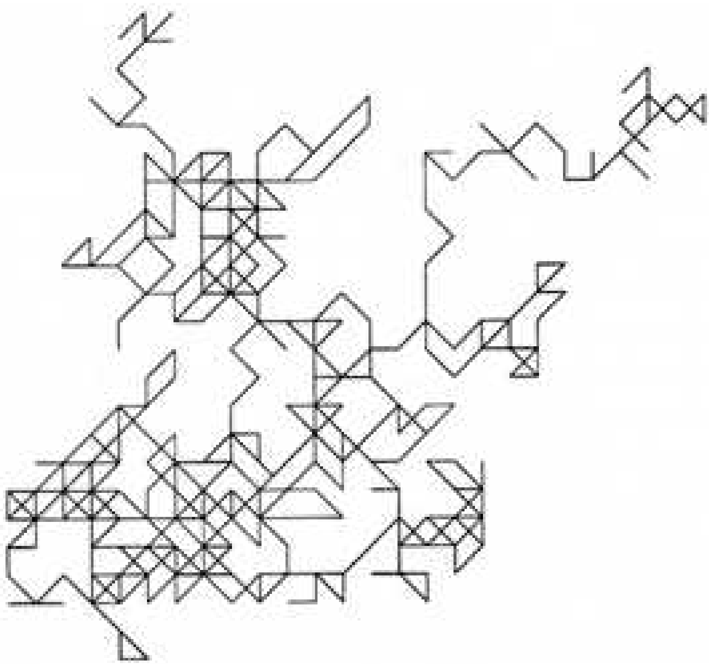

FIGURE 2.9 *John Venn's visual representation of randomness,* The Logic of Chance *(1866).*

generator programs use deterministic algorithms, so they are more correctly referred to as pseudorandom number generators since the sequences of numbers they produce are purely deterministic and merely approximate true random sequences. Although computers are determined systems, the sciences have found it necessary to incorporate random numbers into programs to simulate biological or sociological phenomena. Within the mythology of Dada, Arp's work was presented as the product of pure chance, and Surrealist automatism revealed the actions of the unconscious. However, the computer's random procedure distanced the artist entirely from the process. The computer artist needed to define the parameters of randomness prior to beginning, whereas modern artists most often encouraged chance during the actual artistic event. For computer artists, randomness was more than a metaphor of creativity; it was the actual means or methodology of realizing machine

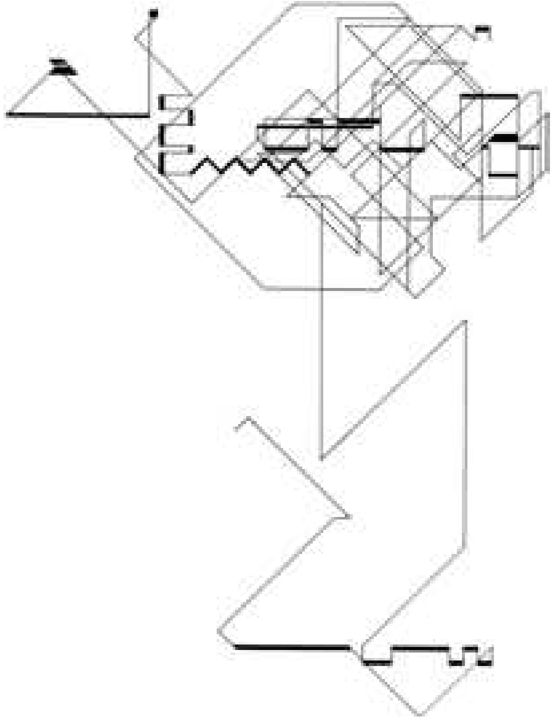

FIGURE 2.10 *Manfred Mohr,* P018 Random Walk, *1969. Computer-calculated drawing on paper, 23.5 × 19.7 in. Courtesy of the artist.*

production. “The computer acquired a creative role,” said Noll, “by introducing randomness or by using mathematical algorithms to control certain aspects of the artistic creation.”[49] Bense pointed out that randomness stood in for intuition. Following Bense, Franke concluded that a “clear-cut description of a work of art” required certain degrees of freedom, which the artist filled intuitively.[50] Franke also observed that the making of computer art as the simulation of an artistic process must “capture intuition in the form of a model.”[51]

In many ways, randomness was a procedure with which to disrupt the predictability of the computer. For some, however, aleatory behavior suggested a world of possibility, and many of these, such as Anthony Oettinger, viewed the random computer as a creative actor rather than as a simply generative instrument. When the computer generated unexpected or serendipitous results, many saw the resulting structures as novel discoveries (note the allusion to chance in the title of the exhibition *Cybernetic Serendipity*). Even though the computer follows deterministic laws, the laws have complicated consequences that are extremely difficult to predict. As Charles Csuri suggested, it was "impossible to visualize" what would happen once the random procedure is initiated.[52]

The other more enduring use of mechanical chance in computer art was the generation of multiple designs, series, and permutations. In West Germany, mathematicians soon recognized that one could set up an algorithm for generating entire families of forms. Using random numbers to determine where and how to place graphic elements allowed the artist to produce new aesthetic configurations. A repertoire of objects would be generated in which the artist could make an aesthetic decision, eventually choosing the parameters that were producing the most interesting object.

The stochastic procedures implemented in Georg Nees' *23-Corner Graphic* (Figure 2.11) provide a good example of the way random parameters and generative functions produce variation in figure and form. The program for each graphic "repeats generative fundamental operations" so that a repetition of forms is produced, and also the random parametric values ensure that the form is diversified.[53] Simple rules are established in which points are distributed randomly within a figure square and joined by lines, resulting in different configurations. Marc Adrian, writing in response to the 1969 Vienna exhibition *Kunst und Computer*, believed that the importance of computer art was found in it "aleatoric moments," where a "practically inexhaustible number of dissimilar realizations is possible."[54] The mathematical field of potential was to have an enduring effect on computer art consciousness, yet art critics seemed indifferent, not realizing the impact this new process would eventually have on art.

Although there were relatively few computational processes available to computer artists, there was a significant variety and range in early computer art. This heterogeneity was another factor that prevented computer art from being confined to an early abstract modernist paradigm. Moreover, the variation in content, especially in Japan, contradicts the frequent charge that computer art had an unvarying aesthetic. Generating abstract configurations from mathematical parameters was not the only computer art procedure

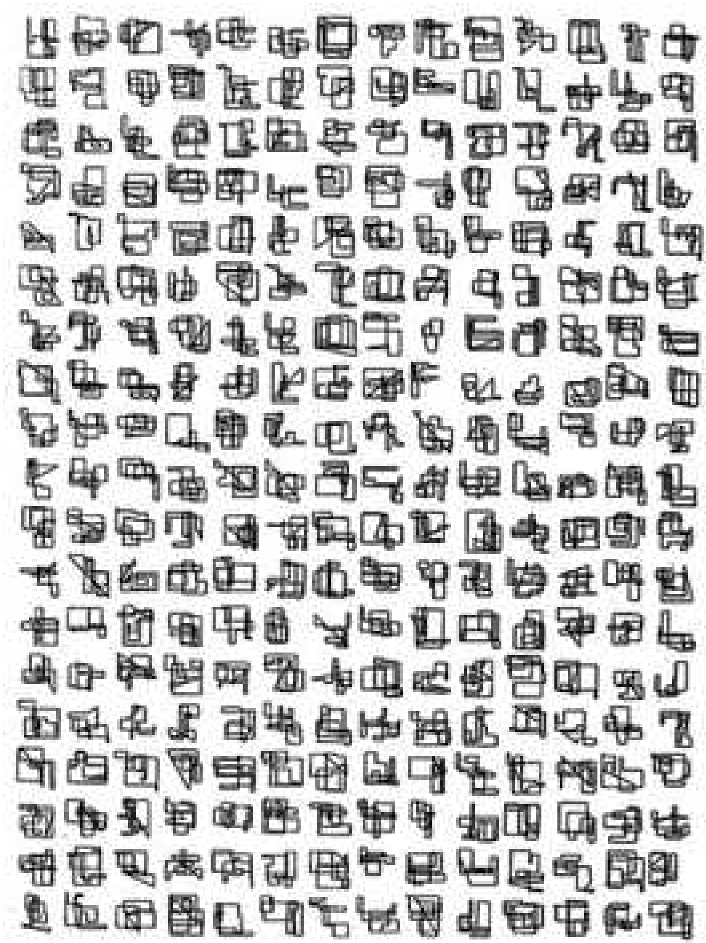

FIGURE 2.11 *Georg Nees,* 23-Corner Graphic *(also known as* 23 Vertices*), 1965. Courtesy of the artist.*

available. In the United States and Japan, technologists were developing new techniques whereby existing visual imagery could be put through a transformative process. The techniques employed resulted from formal scientific research relating to mathematical investigations of visual phenomena, such as the human perception of pattern. While there had been plenty of mathematically conceived figuration, many technologists saw the pivotal aspect of computer art to be in certain techniques described as picture processing. Pioneers of these techniques, Leon Harmon and Kenneth Knowlton, of Bell Labs, defined them as "either the transformation of graphical material, or the generation of pictures from data or abstract rules alone, or combinations of these operations."[55] Seen as revolutionary, the picture processing technique enabled the computer to recreate the visual world as well as transform it through various morphological processes. Optical scanners automated the task of entering visual data into the computer and in effect revealed the potential of machine vision. Picture transformation or transposition established the framework or parameters that manipulate picture information. This included the interpolation of picture data—a form of picture analysis—involving the transformation of a linear image into another through the calculation of a variable number of new values between two existing values.

Even though much of the first computer art was abstract, consisting of mostly geometrical elements, artists such as Charles Csuri introduced figuration into the computational process. Csuri, one of the only trained artists working in the area of computer graphics, produced, along with programmer James Shaffer, the first artist figurative award-winning computer artwork, *Sine Curve Man* (Figure 2.12). First taken from a hand-drawn picture by Csuri, the visual information was digitalized and the coordinates were assigned to its outlines. After the data was transformed with sine-curve functions, the composition was plotted. As a symbolic action, the human, or at least its representation, is encoded into information to be processed. The digitization of human information or form became an enduring idea within the 1990s discourse of virtuality, especially as the avatar emerged as a potent cultural symbol in the new digital age.

However, critics such as Canaday found picture processing to be "tricky" distortions, "momentarily diverting at best, but frequently just plain ugly and always pointless."[56] His criticism came from the fact that no subjective interpretation was done by the artist—the pictures were merely "fed" into the computer to be transformed. Ironically, what Canaday called for, explicit in his title "Less Art, More Computer, Please," was more mathematically inspired and precisely generated art, what he saw as the computer's essential talent. But as visual computing developed, it was picture processing that became its core pursuit and application.

FIGURE 2.12 *Charles A. Csuri,* Sine Curve Man, *1967. Black ink on paper. IBM 7084 and drum plotter, 41 × 41 in. Courtesy of the artist.*

What is missed by critics is that the early stages of computer art revealed the coalescence of logic and perceptual elements within the digital image. Through picture processing, the mechanisms of logic internalize traditional pictorial representation in revolutionary new ways. In Harmon and Knowlton's *Studies in Perception: Gargoyle* (Figure 2.13), discrete symbols are combined to produce the pictorial image—an image of the most famous gargoyle on the westwork of Notre Dame with Sacré-Coeur Basilica in the background. The original picture, in this case a photograph, is treated as merely

FIGURE 2.13 *Leon Harmon and Kenneth Knowlton,* Studies in Perception: Gargoyle, *1967. Courtesy of Kenneth Knowlton.*

visual data and converted from analog into digital. Once digitally encoded, the image is overlaid with a grid and transformed into a series of tone value indicators, which allows the pictorial information to be manipulated in any number of variations. In this case, the tonal values are assigned to a micro pattern of iconic symbols (Figure 2.14). These isolated ideograms were a precursor to what became known in computer graphics as the picture element or pixel. The transformation of acquired imagery became a major idiomatic practice in the coming decades.

The Tokyo-based Computer Technique Group (CTG), established in 1966 by a group of young engineers, also developed a number of data transformative techniques. The group consisted of eight individuals whose professions included architectural

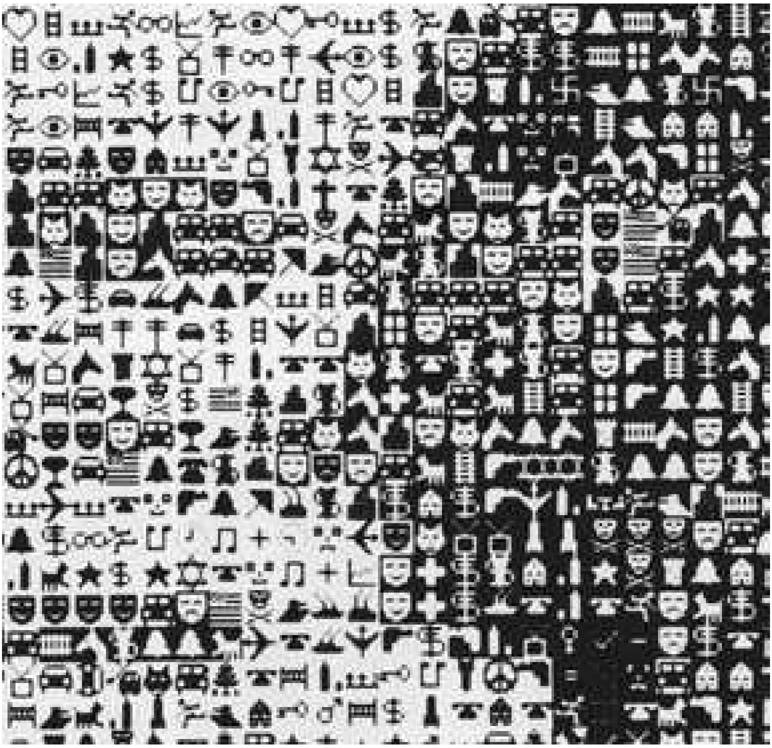

FIGURE 2.14 *Detail from* Studies in Perception: Gargoyle.

design, behavioral science, and systems engineering. They produced a manifesto of sorts which claimed, as Jasia Reichardt wrote, the "restoration of man's innate rights of existence by means of computer control."[57] They saw themselves as "brain workers" in this operation.[58] Beyond producing computer-generated artworks, they created mathematical models for community developments. They also engineered a computer that completed paintings in a gallery environment. Entitled *Automatic Painting Machine No 1*, the computer installation became a well-publicized event in Tokyo. Reichardt recognized that the images produced by CTG were not only different from those produced elsewhere, but were the "most imaginative."[59] While Japanese computer art shares many elements with U.S. and European computer art, it does have some distinct qualities. The computer artwork of the Europeans was entirely abstract, while the Japanese produced predominantly figurative work. They were far less formal than their German and American counterparts, injecting whimsy into their work. Some of the more adventurous work they called "computer metamorphosis."[60] *Return to Square A* and *Return to Square B* (Figure 2.15) were a prime example of figurative and abstract transformation: a square is transformed into a profile of a woman and then back into a square.

Along with the interpolation of visual data, which had also been practiced by technologists in the United States, the CTG produced a series based on the image of the late American president John F. Kennedy. With a similar system to the Harmon and Knowlton picture processing technique, CTG subjected an image of Kennedy to a deformation program that scanned the image, transformed it into digital encoding, and then transformed it into a net pattern. The rather impish *Shot Kennedy No. 1* (Figure 2.16) takes data from a photograph and converts it into straight lines that converge at the point relative to where Kennedy was shot. The engineers used other American iconography such as Marilyn Monroe and Coca-Cola in their computer art. This contrasts with the American experience in which images were arbitrary. There is some evidence to suggest that the Japanese were influenced by Pop art iconography. Japanese Pop art, a short-lived movement in the early 1960s, may well have influenced these engineers. This Neo-Dada generation of Japanese artists also

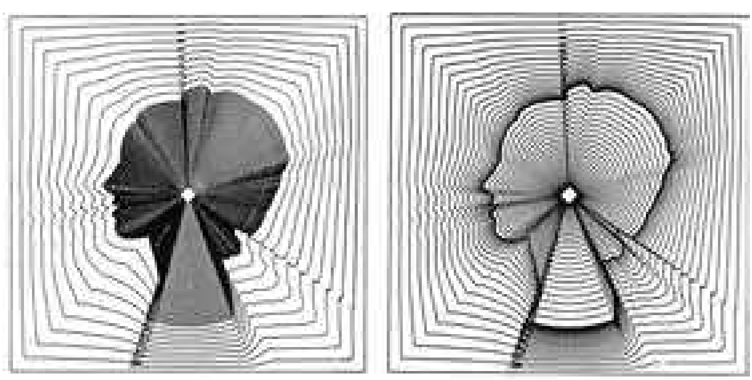

FIGURE 2.15 *Computer Technique Group,* Return to Square A *(left) and* Return to Square B *(right), 1968. Courtesy of Kohmura Masao.*

FIGURE 2.16 *Computer Technique Group,* Shot Kennedy No. 1, *1968. Courtesy of Kohmura Masao.*

took an interest in reproductive technologies, producing imitation art and a type of Pop art process called "imitating the imitators."

Like the Western Europeans, the Japanese attempted to place computer art on a theoretical foundation. Haruki Tsuchiya in "The Philosophy of Computer Art" (1969) was the first to ask the question of what was the philosophical nature of computer art and its implication for the world of aesthetics.[61] Going beyond the American insistence on the suitability of the computer as an instrument, the CTG suggested that it was "not enough only to say that the computer is a good tool for an artist—we must discuss what computer art is."[62] Most importantly, though, CTG was the first to envisage the artist as a constructor of a system—a system that would create large amounts of form rather than individual artworks.

Rather than prefiguring the parameters of a program and then merely letting the computer generate a single figure, the Europeans and Japanese began conceptualizing computer art in terms of an art-making system. Because the system prevails over the form, the program itself becomes the work of art. This idea would become central to orthodox computer artists in the 1980s. The works, which were a series of repetitions and variations with subtle differences, are mere by-products of the system. One of the members of CTG, Masao Komura, proposed the thesis that true art was the discovery of a system.

Many mainstream critics saw the potential for endless repetition of slightly varying forms as monotonous, with Canaday finding this "familiar type of computer art" tedious.[63] Yet in 1970, the year the conservative critic wrote his opinions, a significant shift in computer art practice was taking place. The following chapter, "Virtual Renaissance," explores this shift in praxis. Expanding beyond the mathematical mysticism and formal aesthetic traditions, there was a move toward the traditional art genre of landscape. This was caused by a shift away from the scientist/technologist model toward artists who possessed hybrid abilities. The emergence of the "artist-programmer," a term first used by Noll in 1962, corresponds to a new-found optimism in computer art. Crucially, at this time women entered the once male-dominated domain of computing. Their presence resulted in a raft of new criticism and historical accounts. Although the rational and reductive were still privileged, and the empirical study of art remained hegemonic, artists began introducing subjectivity and intuition into the ultra-objective world of computer art. Traditional genres, such as landscape and figuration, began to materialize. In addition, artists began working against the precision and order of the machine. The systematic exploration of a field of possibilities, investigated tentatively in the 1960s, became a major paradigm in the 1970s, with heuristic methods developed for surveying the aesthetic forms and objects generated by computers.

CHAPTER THREE

Virtual renaissance

"A new kind of renaissance is beginning," artists Colette and Jeffery Bangert announced in 1976, "All those now working visually with the computer are Giottos announcing the coming of a new visual age."[1] Fellow computer artist Ruth Leavitt, with similar unbounded confidence, believed that soon a "Leonardo of computer art will come."[2] These two proclamations typify the newfound optimism of computer artists in the 1970s, and demonstrate how the humanist dream for cultural unification, so dominant in the 1960s, had become a central ideology in computer art discourse. Computer artists increasingly reflected on the Renaissance, with its natural blend of the sciences and humanities, as a template for practice and beacon for inspiration. Some even held the then hyperbolic belief that this period in the development of computer art was, as Vladimir Bonačič asserted, as "significant as the Renaissance."[3] Leavitt, along with a myriad of other artists, evoked the revered Renaissance figure of Leonardo da Vinci. Leonardo, as the exemplar for creative genius and unified practice, became an icon and central trope within computer art discourse. The new breed of computer artist easily identified with Leonardo. Like the great master, the computer artist required wide-ranging cultural and scientific learning and a natural curiosity that took the artist far beyond normative paradigms. For Leavitt, the new computer artist was—like the great master—the "true universal person," as she described.[4] *Leonardo*, under founding editor Frank Malina (and later under his son Roger), emphasized the Renaissance dream of cultural unification through the journal's mission and title. Even critics of computer art, such as

Robert E. Mueller, invoked Leonardo as representing the symbiosis of science and art with the potential for resolving humanity's problems.[5] However, the artistic zeal that defined the computer art renaissance would be more of a mirage, as disparaging criticism and competing interests would eventually dissolve the hope and optimism once held.

It was apparent to all those involved in computer art that if the movement was going to be sustainable it would require its own mythology. By the early 1970s, the momentum that computer art had harnessed from the Art and Technology movement was rapidly dissipating as that enterprise disintegrated. The demise of the Art and Technology project was relatively swift. Two significant events in the early 1970s spelt the movement's end: first, the closure of the Howard Wise Gallery in New York, which for eleven years had been the primary promoter and sponsor of new technological art forms; and second, the closure of the ambitious *Software* exhibition at the Jewish Museum in New York—curated by Jack Burnham—as a result of a number of technical disasters. According to Douglas Davis, other exhibitions opened with a "great flourish, only to run slowly down piece by piece, as time passed."[6] Technical difficulties and cost not only discouraged many artists from experimenting with advanced technology, but also contributed to public disenchantment.[7] Large institutions were less likely to exhibit technically complex exhibitions. In 1969, the Smithsonian Institution in Washington, D.C., imported the entire *Cybernetic Serendipity* exhibition from the Institute of Contemporary Arts in London, and then decided not to install it because of freight problems and the exhibition's technological complexity. Exhibition space was also a problem. Virtually in every large anthology exhibition of technological art, the premises were too small. For Davis, the careless and inadequate installation by the art establishment reflected insensitivity toward the technological art and betrayed what was really a "facile acceptance" by the art institutions.[8] Coupled with the dramatic decline in public interest, the avant-garde capriciously abandoned the movement. Movements such as pop art, environmental art, fluxus, happenings, and process art, which had courted technology's potential as a path of aesthetic experimentation, no longer found it viable.

Beyond technical problems and the unresponsive and ill-prepared art world, the once celebrated collaborative approach broke down.

The optimism with which avant-garde artists courted industry collaboration cooled considerably by the end of the decade. By the early 1970s, EAT, which had organized and coordinated many of these collaborations, was in crisis. EAT had suffered terribly at the hands of the Pepsi-Cola Company, which withdrew its support after Klüver and his colleagues had designed an intelligent environment for the company's pavilion at the 1970 Osaka World's Fair. This, according to Davis, cost EAT heavily in morale and public support. For the critics and artists, who opposed collaboration with profit-oriented firms from the start, the crisis proved their point. In 1971, Max Kozloff in his *Art Forum* piece "Multimillion Dollar Art Boondoggle" gave what Burnham described as the "most vicious, inflammatory, and irrational attack ever written on the art and technology phenomenon."[9] Kozloff depicted the artists involved in the "lavishly funded" A&T project held at the Los Angeles County Museum as "fledgling technocrats, acting out mad science fiction fantasies," while the "more sophisticated artists he envisaged as cynical opportunists."[10]

The economic depression following the Vietnam War also significantly challenged the Art and Technology movement's viability. There were significant cutbacks in government and corporate support for the arts which threatened the expensive technological collaborations. Moreover, the Art and Technology movement's demise must be viewed in relation to the growing discontent surrounding the Vietnam War and the worldwide protest over social inequality, which reached its apogee in the late 1960s. Although artists and scientists had attempted to overcome the profound fissure between culture and science, what John Cohen called the "chief occupational diseases of the age,"[11] the collective mood, characterized by the rising counterculture, counteracted and negated the utopian sentiments advocated by a small band of likeminded artists and scientists. To begin with, scientific humanism had become highly questionable among counter culturists who linked the problems of modern society to the enduring ideology of Enlightenment science, with its rationalist and mechanistic worldview. Theodore Roszak's *The Making of a Counter Culture*, published at the close of the decade, attempted to deprivilege science and its ways of knowing. The critique of science, found widely through literature in the 1960s, highlighted the misuse and abuse of science and questioned science's status as the dominant knowledge system. Another highly influential text, Mumford's *The Pentagon of Power* (1970), took a deeply pessimistic view of a technology-driven science. More popular with the rising counterculture was the work of Herbert Marcuse, who achieved a cult status in the early 1970s. Charting the ideological context of technology in government and business, Marcuse informed the genesis of postmodern sensibility in the 1970s, which eventually rejected the computer as a system-based machine that institutionalized and dehumanized the individual. By the early 1970s, much of the art world perceived, as Burnham suggested, a "nefarious connection between advanced technology and the architects of late capitalism."[12]

The cultural perception of technology was not the only problem besetting the Art and Technology movement. Internally, there was an inability to bridge the cultural divide. The "semantic curtain," as computer scientist Walter Finke described it, impeded collaborative efforts.[13] As he saw it, a "language barrier," which was as "real as any that exist in the world," separated the technocrat from the remainder of society.[14] Finke identified a growing problem within technology-based research industries, which resulted in a disjuncture between the technologists and the rest of society. He identified logic, hypothesis, scientific method, and the appeal to specific audiences as the means for the technologists to advance in their discipline. Finke went on to say that "by and large this society [of technologists] is preoccupied with its own ponderously constructed orthodoxy" and "stands aloof."[15] Shackled by a "consuming allegiance to the Scientific Method" and protected by the organizations that employ them, the technologist was becoming ever more introspective.[16] During the early 1970s many articles appeared that described the problem associated with collaborative efforts between artists on the one hand and the scientists, engineers, and technologists on the other. With the different modes of language and methodology, the scientists complained that they simply could not understand the artists or their motives. Artist and designer, Robert Preusser outlined the problem as follows:

> Rather than allowing technology to play its historical role in the evolution of visual form, the artist persistently imposes preconceived rhetoric upon the vernacular of technics. Having discarded all traditional concepts of art except the concept of the artist himself, he resists sharing his signature with those of

> other disciplines on the forms they might create in concert. While it is true that the engineer is frequently called upon to assist in technological matters, he is usually an accessory after the fact and rarely encouraged to collaborate creatively in the search for relevant, contemporary visual form. Because of this failure to engage specialists at the conceptual level, the visual potential of many technological territories remains unexplored.[17]

Preusser also acknowledged that the scientist was remiss in approaching the most pressing cultural challenges. Most scientists were "reluctant to extend their concerns beyond the technical aspect of their disciplines," and they "perpetuate the myth that science and art are foreign."[18] For Frank Malina, the artists considered scientists "uncooperative because they tell the artist that their ideas violate the laws of nature, demand inventions that have not been made or would cost vast sums of money to be accomplished."[19]

Because the artist and scientist often reduced each other to caricature, the sustainability of collaborative projects and the utopianism espoused by Rauschenburg, Klüver, and Cage evaporated. As Jonathan Benthall wrote at the start of the new decade, "Great hopes have been expressed about the reuniting of art with science and technology ... but this area of creative activity ... has proved to be difficult both theoretically and practically."[20] Claes Oldenburg, one of the high-profile artists involved with the Los Angeles County Museum of Art project, pointed out that the process of working with an engineer was "painful, for both sides ... It's a challenge to the artist's subjectivity."[21]

The collaborative effort within computer art was also a difficult affair. Because computers were restricted until the late 1970s to governmental, industrial, and academic settings, collaborative endeavors represented the only possible way artists could employ the digital medium. By the end of 1969, the Japanese computer art group CTG, which had shown great promise, disbanded because of problematic collaborations. Haruki Tsuchiya said that the collaborative effort had not been as easy as expected and that ultimately artists and technologists are essentially different.[22] Mezei felt that collaborative efforts were on the whole disappointing and that both factions remained committed to their own narrow understanding.[23] Noll was one technologist who signaled the difficulty in cooperative ventures; the experience resulted in his refusal to work with artists. Noll concluded that artist/scientist collaborations were ineffective because of the artist's inability to translate ideas into formal scientific languages. Noll had become discouraged at the inability of artists to verbalize their intentions. Likewise, Knowlton described the different attitudes that artists and programmers possessed. Reemphasising existing stereotypes from the *Two Cultures* debate, Knowlton used terms such as "illogical, intuitive, implicit, direct, impulsive, inexplicit, inarticulate and vulnerable to criticism" to describe the artist.[24] In countering these typical artistic traits, programmers required a methodology that was "constricted, constrained, logical, precise, ritualistic, defensive and well-prepared with their defence."[25] Knowlton in the coming decades would provide a more nuanced account of his collaborations, regretting some of the generalizations made in his previous writings and identifying the productive and distinctive outcomes born through these associations.[26] While these collaborative ventures are some of the most unique in the history of twentieth-century art, they remain problematic even today, as disagreement over copyright or what role each party played in the production of the artwork often surfaces.

In the short term, computer art's fate seemed tied to the Art and Technology movement. After reaching the height of popularity with the international exhibition *Cybernetic Serendipity*, computer art saw its public support begin to wane. Many artists retreated from collaborative efforts and from what Benthall described as the "difficulties of operating in the no-man's-land where art overlaps with science and technology."[27] However, harnessed to an ever-evolving technology, computer art found support in a number of nascent industries. More importantly, trained artists showed increasing interest in the computer. Inspired by the *Cybernetic Serendipity* exhibition, many realized that computer art could only have a future if artists took to the medium. The Japanese technologists from CTG believed that the artist, not the engineer, should explore computer art. Franke also recognized that computer art's viability was linked to its engagement with the artistic community. For Franke, computer art needed the "habitual methods" and the "competition" of the art world; if not, it would "remain ineffective as long as it is confined within scientific institutes and laboratories."[28]

After the large-scale exhibition and new publications by Franke and Reichardt on the subject, computer art appeared to hold great promise. Some believed that computer art was more than a "passing fashion" and that it could be of "decisive importance for the next millennium."[29] Further, computer art had the "potential of becoming great art" and from it, William Spencer Jarnagin concluded, "will emerge master computer artists analogous to Picasso."[30] In 1969, Georg Nees published the first doctoral dissertation on computer art.[31] Also in that year, the Computer Arts Society was formed in London to promote the creative potential of computers in art. Founded in 1968 by George Mallen, Alan Sutcliffe, and John Lansdown as a subsidiary of the British Computer Society, the society was set up to facilitate the growth of computers in art. As a highly successful venture, the society produced the magazine *PAGE*, which featured international computer artists' works and seminal writings concerning computer art practice. Encouragingly, Charles Csuri's computer artwork *Hummingbird* was purchased by the Museum of Modern Art in New York for its permanent collection. In 1970, an international contingent of computer artists, most of them still calling themselves mathematicians and technologists, exhibited at the Venice Biennale. For the first time, Lecci, Nake, Nees, Franke, and the Japanese group CTG exhibited next to works by constructivists such as Josef Albers and Max Bill.

Computer art's future was also becoming more secure through new publications. Grace Hertlein, one of the chief computer art commentators in the 1970s, expected that "given greater space in the mass media" the audience would eventually widen for computer art.[32] While there was no support from mainstream visual art publications, fortunately the Art and Technology movement provided a legacy of interest for technologically orientated art. The international journal *Leonardo*, with its Renaissance inspired vision, was the most significant. The journal, first publishing in 1968 at the height of enthusiasm for cultural unification, was crucial to computer art's feasibility. *Leonardo* eventually assumed the popularizing and disseminating role that *Computers and Automation* once held and became a lasting voice for computer art. Adopting an international outlook, the journal focused on the intersection between art, science, and technology. Modeled on scientific journals, it called for scientists to write about original aspects of their work for the benefit of colleagues and the general field in which they worked.[33] As a vehicle for exchanging ideas and technical information, the journal aimed, as the founder

Frank Malina outlined, to address the "overtones of secrecy" that permeated the arts.[34] In contrast to the commercial art journals of *Art Forum*, *Art in America*, and *Arts*, which critic David Carrier saw as Marxist or post-structuralist, and the historical journals of *Art Bulletin*, *Burlington Magazine*, and *Art History*, which were extensively academic, *Leonardo* was viewed as a more objective and wide-ranging account of the contemporary world.[35] Sharing the sentiment of Franke and others, *Leonardo* was to disseminate knowledge, as one of its editors described, in a clear, rational, and precise way so as to "dispel mystery rather than create it."[36]

Apart from *Leonardo*, there were a number of major publications devoted to computer art. Available after the first wave of interest in the late 1960s, the seminal texts included Franke's book *Computer Graphics—Computer Art* (1971) and Jasia Reichardt's book *The Computer in Art* (1971). The period also witnessed an increased prevalence of articles devoted to computer art across several different disciplines, appearing frequently in science, mathematics, engineering, and computer graphics journals. A common presumption which persists today is that computer art lacks a significant discourse. This presupposition is incorrect. Because of its interdisciplinary appeal, there was extensive literature on the subject, more so than the avant-garde movements of the day.

Perhaps the most significant reason for the resurgence of computer art was that the artist, avoiding the negative effects of collaboration, began learning computer programming. This resulted in a shift away from the dominant position held by scientists and technologists. As previously discussed, the original computer art exhibitions were made up entirely of scientists. When the major international exhibition *Cybernetic Serendipity* was held, there were very few trained artists engaging with the computer. As the curator noted, "only three artists [had] actually produced computer graphics, while the rest to date had been made by scientists."[37] In the 1970s, scientists were no longer the primary practitioners, and artists were no longer dependent on their expertise. These artists, reluctant to commit to a broad idea of a technology-based art, which characterized artists from the Art and Technology movement, sought to consign themselves to the narrower field of computing. While the integrated media experiments of the past had been technically problematic, the computer, which was now more readily available, became a much more viable instrument for experimentation. Artists were now searching for knowledge and skill in diverse disciplines.

In the 1970s, as Dietrich wrote, a "growing breed of technological artists with hybrid capabilities started to appear."[38] According to Duane Palyka, the computer artist must be one that can cope with the dualities of two fields. The artist must possess a "flexible enough identity to accept the interflow of ideas from one discipline to another" and be able "to pursue what is interesting in spite of the labels that have been attached to it."[39] By the early 1970s, the artist-programmer began to materialize. Manfred Mohr proudly declared that he was self-taught in computer science, Edward Zajec learned programming and taught it to artists, and Duane Palyka held degrees in both fine arts and mathematics. The artist-programmer duality was central to the Leonardo mythology and the dream that the computer artist was an agent of cultural conciliation. As Reichardt announced in 1974, "The bridges between art and science are finally only built by those who embody something of the two disciplines."[40]

In contrast to the declining Art and Technology movement, computer art expanded. By 1975, *Computers and People* (formerly *Computers and Automation*) featured the work of 41 artists from 11 countries in its annual exposition.[41] There was also the 1975 NCC Art Exhibition of computer art, which was the largest to date. By 1978, there were 30 times more computer art practitioners than a decade earlier. Once exhibited in isolation and within modest settings, computer art began to be shown in larger venues. A considerable portion of the venues included universities and polytechnic institutes that had recently incorporated computer science within its engineering departments. Subsequently, there was an expansion of computer courses including, for the first time, computer art classes.

A significant reason for the new artist paradigm was increased emphasis on computer literacy in universities and colleges. In fact, many of the new audiences for computer art were made up of students studying computer science. This pedagogy was part of the new agenda for liberal arts that had begun to institutionalize technological literacy in the United States. This included general courses plus research projects on the computer and its systems. As part of this general move toward technological literacy, computer art had been added to the curriculum at the major state universities. The shift toward this demographic meant that computer artists were no longer an elitist group of technologists, and the new access and availability of computers through educational institutions meant an end to computer art being produced in military laboratories.

Perhaps what lifted computer art's profile and prevented it from meeting the same fate as the Art and Technology movement was the advent of the graphics industry. While many early commentators believed visual arts was the field most likely to benefit from the computer, graphic design proved the most successful. Indeed, since its inception, the computer art exhibition has presided over a mix of utility and artistic endeavor. Franke's 1971 publication *Computer Graphic—Computer Art* is an early testament to the computer/graphic art nexus. Often the graphics community was indistinguishable from the computer art community. In the early 1970s, there were a number of conferences and symposiums that situated computer graphics as an important yet somewhat modest field within computer science. In the 1970s, the discipline of computer graphics grew substantially with a proliferation of journals and foundational textbooks. In 1973, the inaugural SIGGRAPH (Special Interest Group on Computer Graphics) conference was held in Boulder, Colorado. SIGGRAPH would become a major exposition and trade show for graphics research and, significantly, a crucial popularizer of computer art, especially in the 1980s when an exhibition component was added to the annual conference.

With universities and research laboratories working toward solving fundamental problems facing the production of digital images, the application for computer graphics widened considerably. In the United States, these facilities included Bell Labs, University of Utah, New York Institute of Technology, MIT, and others. The industry grew significantly—by the late 1970s, the entire value of all of the computer graphics systems, such as hardware and services, would reach a billion dollars in the United States. In the early 1970s, institutions were interested in converting much of this early work into commercially marketable applications. Drafting, remote sensing, military simulation, medical imaging, and business graphics were all possible fields in which computer graphics could be utilized. The entertainment industry would also embrace computer graphics and its capabilities, with computer graphics and animation being introduced to mass audiences through the world of television and computer games. The video game industry, still then in its infancy, had a future that appeared assured once digital technology fully infiltrated the once analog arcade. Many of these developments were the result of pioneering artists such as John Whitney and Charles Csuri who developed various animation systems. One result was the formation in the 1970s of a number of animation and special effects houses, which serviced Hollywood film companies eager to incorporate the latest photo-realistic computer imagery in film. By the late 1970s, computer-generated imagery was becoming increasingly ubiquitous on television, print, and film.

With the increased enculturation of the computer and its imagery, artists felt a new congeniality toward the computer. On a practical level, artists viewed the rise of the computer as another technical innovation and saw their use of the computer in the arts as a logical extension in a long tradition of using the most advanced techniques available. On a sociological level, artists felt it appropriate to make use of an increasingly ubiquitous machine. Lillian Schwartz, one of the first female artists to use the computer in the production of art, reasoned that by disregarding the computer, one would be "ignoring a large part of our world today."[42] Likewise, Lloyd Sumner, one of the first American-trained artists to employ the computer, felt that the computer was the only "proper medium" to express the technological world.[43] The growing concern to understand the new social and cultural realities of the post-industrial society through the computational medium enhanced the relevance of the computer. In the early 1970s, these new technological realities had been reconceptualized by the American sociologist Daniel Bell in his highly influential book *The Coming of the Post-Industrial Society* (1973). Overall, discourse on the societal effect of advanced technology was on the increase. The futurologist Alvin Toffler warned in his book *Future Shock* (1970) that the accelerative nature of technological change required one to understand the latent potential of the future. Consequently, technological futurism and forecasting, which was a functional pursuit of the computer, became instinctive within computer culture. These futurological narratives eventually surfaced in computer art discourse. Commentators and artists increasingly forecasted the outcomes of computers in art. Futurology and narratives of progress became key elements in computer art's claim to be an innovative and original art form. Much of the writing was caught up in the fallacy that new technological inventions would bring about a complete revolution for the good; in this case, the computer would provide democratizing and unifying elements within art. While the futurology within computer art discourse was often exaggerated, there were also some remarkably accurate prophesies made by commentators and artists. Some prognostications did not eventuate, as seen in two of these statements by Franke: "At the very least, art students will in [the] future be taught programming as a matter of routine."[44] Again from Franke: "Most likely the painters and sculptors esteemed today will nearly have been forgotten, and instead the appearance of electronic media will be hailed as the most significant turn in the history of art."[45] Three decades have passed and the hegemony of traditional media is still in place and digital artists still struggle for acceptance. In contrast, however, there are countless examples where predictions have been correct, with Grace Hertlein and Jasia Reichardt being particularly prophetic.[46]

Another factor that made computing more palatable for the artist was the revision and reshaping of scientific ideas by new counter cultural forces. The cultural historian Charlie Gere recognized the emergence of a "second order" cybernetics that articulated a "new and positive conception of technology."[47] Beyond the social theorists, such as McLuhan, and the avant-garde artists, such as Cage, the most significant factor in this shift was the formation of a technologically minded counterculture. California, the seat of West Coast counterculture, became home to the burgeoning Silicon Valley, the geographic area that drew together companies and individuals involved in computing research and development. This environment allowed for the melding of the original counter-cultured desire for experimentation and an alternative lifestyle that emanated from San Francisco with the technology-oriented entrepreneurial capitalism of Silicon Valley's technocracy. Within this environment, scientific theories such as cybernetics were infused and reinvigorated by the holistic and ecological countercultural thinking found in Steward Brand's Whole Earth Project. The engineering paradigms that characterized 1940s and 1950s cybernetics gave way to the interconnectedness of nature and the relation between living beings and the ecosystem. Cold War technologies would be "stripped" of their militaristic aura and reimagined under a type of cybernetic idealism in which a new generation of technology would be thoughtfully applied for the betterment of society.[48]

Another important phenomenon to emerge from the 1970s countercultural computing world was the "hacker." The hacker culture developed from the large university laboratories, where young men intrigued by the possibilities of computing developed an almost hermetic devotion to the computer. Many hackers, who were from a long American tradition of electronic hobbyists and tinkerers, were fascinated by the possibility and challenge of building a digital computer. The hacker is a significant shift away from the priesthood of the machine that characterized the technicians and programmers from the 1950s and early 1960s. While still devoted to the computer, the hacker was seduced by the power and elegance of programming and the ability to personally build one's own computer system. Self-reliance, commitment to programming, and an adoration of the computer also typified the new breed of artist-programmer. With a growing mythology surrounding the hacker, artist-programmers began to formulate their own distinct cult around a commitment and devotion to the computer. Jean-Pierre Hébert was an artist who personified the hacker type. After working as programming engineer in 1959 for IBM's new operation in Paris, he began thinking about the possibilities of making art with the computer. Alone and completely divorced from the art world, he built an image-generating system on Hewlett Packard's earliest personal computers. For a decade he experimented in isolation with different computational machines, devices, and programming languages, building a practice that would see him become one of the most prolific computer artists and a founding member of the Algorists (see Chapter 4 for more on Hébert).

Beyond the appearance of the trained artist, the most invigorating factor within the computer art project was the influx of female artists, writers, and critics. In the 1970s and beyond, women became primary agents in the theorization and criticism of computer art. Jasia Reichardt's publications' *The Computer in Art* (1971) and *Cybernetics, Art and Ideas* (1971) marked her as the most astute commentator on the computer art phenomenon. This is besides her curatorial work on the landmark *Cybernetic Serendipity*, which initiated much of the worldwide interest in computer art. Other female computer artists in the 1970s became prolific writers as well. Grace Hertlein wrote extensively on computer art for the journal *Computers and Automation*, and Ruth Leavitt gave voice to a range of computer artists in her seminal publication *Computer and Artist* (1976). In addition, the visionary works and writings of Lillian Schwartz, Vera Molnar, and Colette Bangert shaped computer art discourse. In the following decade, women would also take the key role in criticism through the work of Cynthia Goodman, Margot Lovejoy, Patric Prince, and Anne M. Spalter; and there emerged an ever-increasing group of successful computer-based female artists.[49] Darcy Gerbarg and Copper Giloth organized the first art exhibitions in conjunction with the SIGGRAPH conference. Curated by Gerbarg, the inaugural 1981 exhibition included a raft of pioneering female artists, including Lillian Schwartz, Joan Truckenbrod, Ruth Leavitt, Copper Giloth, and Colette Bangert. Giloth would chair the following two annual SIGGRAPH exhibitions, including 1983's highly successful "Exhibition of Computer Art" international show.

Many have noted the gender politics of twentieth-century science and technology, especially in engineering that is traditionally associated with men and masculinist ideology. Likewise, computer culture, which emerged from engineering and militaristic domains, privileged masculinity. Computer programming, which interestingly had been the domain of women before and during the war, became increasingly male-orientated in the 1950s as its prestige as a challenging and intellectual endeavor grew. Women had been seminal in the development of the electronic computer. Even prior to World War II, women were responsible for manually calculating complex firing tables required for ballistic weaponry—they were in effect "human computers." By the time trained female artists entered the field in the late 1960s, the terrain of computing was becoming increasingly masculine. Since the 1940s, programming had been largely a female occupation. Mimicking the mechanical operation of the telephone switchboard, the programmer possessed the long-standing gendered overtones of clerical work. The male engineer, conversely, was the "planner" whose role was deemed more analytical. In the professional hierarchy, the male was associated with technical mastery and intellectual analysis, while the female role of programmer was associated with rudimentary manual labor, even if the business of programming was a highly demanding ability, requiring various creative and analytical skills. In the late 1960s, however, programming would become stereotypically a masculine endeavor, making the profession, as historian Nathan Ensmenger writes, "inhospitable to all but the most adventurous and unconventional women."[50]

It seems surprising in the face of the counterculture's technophobia and the feminist critique of industrialization that female artists were able to move into the masculine world of computing with relative ease. When Lillian Schwartz made the decision in 1968 to employ computers to create art, she was required to enter a field with arguably the strongest masculine culture—engineering. Therefore, we expect Schwartz's experience would have been a negative one, reflecting the institutionalized sexism that engineering was notorious for. Yet we find the opposite to be the case. The artist found early computing to be devoid of gender bias. Compared to the patriarchal power structure that defined the mainstream art world, these women found the emergent field of computing to be relatively open. In the formative years, social norms proved to be more fluid and gender barriers remained unconstructed, even though computing would masculinize soon after.[51]

While there were exceptions, women tended to not be excluded as they had been in the field of engineering. Lillian Schwartz was invited to work at Bell Labs and stayed, forging a celebrated career. For Schwartz, there were no gender issues. For the artist, the shift was relatively straightforward because she had always worked with the latest technologies, and she had no concern over how her computer work would be received because her pre-computer art was already successful. Schwartz was not actively seeking equal rights within a male domain. This corresponds with Cynthia Rubin's account of her transition to computer-based art. Beyond the aesthetic flexibility of the computer, Rubin remained in the computer art field because it was open. According to Rubin, "anyone who had a new idea was welcomed" as gender, race, and position within the computer community were not a central concern.[52]

Historically, the gender shift parallels the increased participation of women in the engineering and computing fields in the 1970s. Another facilitating factor was the Women's Movement and the resulting influx of women into the visual arts. Moreover, other creative fields once dominated by men were witnessing a shift; for example, at the same time a generation of female science fiction writers came to prominence.[53] For many feminist artists, painting was considered too masculinist or at least too closely associated with an overt masculinist history of Western art. Hence they were particularly attracted to non-mainstream mediums, which they felt were suited to feminist subject matter, such as textiles and performance. On the other hand, Spalter suggested that females were attracted to the computer for similar reasons, because "unlike traditional fine art media, [the computer] does not have a history of primarily male practitioners."[54] While this is true, feminist themes are not common among female computer artists (unlike textiles, performance, video, and photography), and male scientists and technologists did dominate computer art production in the 1960s (as would be expected given science and engineering's long masculine bias). It appears that computer art was such a new medium that male practitioners were yet to construct a history that favored them. In addition, the computer itself appeared to be equally seductive to both genders. After all, some of the most insightful and passionate writings on mechanical calculation have been made by the nineteenth-century mathematician Augusta Ada King, Countess of Lovelace. In the computer art world, gender issues in the 1970s seemed to be eclipsed by the absorption in and enthrallment of the computer's innate potential. However, new research suggests that artists were experimenting with gender issues in the early 1970s.[55]

Even though there were female computer artists who raised gender issues in their work, it was not as prevalent a theme as it was in video and performance art. On the whole, there was little overt polemics involved in the use of the computer by women in the early 1970s. This contrasts with artists using video which became, as Margot Lovejoy described, an "alternative, progressive, and flexible medium for expressing their political and cultural objectives."[56] Like their male counterparts, female computer artists were largely devoted to the potential of the computer and its processes, rather than its potential as a political tool. Nevertheless, female artists overcame the fallacy that computer technology was inherently masculine. It became clear that computers did not embody masculinity; rather the medium had in the early years of computer art been culturally constructed as male preserve.

The movement of trained artists into the field meant that computer art evolved more humanist sensibilities. Intuition, subjectivity, and poetics began to replace the omnipresent rhetoric of abstraction and the overwhelming instrumental view of a depersonalized art. In the late 1960s, pioneering computer artists such as the Brazilian Waldemar Cordeiro and the American Lloyd Sumner pursued overt humanist themes. They were the first artists to bring human emotions into what Benthall described as the "cold and cerebral world" of computing.[57] Lloyd Sumner was the first to use the computer solely for aesthetic means, and his publication *Computer Art and*

Human Response (1968) was the first text devoted entirely to an individual computer art practice. He was also the first artist to sell substantial amounts of his work. In fact, in 1971 he funded much of his famous round-the-world bike expedition by selling computer artworks and lecturing on the subject.[58] Sumner's travel memoir, *The Long Ride* (1978), which records the artist selling and making computer artworks to finance the next leg of his journey, became legendary amongst adventure cyclists. Even with his success—he was exhibited in *Cybernetic Serendipity*—he does not feature in key histories of digital art.

Independent of any research program, Sumner started producing computer-generated drawings in 1964. Although he studied art at the University of Virginia, it should be noted that his primary study was engineering. It was while working at a part-time job at the campus computer science center that Sumner first came in contact with computing. His dual art and engineering background equipped him to realize the potential of the machine as a mechanical aid in art making. Each drawing was fully preconceived, with Sumner sketching out the drawing by hand before programming the computer. A significant portion of his computer-generated art was completed in 1967 when he was an artist-in-residence at the University of Virginia. Although many of his computer drawings were relatively simple geometric linear designs, some were subtle designs, emitting interesting visual effects. They were visually descriptive in form and title, which made them popular to a traditional art public who thought the usual abstract representation lacked human expression. So popular was this new art form that at an exhibition at the Montreal Museum of Fine Arts his work sold out in the first day, which was highly unusual for a computer art exhibition. Encouraged by this, Sumner attempted to make a career out of computer art by marketing his work under the title Computer Creations. Benthall remarked that Sumner was one of the few computer artists who actually made a "living from their work."[59]

Following the conventional model, Sumner's book begins with a simple description of the computational process, but then moves to a poetic and lyrical style, which contrasts with the objective and goal-orientated writing of previous technologists. However, Sumner was acutely aware of the suspicion with which the orthodox art world regarded what was at the time a foreign and extraneous device. Sumner opened his book with a plea to the reader not to prejudge his art because of its mode of construction. Each image is accompanied by a short, often rudimentary musing on the work and its meaning. Overall, it is a highly romantic text. The humanist passages mix the personal and highly spiritual with the abstract and mechanical. Ideas of love, hate, and beauty are interwoven with science, space travel, and information theory. There is an overt optimism expressed toward technology. The computer and its peripheral devices become central figures in the art form. Works such as *The Magnificent Machine* are devoted to the intrigue of all machines. Sumner, humanizing and personifying the computer, dedicates his book: “To my good friends the Burroughs B5500 and the Calcomp 565.”[60] Starting a trend that many computer artists followed, Sumner is photographed with his computer (Figure 3.1). The sociologist and psychologist Sherry Turkle had begun to notice how engrossing the computational medium can become for users, so much so that the interaction with the machine “offers the illusion of companionship.”[61] Computer artists such as Grace Hertlein, who invoked the idea of the “joyous machine,” followed

FIGURE 3.1 *Lloyd Sumner generating computer art with a Burroughs B5500 computer and Calcomp 565 plotter, ca. 1968. University of Virginia. Courtesy of Jean Sumner.*

the highly reflective relationship that Sumner and others entered into.[62] This complete adoration of the digital machine, an element not present among the Art and Technology artists, was something not seen since the writings of nineteenth-century photographer Peter Henry Emerson and William Henry Fox Talbot, who both wrote evocatively about the camera's almost magical powers of representation.

Like much of the computer art of the 1960s, Sumner's work was a combination of geometric abstract figures. *Intuitively Yours* (Figure 3.2), a basic abstract geometric pattern that creates a subtle moiré effect, illustrates the artist's appeal to intuition. Although the computer generated the images, Sumner reminded the viewer that the conception and perception of the image was fully human. While Sumner's drawings are a combination of abstract patterns and geometric spatial forms, many express the quality of organic shape and movement. These drawings, which he called "Sumnergrams," were defined as smooth curves and the recursion of flowing lines fashioned into closed loops. With this process, Sumner produced the first self-portrait generated by a computer (Figure 3.3), creating in the process an early example of a digital avatar.

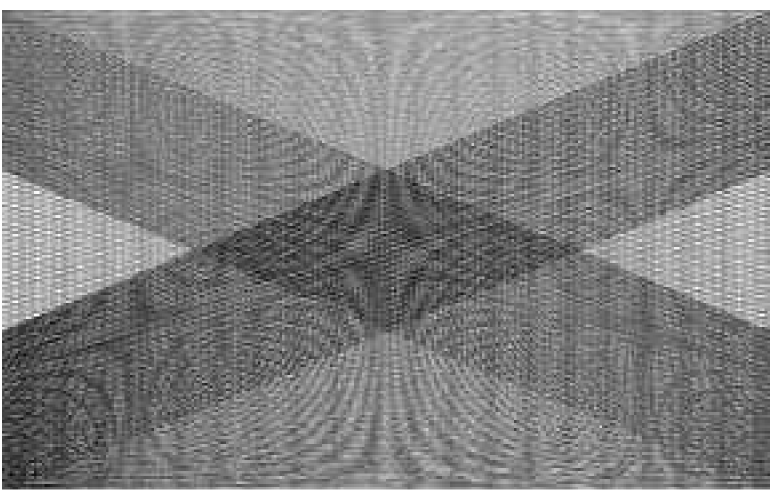

FIGURE 3.2 *Lloyd Sumner,* Intuitively Yours, *ca. 1968. Courtesy of Jean Sumner.*

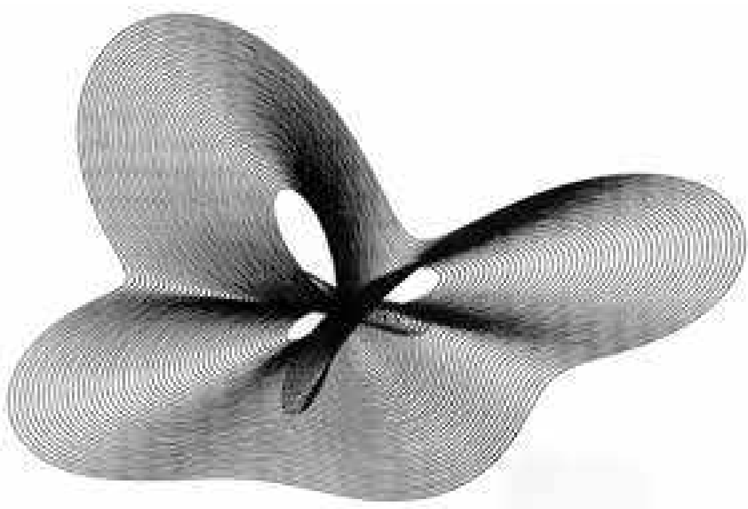

FIGURE 3.3 *Lloyd Sumner,* Self-Portrait, *ca. 1968. Courtesy of Jean Sumner.*

Apart from his humanistic approach, Sumner began the trend away from hard-edge geometric abstraction. In the 1970s a variety of personal expression developed among the new artist-programmers. The emphasis began to shift from the will to discover new aesthetic laws to the representation of natural forms and structures. For the artists, inspiration increasingly came from outside rather than inside the world of computing. Increasingly, too, traditional genres were becoming popular.

While much of the computer art of the 1960s evoked an organic quality through the generation of symmetrical geometric figures, the artists of the 1970s were looking to redefine their relationship to nature through the landscape motif. Early computer art was dominated by geometric abstraction, and technologists and artists were quick to trace their hard-edge, linear aesthetic back to early abstract modernist movements, such as constructivism. Artists were crucial in shifting computer art away from the cool rhetoric of mechanical abstraction—toward styles informed by the organic and the human. For example, in the early 1970s, Grace Hertlein completed the naturalistic work *The Field* (Figure 3.4), which employed traditional drawing mediums such as paper, pens, and inks

FIGURE 3.4 *Grace C. Hertlein,* The Field, *1970. Paper, ink, Rapidograph brushes and pens. IBM 1620 and Calcomp plotter. Courtesy of the artist.*

to produce more biological effects. Artists deliberately subverted the precision and symmetry of the computer, pushing their practice toward inexactness and disorder. Bangert, who sought to humanize the computer, produced landscapes with her husband that simulated expressionistic strokes of the human hand. *Large Landscape: Ochre and Black* (Figure 3.5) simulated chaotic patterns through random

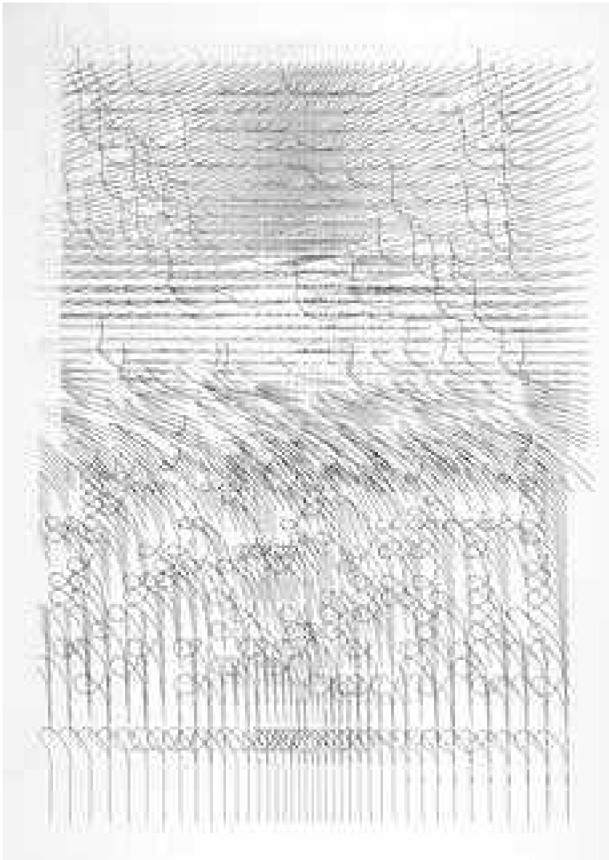

FIGURE 3.5 *CS & CJ Bangert,* Large Landscape: Ochre and Black, *1970. Ink on paper. © Spencer Museum of Art, the University of Kansas. Gift of Colette Stuebe Bangert and Charles Jeffries Bangert, 1999.0232.*

generators. The symmetry and precision that gave 1960s computer art a mechanistic appearance shifted toward inexactness and disorder, as the artist worked against the accuracy of the computer. This trend toward mimicry of the artist's hand or the engagement of traditional genres was not admired by critic John Canaday, however. Though he believed that the Bangerts' computer art was "appealing" in its "sensitivity," the critic believed that these approximations of the artist's hands were facile and not worth the effort involved.[63]

"But if there is to be such a thing as computer art," the critic asserts, "surely it must start with a recognition of the computer's potential for new expressions rather than with the premise that it can be taught old ones."[64] Exactitude for creating linear complexity was for Canaday the real virtue of the digital machine; simulation was not. For other critics, the more humanist-inspired work, though a move away from cool, mechanical-like abstraction of the early years, still possessed the mark of the machine. The artist was perceived as complicit in a type of mechanical subterfuge.

Although the 1970s is often viewed as an unremarkable decade in computer art history, there is evidence to suggest that artists of this period provided the crucial ideas, such as generativity, the algorithmic, and heuristic exploration, that became key in the coming decade. Although their practices varied, artists such as Manfred Mohr, Harold Cohen, and Vera Molnar developed methods that were important for the transition between the early 1960s computer art paradigm of revealing art as an abstraction and the 1980s artist-programmer paradigm of creating and then exploring an open-ended art-making system.

While traditional art genres such as landscape and self-portraiture began to surface in 1970s computer art, they remained in the minority. Motifs and metaphors derived from nature only became widespread in the 1980s. Like the 1960s, geometric abstraction dominated in the 1970s. The rational management of the art-making process and the impulse for reduction remained a governing principle amongst artists. In the 1970s, there was no retreat from formalization and the mathematization of art. In some quarters, the demystifying critique of art through empirical method remained a viable project. Following the work of psychologist Michael Apter, theorists such as Franke were still advocating the cybernetics approach to art.[65] Franke believed that cybernetics would "bring an end to the era of sophistry in the discussion of art."[66] For Franke, a science of aesthetics still remained a key project:

> A science of aesthetics is making itself evident, which contradicts some important traditionally accepted concepts of art. As in the natural sciences, the science of aesthetics allows only statements that can be analysed logically and then be verified to determine if they meet the truth of facts. Only in this way can one escape from the morass of verbal rhetoric so much of today's hypothesizing on art.[67]

While experimental aesthetics was seen as the new theory that would make art a science, new interest in artificial creativity renewed the belief that the computer could “amplify or supersede” the artist.[68] As Hiroshi Kawano announced in 1975, “logical activity” is the essence of art, while reason is the “*raison d’etre* of computer art.”[69] Even the Bangerts, who were involved in more subjective themes, were attracted to the “rational approach to art” as a way to understand and clarify previous and current visual concepts.[70] Also, in an attempt to “seek a concrete answer” to the mysteries of aesthetic appreciation, Vera Molnar wanted to work in a consciously empirical way.[71] In the tradition of Max Bense, Molnar believed that the “underlying principles for giving aesthetic satisfaction to viewers…can be found.”[72] The human sciences were for Molnar the key to solving the riddle of art’s aesthetic reception. New experimental aesthetics coupled with advances in perception psychology represented the ideal conceptual tool to generate “good pictures.”[73] Manfred Mohr also recognized the fundamental advantage of logical, precise, and objective methods. As Mohr suggested, programming the logical features of art forced a “maniacal precision” onto the artist,[74] which resulted in a “clearer image of the creator’s thinking and intentions.”[75] For Mohr, the forced objectivity was an important way to deny all modes of artistic subjectivity.

Rejecting the metaphysical and speculative aspect of image creation for the technological moment, Mohr recognized part of his project was breaking down the mystic barriers of the artistic process. Mohr perceived that a general shift was occurring in the arts away from “uncontrollable metaphysics to a systematic and logical constructivism.”[76] Likewise, Cordeiro believed that the skillful utilization of the computer had the great value of “demystifying traditional art and contributing toward the analysis of mental processes in artistic activity.”[77] Nevertheless, Mohr wanted to distance himself from the mathematics project by stressing that his art was not about the system of logic, but rather the “visual invention which results from it.”[78] Mohr stated that he was “not trying to illustrate cold mathematics, but a vital philosophy.”[79]

The rational treatment of art is most apparent in the work of Harold Cohen. For many in the sciences, his work has become an important model of the art-making process. Cohen’s practice paralleled the rise of interdisciplinary study into the subject of creativity. In fact, Cohen's work is a prime illustrative example of this and related fields such as artificial intelligence. Although Cohen has a unique place in the scientific study of artificial creativity, the artist's placement in the history of computer art is problematic. He held in disdain the computer art community and its conception of "computer art," what he described as "those interminable geometrical figures."[80] Working in relative isolation from the computer art community, he preferred the difficult and relatively new field of artificial intelligence. He was the first artist to work with artificial intelligence paradigms in an extensive way. It was through his *tour de force*, the autonomous programmed robotic drawing machine AARON (Figure 3.6) that he became the most widely regarded artist working with computers. Cohen found great

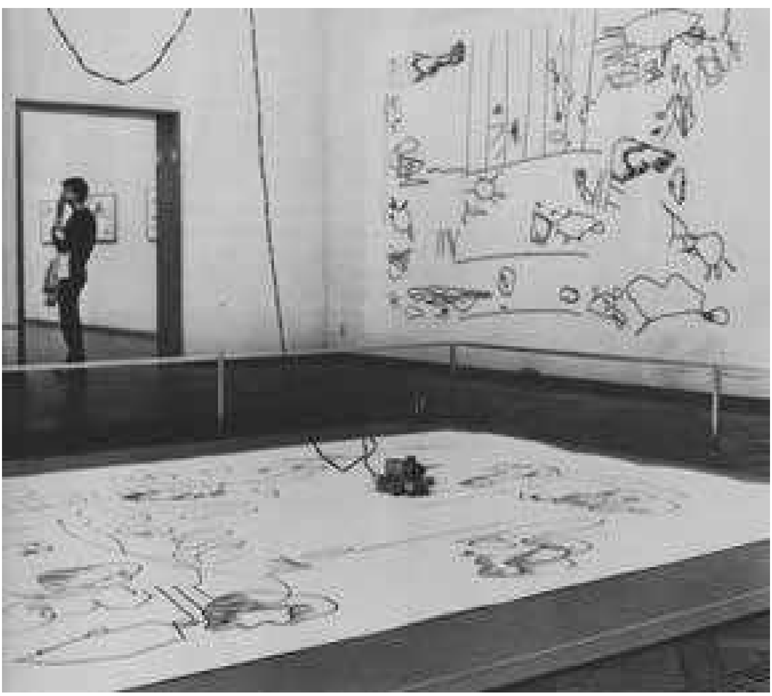

FIGURE 3.6 *Harold Cohen, Stedelijk Museum installation, Amsterdam, 1977. Showing the computer-driven "turtle" in action and completed large and small drawings on the gallery walls. Courtesy of the artist.*

success in the 1980s, gaining entrance into art periodicals and daily newspapers, such as *Art in America* and the *New York Times*, a feat other computer artists never achieved. Beyond the relatively autonomous scientific discourse surrounding his work, Cohen has written extensively on his work, its meaning, technical aspects, and significance.

Like many of the artist-programmers, Cohen turned his back on a highly successful career as a painter to be involved in the difficult and unforgiving area of computing. After moving to California, which had become the center for computing research and development, Cohen, with much difficulty, taught himself how to program. From that time on, programming exerted a curious allure over the artist. It was, as he once stated, a "genuine psychedelic experience."[81] The artist was surprised at how programming extended one's mental capability, allowing one to develop and shape dormant mental faculties. Independently of the artificial intelligence community, Cohen began to appreciate how these computer programs were like human cognition. If art making was in simple terms analogous to a series of decisions—the powerful *if-then-else* statement in programming—then one could employ these conditional statements to select and control the action of a program. This in turn could autonomously create an art object. Characterizing the human art-making process as a continuous changing pattern of decisions based on the artist's awareness of the work in progress, Cohen sought to program such artistic behavior into a computer model. Though artists, critics, and theorists speculated on the essence of art-making, there was no means of testing their theories. For Cohen, the computer could permit a rigorous test of ideas about art-making which may lead to knowledge on the process itself. Similar to Bense's abstract aesthetics, Cohen's project was a further attempt to rationalize and model human creative faculties in the hope of generating new knowledge.

Unlike other artists involved with computers in the 1970s who viewed the computer as a new medium for fine art production, Cohen envisaged the computer as a tool to explore and refine his ideas about the nature of visual representation. However, building a program that investigated art-making behavior proved difficult. It took a number of years before Cohen found the right research environment and technical knowledge required for such a speculative project. Through Edward Feigenbaum, a pioneer of artificial intelligence at Stanford University, Cohen gained access to the necessary resources. According to McCorduck, Cohen applied to the National Foundation for a grant and was turned down. As one of the reviewers declared: "How can Professor Cohen hope to learn Fortran? He's an artist."[82] His entrance into the world of artificial intelligence was initially straightforward, as he had independently arrived at the foundational tenet, the underlying supposition shared by many scientists in artificial intelligence: because the computer is a general-purpose manipulator of symbols, it can be viewed as functionally equivalent to the brain.

Cohen's seminal essay "Parallel to Perception: Some Notes on the Problem of Machine-Generated Art" (1973) outlined his research for the coming decade. Reading like a manifesto, the paper identified contemporary computer art, which he called a "strange manifestation," as preoccupied with the "predetermined transformations" of existing image data. The emphasis was on either generating beautiful and interesting patterns from mathematical functions or enlisting transformative functions in the metamorphosis of existing imagery. For Cohen, simply formulating interesting patterns had no claim to art. "The real power, the real magic," he exclaimed, rested "not in the making of images, but in the conjuring of meaning."[83] Cohen was not attracted so much to the computer's celebrated precision, remarkable versatility, or constant capacity for work, but more to its power to execute functions that parallel those of the mind. Reminiscent of the camera, the computer had become for Cohen democratized: anybody with the appropriate device could access image-making. For Cohen, the computer was not appreciated for its greatest capacities. It was being used like a camera—merely as a tool for representation. This "particular kind of usage," Cohen believed, was the reason why computer art was not considered art. Making the computer serve as a "picture-processor" was the "antithesis of autonomy," and autonomy was the true calling of the computer.[84]

The picture-processing paradigm in computer art was limited to a production-line kind of procedure: an image is fed in, then manipulated or transformed, and finally processed out. For Cohen, this routine lacked the feedback that was part of the human art-making process. That natural feedback system was engaged when the artist encountered the perceptual world and made decisions on the basis of precepts. Any feedback evident in the current computer art process was via the human user, which made it like any other traditional tool. What Cohen suggested was that rather than giving the machine initial digital image data or mathematical functions in advance or when the program needed it, the program could generate the material itself. Without any preliminary input the program would need to be embedded with a behavioral function that would provide the necessary feedback mechanisms within its own structure. The idea of the machine being loaded with a program, executing the program then stopping in one discrete event did not resemble human behavior for Cohen. To have any real equivalence, Cohen envisaged a machine "equipped with an archival memory, running a self-modifying program not once, but hundreds or even thousands of times, and modifying future performance on the basis of past performance."[85] This innovative idea meant that the initial input had little significance for the final outcome—the initial parameters having the same relationship to the stylistic inclinations of the artist's first teacher. The internal feedback mechanism in the program would create its own paths, conduct its own investigations and modify its own behavior on the basis of the response it generates. This made Cohen's project unlike any other computer art practice.[86]

The key point of "Parallel to Perception" was Cohen's suggestion that the "computer was capable of autonomous art-making behavior, capable of initiating its own material to act upon—far beyond so-called computer art where the machine only transformed material presented to it."[87] It had implications for the Western delusion of "real creativity" and "originality," McCorduck suggested, which were traditionally seen as *a priori* in the mind of the genius artist.[88] Cohen seemed to be hinting that if one deduced art-making principles and externalized these in the form of a program, this program could evolve much like the human artist. Like the stance of previous scientists and technologists, this was an affront to humanism and its artistic tradition.

To embody this new understanding on visual representation, Cohen developed the program AARON, which would later become the oldest continuously developed program in computer history. With AARON, Cohen was attempting to discover the nature of the creative act by constructing a counterpart to human cognitive processes that underlie the making of visual images. AARON captured the essence of the artist's hand through the robotically drawn line, which was "vital if the viewer was to believe that the marks were the product of a system essentially like human cognition."[89] Unlike previous computer art, there was no preplanning of drawn lines (Figure 3.7). AARON would make a series of marks dependent on a feedback mode. Essentially, the interaction of cognitive primitives devised by Cohen produced the drawings. AARON possessed all of the knowledge and understanding it needed to complete a picture. Possessing a memory of its previous position, the program knew where it was and where it needed to go. AARON ended a picture when it had satisfied the parameters of extending graphic elements throughout the picture space. This is one continuing difference between AARON and other computer art programs: AARON had an awareness of where it was located and what remained to be completed.

Cohen's early "machine-generated art," as he called it, was first introduced to the art community in 1972 at the Los Angeles County Museum of Art. Rather than responding to the artistic idea, the audience was captivated by the physical mechanical device. They

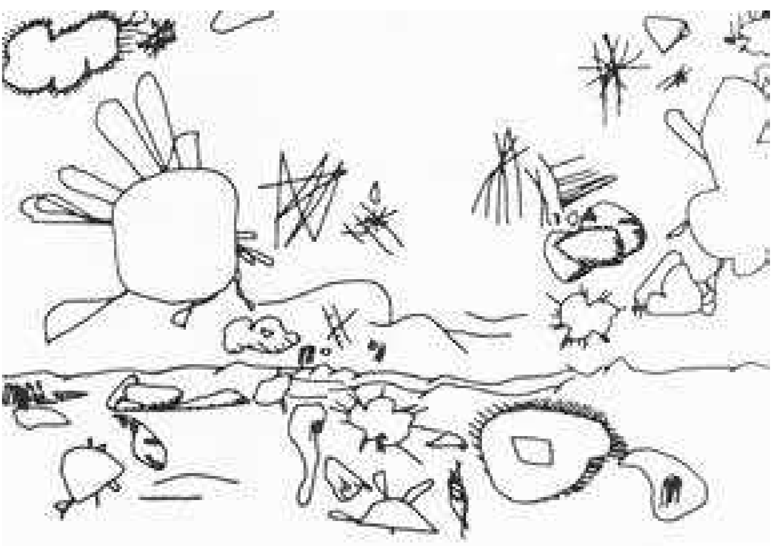

FIGURE 3.7 *Harold Cohen, Drawings from the San Francisco Museum of Modern Art, 1979. Generated by the program AARON. Courtesy of the artist.*

attentively watched the computer as it produced the drawing. Many believed the machine possessed sentience. When the pen paused, people would believe that the machine was "thinking of what to do next."[90] The audience relished in what Turkle described as the computer's sense of aliveness.[91] When the pen moved to the other side of the paper, they believed that it was to "balance what it had done on the other side."[92] When Cohen revealed that the program was searching for some space to continue the drawing, the public was suitably chagrined by this technical response. Cohen reported that it was hard for the audience not to "anthropomorphise the machine's activities."[93] However, he always insisted that his art was not about the spectacle of the mechanical device and that he had no great interest in machines and their peripheral devices.[94] He believed that the difference between drawing by hand and drawing by means of a mechanical device was essentially trivial. The audience needed to be reminded of the programming process—that the machine's identity that animated the drawing process resided in the knowledge that had been extracted and externalized from the artist's mind. As if trying to counter the power of the machine or the frequent criticism that computer artists merely push a button and art comes out, Cohen vigorously announced: "*I* give the machine its identity. *It* is doing what I have in mind."[95]

Nevertheless, part of computer art's great public appeal was watching a machine complete human activity. Whether in the form of Cohen's robotic drawing system AARON (Figure 3.6) or the self-directed motion of Manfred Mohr's plotter (Figure 3.8), the strange autonomy and animation of the machine was a key factor in computer art's wider public appeal. As outlined in the previous chapter, the unforeseen behavior of the computer, what theorist Tim Binkley called the "wily computergeist" had also become a significant mythology for computer artists. This was not a new phenomenon. Machines that bewitched their makers and their audiences had a long tradition. Machines that exhibited independent control had for centuries evoked wonderment. These mechanical marvels known as *automata* (from the Greek word *automatos*, acting of one's own will, self-moving) inspired a whole spectrum of emotions: from astonishment at the machine's lifelike motion, to extreme indignation over the Promethean powers it seemed to engender. The automaton represented both the physical and mental attributes of the human. Automata reached

FIGURE 3.8 *Roswita Mürle, Manfred Mohr, Estarose Wolfson, and unknown visitors in front of the flatbed plotter. Photos from the opening, May 11, 1971. Manfred Mohr*—Computer Graphics—Une Esthétique Programmée, *ARC—Musée d'Art Moderne de la Ville de Paris 1971. Courtesy of the artist.*

the height of popularity in the eighteenth century largely due to the lifelike flute player, drummer, and duck built by Jacques de Vaucanson, whose creations amazed both the general public and privileged elite up until the nineteenth century. The mechanical automata emerged with the first clocks in the thirteenth century and confirmed for Descartes and other Enlightenment thinkers that even the most complicated physical processes of animals and men could be explained as intricate clockwork mechanisms. While in the seventeenth, eighteenth, and nineteenth centuries the face of the machine was the mysteriously driven clockwork automaton, in the twentieth century the computer embodied the artificial wonder of mechanical simulation.

However, the will for autogenic creative behavior and strong mind/body dualism that emanated from practices such as Cohen's was not the dominant computer art form in the 1970s. Many artists wanted to shift away from autogenous art making and its hard reductionism and strict intercession toward an interventional approach. Sherry Turkle noted that two styles of computing programming: one was the "hard" mastery based on rational, highly logical, and formalized planning; the second she called "soft" mastery, based on the interaction, intuition, and evolution of a structured system.[96] Cohen exemplified the first, the hard programming of artificial intelligence, which sought to embody creative behavior in a machine. Many artists were developing a more organic method of programming where the artist's creativity worked in collaboration with the computational process.

By continually reworking and stabilizing the program, or developing additional structures in the open-ended processes, many computer artists perceived programming as a process in a state of flux. This impulse was not confined to computer artists. Artists under the tuition of Sonia Landy Sheridan in the "Generative Systems" program at the Art Institute of Chicago were creating generative modes without the use of computers. They were celebrating artist interaction with open and ever-changing systems. For these artists, creation was preceded by successive approximations and directed by the intuition of the artist. Although such artists still thought in terms of modules and systems, they did not preformulate the desired visual characteristics in advance. This approach was a significant shift from that of the 1960s when the desired instructions were punched onto cards and then fed into the computer. Here, the design process took place exclusively in the conceptualization, prior to running a program. This resulted in "blind" input with no real-time abilities for response after request for action. Mechanical plotters were relatively slow compared to the processing speed on the computer. A significant breakthrough came when display media and the cathode-ray tube appeared. Now artists had a display medium that matched the processing speed of the computer.

One such artist to use the more intuitive method of programming was Vera Molnar. The French artist had a long history in the European New Tendency movement, being one of the co-founders of GRAV. In 1968, sometime after the demise of GRAV, Molnar began to employ the computer in her work. Prior to using the computer, Molnar had developed a system of work in which simple abstract geometric pictures were generated by altering the dimensions and propositions of a number of elements; what the artist called "small probing steps."[97] Once computers became available, her programmatic process was easily amendable to mechanization, and, importantly for the artist, the computer overcame the physical and temporal limitations of her often-laborious manual processes.

Starting with preconceived aesthetic principles in mind, Molnar made modifications until an aesthetically appealing design emerged. By comparing successive pictures that have undergone modification, Molar locates the particular trend that produced the most aesthetic result. Because the artist cannot fully predict the outcome, the results are often surprising and unfamiliar. "What is so thrilling to experience," the artist recorded, was "not only the stepwise approach toward the envisioned goal but also sometimes the transformation of an indifferent version into one that I find aesthetically appealing."[98]

By modifying the parameters as the form developed, the artist was able to steer the form toward aesthetic maturity, which was a common metaphor in the work of the 1980s computer artist, especially as artificial life theories became popular. Working with a program entitled RESEAU-TO, Molnar aimed to explore systematically the possibilities of a program that visualized, in an exhaustive way, all images that could be generated within the particular program. While many artists set the parameters or grammar specifying the way the algorithm should vary, Molnar elaborated the rules as the work developed. The linear process of successive steps gave the impression of transforming geometric figures from visual order to disorder. Interested in the transformative aspect of the works, the series revealed the variation and general trend of modification. No form was exhibited in isolation; the relationship within the array carried the aesthetic meaning. This serial technique is apparent in computer drawings from her artist volume *Computer-Picture-Book* (Figure 3.9) in which concentric squares are displaced and visually fractured by changing the mathematical parameters.

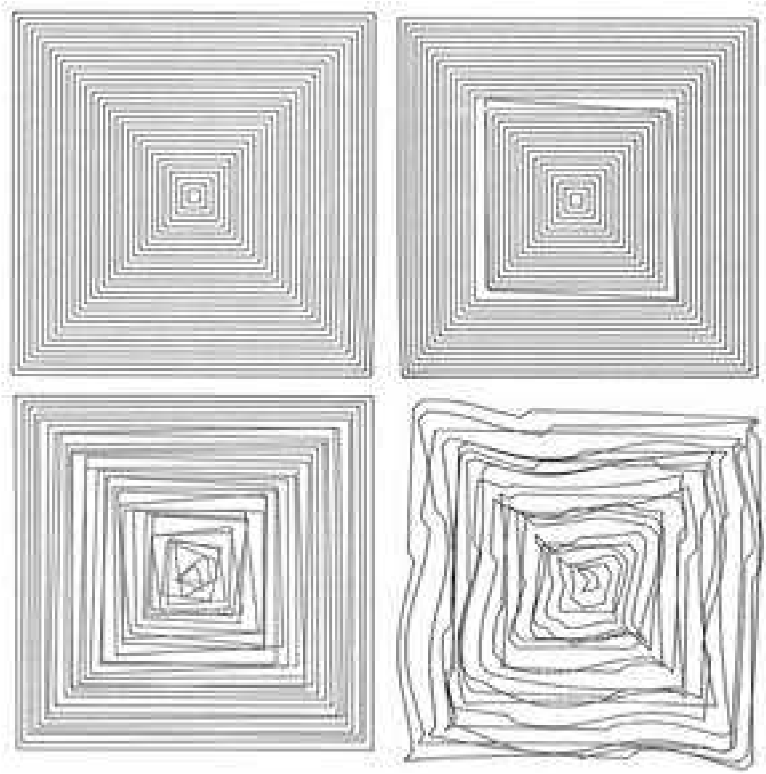

FIGURE 3.9 *Vera Molnar, computer drawings from the artist book* Computer-Picture-Book, *1974. Generated by the artist's program RESEAU-TO. Courtesy of the artist.*

Molnar called her responsive editing process the "conversational method."[99] Sharing Molnar's vision, computer artist Edward Zajec believed that the "far-reaching consequence" of computer art was not in the art objects themselves, but in the process by which they were made. The new aesthetic would "no longer be on form and contemplation, but rather on formation and interaction of man and the machine."[100] This corresponded to Turkle's understanding of "soft mastery" in which the interactive, conversational, and responsive method allowed form to emerge from the programmer's interaction with the medium. It is, as Turkle suggested, "more like a conversation than a monologue."[101]

Molnar brought a diversity and scope to processes, placing a greater emphasis on computer-aided art than on the autogenic character of the computer in previous computer art. Rather than merely setting the machine in motion, she employed the computer in different parts of the artistic process, thus effectively displacing the machine from the central position of creation.

As a self-governing art maker, the computer was envisaged as a "generator" of diverse designs and aesthetic objects. Through the machine's generative capability, the computer could imagine forms that were beyond the artist's mental and productive capacity. For visual researcher Béla Julesz, the computer constituted the work of thousands of people creating limitless variations, and in doing so it spawned ideas that would never have occurred to the individual. Robert Mallary also believed that the synergistic use of the computer worked best in the context of man–machine interactions in which the computer was a tool for augmenting the creative process by making available to the artist a multitude of design options that would not necessarily arise from a traditional process. Likewise, artists began viewing the computer as a device that accelerated and extended the processes of thought—a type of visual thinking. The computer's increasing production capabilities allowed the artist to become an explorer and analyzer rather than a designer and engineer. Hence the aesthetics of navigation emerged as a potent concept in future computer art and became crucial to the understanding of new media, cyberspace, and gaming in the 1980s and 1990s.

The key feature of computer art's exploratory process was the heuristic search. The Greek word *heuriskein* meant to discover. Heuristical method had been an important part of problem solving in computer science, especially in artificial intelligence research that relied on heuristic procedures to provide solutions for systems with vast potentiality. Under heuristic programming procedures, the computer searches through a number of possible solutions at each stage of the program; it evaluates solutions for the stage it is working on, chooses a "good" one, and then proceeds to the next stage. Essentially, heuristic programming is similar to problem-solving techniques such as trial and error, which are methods used in everyday life. Heuristic bias is most helpful when there is an exhaustive sea of possibilities. Although the typical "rule of thumb" used in heuristic programs effectively limits a search within a set of possibilities, it never guarantees the successes of choosing the correct answer. Only a step-by-step systematic or analytic search will achieve the desired result. However, the cost of the processing time makes it untenable.

For the artist who was not looking for a certain empirical result, the method offered the opportunity to guide and control the transformation of form in any direction, which meant a certain semblance of freedom in a determined system. Molnar and others began to use heuristic methodology to navigate the sea of possible forms generated by the computer. While previous art systems had prefigured conditions, Molnar intuitively elaborated rules, effectively evolving the form over time. Molnar's heuristic model was open-ended and did not move toward any particular goal except to produce, as she suggested, good pictures. In many ways this method had been prefigured by Laposky, whose early electronic abstractions were discovered through an open-ended, interactive process in which the artist must choose the most aesthetic from a plethora of similar forms.

The computer's power to generate visual form within a specific logical framework evoked for the artist a sense of the limitlessness. While in the 1960s the visual range was restricted due to computer hardware limitations, with the progress in technology, such as large memory and more powerful processing, the potential to produce an ever-increasing variety of forms became possible. It meant that the computer could in the space of minutes produce exceedingly large amounts of visual form from one simple schema. For Mohr, the computer was an accelerator for "high-speed visual thinking."[102] And as it had for Molnar, intuitive aesthetic judgment became a key technique in Mohr's creative process.

A fellow European contemporary of Molnar, Mohr became one of the most celebrated computer artists of the 1970s. In terms of exhibitions, critical attention, and lasting practice, Mohr is undoubtedly one of the most successful computer artists. Paralleling the semantic distinctions of Cohen, Mohr spoke of the "generative artist" and "generative art" because for him the term "computer art" failed to encapsulate the idiomatic form of the medium's key methodology. Proponents of his work also agreed that such a "frivolous formula" should not be assigned to Mohr.[103] As one of the first artistically trained pioneers of the medium, the German-born Mohr forged a rigorous and astonishingly consistent practice. His aptitude and ability was immediately recognized. In the early 1970s, commentators such as Grace Hertlein praised him as a "superior computer artist."[104] Fueled by a highly intellectual and scientific approach, Mohr's work had the "confidence of an accomplished artist," said Hertlein, which stood in contrast with the "more accidental, less controlled, and less sophisticated work of other computer artists."[105] Mohr's popularity was in part due to the interest he generated across disciplines. The science world found his thoughtfulness, rationality, and consistency engaging, while the art world admired the purity of abstraction and expressive intuition he displayed, electing him a member of the American Abstract Artists in 1997.

Compared with Cohen's autogenic practice, Mohr and Molnar viewed the computer as a tool of enhancement. The computer had no shaping purpose itself but only carried out the processing of forms—more an extension of "artistic potentialities," as the critic Thomas Kurtz wrote.[106] Although the aesthetic result was not essentially different from the other artists, what fascinated Mohr about the machine was its ability to extend the artist intellectually and physically. Mohr believed that human thought could be "amplified by machines" and could thus raise our "consciousness to a higher level of comprehension."[107] Importantly, this extension occurred both intellectually and visually, making the computer a legitimate medium in both scientific and artistic realms. For Mohr, aesthetical research was where the computer could unite both models: the mental and visual experience. Like Cohen and other computer artists, he believed this rational method would enable a fuller understanding of the creative process. "Through detailed programming analysis," Mohr wrote, "one is able to visualize logical and abstract models of human thinking, which leads deep into the understanding of creative processing."[108]

The most sustained and significant influence on Mohr's thinking and practice was the writing of Max Bense. Under the influence of Bense's semiotics, Mohr shifted from action painting toward the rational construction of art through a more consciously systematic and abstract approach. After an intensive study of the semiotician's writings on generative aesthetics, Mohr became an exponent of Max Bense's theory, adopting his term "generative art" to describe his own works. Through Bense's theories, Mohr attempted to understand the semiotic state of the sign in art. His work was concerned with the semiotic relationships between signs and systems. His *P-120-A Meta Language II* (Figure 3.10),

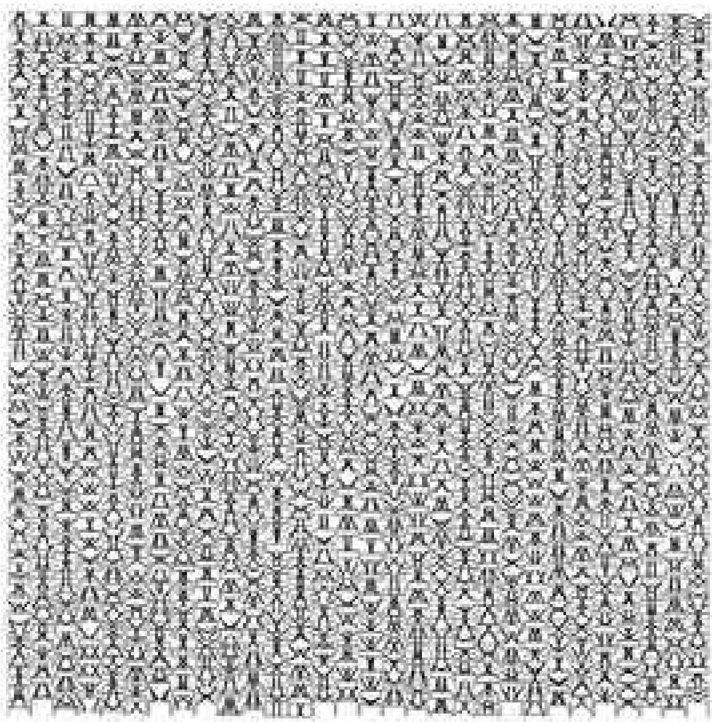

FIGURE 3.10 *Manfred Mohr,* P-120-A Meta Language II, *1972. Plotter drawing on paper, 19.7 × 19.7 in. Courtesy of the artist.*

which is a constellation of hieroglyphic-like marks varying in small increments laid out on a matrix, shows his increasing interest in linguistics. As he explored the syntagmatic relationship between the forms or signs in the visual paradigm, Mohr's images become indexes of the algorithmic system that generated them. Mohr called the signs he generated *tre graphiques* or "graphic entities" as they were often known. Reading his work as a text, the viewer is required to provide a semantic analysis. Algorithms are used to calculate the images, effectively rendering the artist's thinking as visible through computer programs. From 1969, Mohr characterized his approach as "algorithmic thinking," a term that was to be used later in the formation of the Algorists, a movement that Mohr would eventually be associated with.

From 1972, Mohr began employing the structure of the cube as a system and alphabet, and through the years he has always maintained the structural elements and constraints of the cube as his vocabulary. As the mathematical symbol for the representation of the third dimension and a key object in early modernist abstraction, the cube is an appropriate unit for Mohr's algorithmic exploration. In his work phase between 1972 and 1975 (entitled the *Cubic Limit*), Mohr constructed an alphabet of signs from the 12 lines of a cube. Statistical and positioning information were used to generate an array of cubic signs. In other works, combinatorial, logical, and additive operators generated the global and local structures of the images.

For Mohr, the disintegration of symmetry is a basic generator of new constructions and relations. This deconstruction correlates to Molnar's and the Bangerts' movement toward disorder and the increased fascination in chaos and complexity in the 1980s. Toward the late 1970s, Mohr's cubes were divided into two parts by one of the Cartesian planes (Figure 3.11 and Figure 3.12). For each image, the two partitions contained independent rotations of a cube. They were projected into two dimensions and clipped by a square window (the projection of a cube at 0,0,0 degrees). By rotating both parts of these cubes in small but different increments, long sequences of images developed.

The shift toward viewing the computer as a generative medium driven by the algorithmic process mirrored theoretical developments

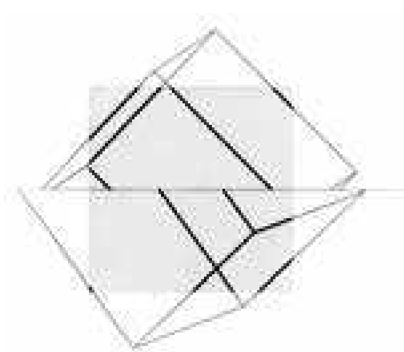

FIGURE 3.11 *Manfred Mohr, P-196-A, 1977. Plotter drawing on paper, 19.7 × 19.7 in. Courtesy of the artist.*

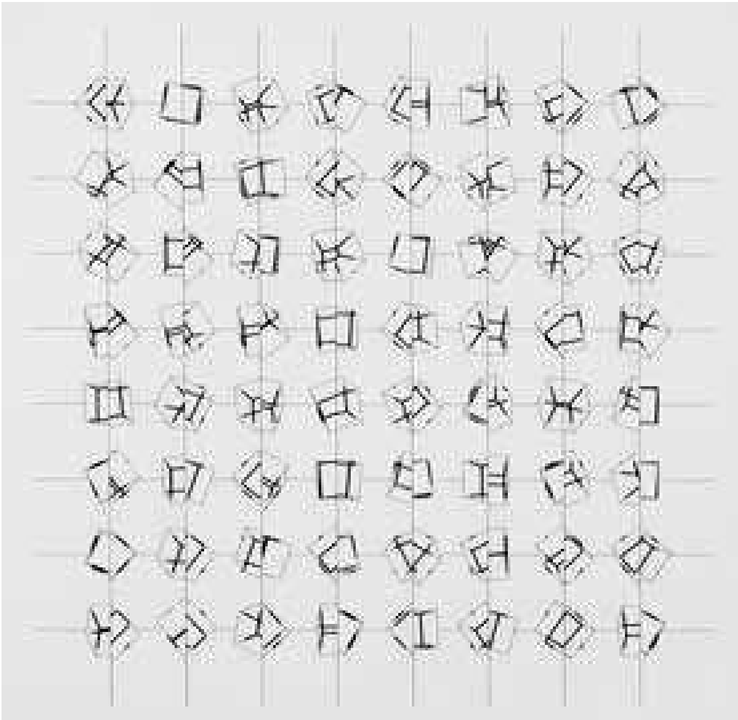

FIGURE 3.12 *Manfred Mohr, P-197-A, 1977. Plotter drawing on paper, 19.7 × 19.7 in. Courtesy of the artist.*

in computer science. At the close of the 1960s, programming was being based on solid theoretical ground. In 1968, Donald E. Knuth published the first of a projected seven-volume series called *The Art of Computer Programming*. Volume One, "Fundamental Algorithms," laid out techniques of programming for which comparatively little theory had been established. Others followed suit, with practitioners looking closely at algorithmic procedures, programming languages, and data structures. By the mid-1970s, artists were advocating a rigorous inspection of the algorithmic process, with Robert Mallary believing that a clear understanding of the algorithm was "an intellectual discipline of the first order."[109]

Following the European abstract aesthetic of the previous decade, researchers further developed aesthetic theory in relation to computational algorithms.[110] The computer scientist James Gips and the aesthetician George Stiny completed a range of investigations that applied “algorithmic methods to art theory and criticism.”[111] This included using algorithmic models for “different aesthetic viewpoints” to “interpret and evaluate works of art.”[112] The scientists were interested in constructing algorithms that generated descriptions, interpretations, and evaluations of works of art. Gips also explored the uses of “shape grammars” to generate a new class of figure, which provided the design elements for a number of abstract paintings.[113] Once a formal system for generating figures was constructed, one could interpret and evaluate paintings along aesthetic lines. By 1975, researchers like Gips had devised a formal system that interactively defined the rules for producing a painting. It used the rules to generate and display the painting and then evaluated the painting relative to the specific aesthetic viewpoint devised.

While much had been achieved in experimental aesthetics, and interest in the movement had widened, criticism concerning computer art only intensified during the 1970s. Outweighing the expressions of positive reassurance and optimism, unfavorable appraisals emerged from many quarters and took many forms. What appeared to be a type of Renaissance—a rebirth of art made possible by the digital revolution—was illusory, more virtual than real. Most criticism was built on the anxieties and skepticism felt in the 1960s. The *Two Cultures* debate continued to frame much of the antagonism between technologists and artists, and the continuing debate over its aesthetic value was fought within this cultural divide.

Computer art had, especially in the European countries, a theoretical foundation in experimental aesthetics and information theory; a series of international exhibitions; a growing legion of artists moving into the field; and a burgeoning industry prepared to provide future support. Yet, with all of these encouraging factors, by the end of the decade it was floundering. As in the previous decade, the mainstream art community remained suspicious of the true intent of the scientist and technologist. For many critics, the scientist was colonizing a once sacrosanct space with an art form that undoubtedly carried militaristic overtones. Even many artists coming into the field in the 1970s feared that the technologist would stigmatize computer art. In 1987, the art historian Cynthia Goodman laid responsibility for the poor critical reception at the feet of the scientist. Even though they did "much to advance computer graphics," their "dubious" aesthetics contributed to the "confusion and criticism of the discipline."[114] Also commenting in the 1980s, Lovejoy believed that the computer in the early stages was "used as an analytic tool for formal Modernist conceptual works rather than as an active partner."[115] "As a result," Lovejoy conceded, "it became stigmatized as a medium for art production and receded into the background."[116] Likewise, in 1999 new media critic Michael Rush felt that "the aesthetic standard" of early computer art was "questionable" because "many of these investigators were first scientists, with non-vocational interests in art."[117]

However, negative assessment was not confined to retrospective accounts. Art critics were highly anxious about scientists transgressing the distinct boundaries of art. While many of the scientists and engineers of EAT only wanted to embed technological sophistication into art, Lillian Schwartz believed that the "scientists often wanted to be considered artists."[118] Also, disputes "arose between the artists and the scientists, and just as some of the scientists declared that they were artists, some of the artists claimed substantial scientific knowledge."[119]

During the 1970s, many artists avowed their claims to computer art. Following the lead of many critics, the artists discounted the impact of scientists and technologists. For a number of artists, including Stuart Smith, the "glamour and mystique" of the medium in the 1960s had dissipated, allowing the serious artist to move beyond curiosity and novelty and assert some of the core artistic capability of the medium.[120] For the artistic community, the scientist fell short of an iconoclast or innovator, which was perhaps an unfair assessment, and so under scientific control, artists believed much of the computer's art-making capability was squandered. Thus, Karen Loewengart, for example, believed that the medium's true beginning rightfully belonged to the 1970s when artists began to play a larger role.[121]

Generally speaking, however, computer art, whether artistic or scientific, was judged deficient. In 1972, critic Robert E. Mueller wrote in *Art in America* (only one of a few articles to appear in mainstream art journals on computer art) that the visual results from computers have been "exceedingly poor and uninspiring."[122] According to Mueller, technologists lacked the necessary knowledge of art and its history, and the visual results, which were mathematically inspired, bored the "sophisticated artistic mind to death."[123] He called the scientists the "Idols of Computer Art," following Francis Bacon's criticism (famously called "Idols of Science") that examined the follies of scientific theorization. Through this paradigm of Idols, Mueller proceeded to criticize every type of computer art that had yet been produced, calling them all "false notions."[124] Mueller, who obtained an engineering degree from MIT before studying aesthetics at NYU, was one of only a few critics with the knowledge to write coherently about computer art processes at the time. Though judging the computer art as lacking, he hoped for a future when the computer would allow direct, real-time manipulation, which did eventuate in the 1980s. Such artistic control he saw in a hybrid of computer and video technology. A year before Mueller's critique, John Canaday, lacking the deep knowledge of Mueller, complained about the overly didactic panels accompanying the works, as they were simply "unintelligible" to the layman.[125] With its technical language and pointless creations, he ridiculed the computer art exhibition that he was reviewing for the *New York Times* as a "circus."[126]

Even exponents (Mueller was perhaps in this category too) believed that the computer art of the 1960s lacked innovation and was, as Mezei asserted, essentially "artless."[127] For others artists, such as Gary William Smith of PAGE, simulating existing styles that were practiced by Noll, Nake, and others failed to explore computer art's new dimensions. For Smith, simulating existing art lacked all innovation because it could easily be completed by conventional tools—a sentiment shared by Canaday. Mallary, another avid artist and commentator, thought that computer art was "yet to make much of an impact," and as it stood in the 1970s, it was "simply not that impressive."[128] Similarly, mathematician and artist Frieder Nake wrote in 1970: "the actual production in artistic computer graphics is repeating itself" and truly "good ideas haven't shown up for quite a while."[129] Even the pioneer computer scientist Edmund C. Berkeley, the individual who years before had popularized the term "computer art," felt that critics and the general public were still adverse to computer art aesthetics because there were no "beautiful, interesting [or] important" computer artworks produced to date.[130]

In the late 1970s, Nicolas Negroponte, the founder of MIT's famed AMG and Media Lab, launched a withering attack on the movement. He believed computer art was a combination of superficial and elemental acts from both the sciences and art which produced an equivalent mediocre product:

> The symmetry and periodicity of the Lissajous figures (easily generated curves on TV screens), transformations into and out of recognizable patterns, and the happenstance of stochastic processing epitomize the current palette of gadgetry used by either the playful computer scientist or the inquiring artist in the name of art. While the intentions may be good, the results are predominantly bad art and petty programming. In almost all cases the signature of the machine is far more apparent than the artist's.[131]

Computer art was continually criticized as "trivial dabbling" or a banal attempt at legitimizing a mathematical art form.[132] It was clear that computer art's appeal to mathematics—the "Queen of the Sciences"—was overpowering for the art tradition. Many felt that computer artists fetishized both the machine and the abstract sciences.

Through the twentieth century, modernist artists and critics found themselves in an ambivalent relationship with the abstract sciences. There have been many artists, such as Max Bill, who gained success from a mathematical approach, while there are others who have been continually condemned for the reductive and rational visions of mathematics.[133] The complex spatial possibilities suggested by a fourth dimension, as well as the curved space of non-Euclidean geometry, were popular among artists in the late nineteenth and early twentieth century. Piet Mondrian described how the eyes of the modern subject or spectator had gradually opened to underlying principles which had up to then been veiled by naturalistic appearance. Likewise, Kazimir Malevich talked of reduction and precision in his writing. However, Malevich had always claimed his paintings were intuitive, while Mondrian always maintained that his work had nothing to do with dogma or mechanical method. Nevertheless, early modernist abstraction for many critics came to represent the vision of technological and mathematical precision. In 1929, the German art historian and critic Carl Einstein attacked what he called the "moralist of pure form preaching for the square, filled with mathematical drunkenness."[134] As art historian Briony Fer suggests, Einstein described mathematically inspired art as a "fantasy—and a puerile fantasy at that—in which mathematics had become like a new kind of fetish object."[135] The critic thought geometric painting just illustrated doctrines which were not only aesthetically unappealing but also authoritarian. These "standardized and hygienic pictures" were, as Einstein wrote, "for us only hypertrophies of order."[136] The late modernist critics took particular pains in dissociating the masters of early abstraction from overt mathematical ties or charges of mechanical thinking. Clement Greenberg spoke of the importance of Mondrian's intuition as a way for the artist to avoid the mechanical. Many pointed to the fact that the constructivists and the members of the de Stijl movement used relatively simple mathematical relations, such as proportions. As mentioned in the previous chapter, LeWitt distanced himself from the mathematical process by claiming that he only required relatively simple mathematical relations.

The rendering and study of mathematical patterns, central to the Islamic tradition, was depreciated or trivialized by the modernist tradition. One only needs to examine the reception of M. C. Escher within the art establishment. Habitually dismissed by artists, Escher's detached perspective which was associated with the "deadeye of science" sent—as one author claims—"shivers through the arts."[137] Yet, the science world has almost universally admired Escher's drawings. Evidently, many from the mainstream art world placed computer art within the same category as Escher's work. For these critics, computer art had an undue reliance on the form and rhetoric of mathematics. In addition, computer artists had an extreme mechanistic view of nature and required continual recourse to mathematical models. Their intimacy with the abstract sciences meant that computer artists were seen to divorce art from psychological, moral, and social life. Whereas the artist creates images freely and intuitively, the computer artists merely explored the limits of an abstract procedure or system. Robert E. Mueller wrote of this secondary, derivative process:

> Though we can say that mathematics is not art, some mathematicians think of themselves as artists of pure form. It seems clear, however, that their elegant and near aesthetic forms fail as art, because they are secondary visual ideas, the product

> of an intellectual set of restraints, rather than the cause of a felt insight realized in and through visual form.[138]

Mueller's criticism conflicted with Canaday. Canaday believed that the real power of the computer was its ability to produce with exactitude a type of pure mathematical beauty from a programmed equation. However, he believed that this object should remain part of the visual sciences. Mueller, though dismissing the secondary nature of mathematically generated art, believed that "Controlled Serendipity," as he described it, had the most potential. Randomizers had a feedback process that allowed the artist to search for interesting results; yet for Mueller it was fully determined and as "equally fallacious" as the other modes of computer art production.[139] For critics, relying on random procedures and the automatism of the machine meant that such artists were disengaged from the humanistic world of meaning and culture. Subsequently, art was reduced to the lowest ethical level by ceding all resemblance of human intuition to a machine.

Computer art was also, as the famed cosmologist John D. Barrow described, "heavily biased toward attracting the attention of our brain's most basic pattern-recognition skills."[140] Computer art became, as Mueller suggested, "like snowflakes and kaleidoscopic or natural forms, quite impressive in themselves as are all manifestations of order to the human mind," but in terms of aesthetic complexity, it did not go beyond basics and thus it lacked resonance.[141] The "Idol of the Kaleidoscope," as Mueller described a certain section of computer artists, lead us to "pleasant design, but not, I think, to art."[142]

By 1970, Nake announced in a highly polemic essay entitled "There Should Be No Computer Art" that he would no longer exhibit his work.[143] According to Jonathan Benthall, in 1971 Nake "denounced the whole concept of works of 'computer art' as a decadent fad."[144] Mezei also left the field citing the direction that computer art was taking was not sufficiently humanistic. The computer specialist Noll, who retired "disillusioned from the field," wrote in one of his many pronouncements that computers in art were "yet to produce anything approaching entirely new aesthetic experiences."[145] Much of the most strident criticism came from computer artists themselves. Cohen, one of the most celebrated artists working with computers, continually attacked the idea of computer art. He thought that computer art was the "most absurd nonsense ever produced in the name of art."[146] Even the editor of *Leonardo* initially expressed doubts over visually based computer art and its ability to generate anything new. As Frank Malina wrote in his opening article on computer art, "I have a critical attitude toward the output of computers instructed by artists."[147] Malina believed that the most "important benefit to be expected from the use of computers by artists will be sociological." The computer could "help to dispel the not uncommon view that computers are monsters rather than highly sophisticated devices."[148] Here, computer art is a mere facilitator for scientific humanism to take the abstract edge off technology. It had no redeeming features in its own right.

The ambivalent regard in which both the art and science communities held computer art was evident in the 1970 ACM national symposium in New York, the exhibition John Canaday reviewed. The original title of the symposium was "Computer Art: Is It a Dismal Failure?" However, after deliberations, the title was changed to the more optimistic "Computer Art: Its Prospects for the Future." There was a similar dilemma in 1974 at a seminar in Israel entitled "The Interaction of Art and Science." From the proceedings emerged two factions: one made up of "fervent believers in the all-pervading influence of computer art" and the second was those who "didn't think that it was art at all."[149] While there was an "impassioned defense" of computer art by both Vladimir Bonačič and A. Michael Noll, the "current state" of computer art was summed up snidely by one of the delegates as "a big load of nothing."[150]

The insecurity surrounding computer art was in part due to the refusal of the art community to validate computer art as art. For proponents of computer art, the computer was a part of an art tradition that saw the artist acquire and explore the latest technology and tools. Franke, defending the stance that machines under the control of humans could create art, argued that it was "patently far too crude a reading of history to assert that, because until now machines have not been used for the creation of plastic art, computer creations cannot qualify as art; yet such a defensive position is still maintained by a number of critics."[151] Although in some quarters there was a gracious, somewhat patronizing support, most resisted attempts to legitimize the form. For example, many within the most esteemed of art institutions, such as the Museum of Modern Art, did not include computer art among their art categories.[152] Some from the humanities argued that computer art failed to contribute anything of value to society or the arts, especially when the political consciousness in art was reaching its apogee.[153] This lack of faith in computer art was not confined to the arts. Many scientists also felt that computer art was inconsequential. Abraham Moles, the scientist who had formulated the influential theory of information aesthetics, made light of computer art as "the kitsch to come."[154] The viewpoint of some from the computer science community, such as Negroponte, was that computer art was "for the most part a Calcomp contest," a novel, yet opportunistic attempt by the printer production company to promote the computer and its imaging capabilities.[155] In many respects, this assertion was correct, as computer companies deliberately used computer art through advertising and competitions to bring a "humanizing aura" to computers and their product.[156] Other critics looked dimly at this overt commercialism too.

By the mid-1970s, critics and practitioners felt the need to defend computer art against persistent criticism. On an aesthetic level, many commentators like Leavitt felt that the criticism of the new medium was unfair since computer art was "still in the highly experimental stages of emergence" and was only progressing relatively slowly "beyond its mathematical and scientific origins."[157] Leavitt felt that the general public and the artist in particular had been "conditioned to react negatively to computers."[158] For Knowlton, the computer was "catching hell from growing multitudes" of humanists who uniformly viewed computers as the "tools of regulation" that suffocated "all things warm, moist, and human."[159] The German artist Manfred Mohr also felt that a "quasi-mystical fear of an incomprehensible technology" was still omnipresent in society.[160] Technophobia and anti-computer sentiment resulted in Mohr keeping his manner of production secret from the art world right up until the 1980s. The only genuine openness shown by Mohr was to the computer science publication *Computers and People*.

This clandestine behavior was not an overreaction. In the early 1970s, Mohr, who was an invited lecturer at the Sorbonne, was faced with violent reactions from students who viewed the computer as a corrupt instrument of capitalist power and control. Mohr quotes: "On one occasion in 1972 in Paris a student accused me of using a devilish capitalistic instrument to make corrupt art … even an egg was thrown at me."[161] The handwritten responses made on a wall panel from Mohr's 1971 first solo exhibition of computer-generated art *Computer Graphics—Une Esthétique Programmée*, which was held at the Musée d'Art Moderne de la Ville de Paris, illustrated the spectrum of responses (Figure 3.13). The wall panel was headed with the question: "Que pensez-vous de la recherché esthetique faite a l'aide d'un ordinateur?" (What do you think of creative research that is assisted by the computer?) One museum-goer responded with "Mohr est des a mort" (Mohr is death), while another wrote: "D'absurd l'ordinateur n'est pas esthetique" (It is absurd, the computer is not aesthetic.)

By the end of the 1970s, many questioned computer art's viability. Even though Franke and Reichardt had added historical resonance to computer art, many still believed it to be facile and trivial—an expired novelty art. In fact, so endemic was the cynicism toward computer art that Reichardt's career was thwarted when she received negative treatment from the art establishment after her involvement with computer art and her curatorial role in

FIGURE 3.13 *Manfred Mohr, Wall Panel (guest book),* Computer Graphics—Une Esthétique Programmée, *ARC—Musée d'Art Moderne de la Ville de Paris 1971. Sprocketed computer paper on a wooden board, 30.5 × 110.6 in. Courtesy of the artist.*

Cybernetic Serendipity. For many mainstream artists, computer artists simply "surrendered to the machine" and produced what was tantamount to mechanical "folk art."[162] On reflection, Mezei wrote that computer art had reached a "plateau of stagnation after an exhilarating start full of promise."[163] The technologist Nicholas Negroponte was more blunt in his 1979 assessment: "Rarely have two disciplines joined forces seemingly to bring out the worst in each other as have computers and art."[164]

Many believed that the union between art and computers had not lived up to initial expectations.[165] As early as 1971, the renowned psychologist John Cohen, writing on the relationship between creativity, technology, and the arts, believed that although mathematics had something to contribute to the arts, its contribution was small.[166] Through the study and implementation of the stylistic and structural attributes of masterpieces, many exponents of Max Bense's formal theories thought it possible to generate masterworks. However, formal aesthetics systems did not fulfill the original ambitions. Although they hoped to mechanize genius, art's secrets remained elusive. As Reichardt rightly pointed out:

> Both Max Bense and Abraham Moles approach such an analysis from the peripheries of the structure of the work, but to this day there isn't a single masterpiece that has been made according to the principles of generative aesthetics. The essential core of a work of art remains still to be fragmented, rationalized and reconstructed.[167]

As a result of these overestimations, the will to uncover art's secrets through empirical methods began to abate by the late 1970s. For most artists and critics, formalist aesthetics was a closed system and exceedingly self-contained. The artist of the 1970s wanted to treat computing like a natural language—rule-governed, yet constantly changing, and by definition open-ended. For the artist, language like art was not an object that could be studied with the law-like precision of science. For them, mathematical rules could not unlock the nature of art. Art had an elusive holistic character that kept it beyond the grasp of science. By the 1980s Franke, in his new edition of *Computer Graphic—Computer Art* (1985), abandoned much of the demystifying rhetoric and truculent anti-spiritual materialism that concluded his first edition.

While interest in computer art continued to grow through the 1970s, its success was negligible compared with video art. Though sharing the same historical context, video art emerged as a potent new form of representation. As major artists entered the field and prompted interest from funding institutions, video was quickly accepted as a legitimate art form. Video quickly became the new avant-garde and attracted a number of high profile festivals. New journals and magazines, such as *Radical Software* and *Art Com*, were established in response to video's phenomenal growth. These publications unified the video movement by giving it a legitimizing history and a strong sense of community. By 1975, group exhibitions, panels, symposia, and magazines were devoted to video art practice. In contrast, computer art remained within the scope of specialist publications and relied on esoteric and highly abstract non-art theories for explanation. Furthermore, the critical discourse surrounding video rose "to greet it," to use critic David Antin's expression,[168] whereas computer art was serviced mostly by the artists rather than critics and theorists. Most importantly, however, the museums, institutions, and funding agencies, which were skeptical at first, embraced video art and gave it stability. Apart from being accepted curatorially, video was supported critically. By the mid-1970s there were a number of large survey exhibitions devoted to video art, including *Video Art* organized by Suzanne Delehanty for the Institute of Contemporary Art in Philadelphia.[169]

Although they both emerged under the influence of the Art and Technology movement, one must acknowledge that video art's origins were different from those of computer art. Video emerged from the television industry rather than the military industry. Importantly, video emerged as a political and aesthetic opposition to commercial television genres. Considered as a tool of social change, video also held the remaining desires of the counterculture. Because of its political dimension, video did not attract the same anti-technology sentiment as the computer. The computer, on the other hand, was never conceptualized in terms of resistance or protest; rather, it was distinctly a result of Cold War paradigms. In addition, the computer was a significantly different media. Video was portable, was relatively cost-effective (especially in relation to computing), was interactive, had immediate feedback, and permitted public broadcast transmission, something that attracted Mueller to the idea of incorporating computing to video. With its documenting abilities, it was a highly flexible medium. With relative ease, video could be incorporated into the fabric of performance and installation practice with all the potential of narrative and autobiographical exploration. This created work of great diversity, which contrasted with the often formulaic work produced with computers.

However, there were many similarities between the two technical art forms. Both blossomed in the late 1960s and were proclaimed as the most advanced and revolutionary media of their day. Like video, which had been praised for being the new democratic art form, computer art was also framed in similar terms. While both were conceptualized through cybernetics and information theory, with video having less direct relevance, video was understood through the new media ideals of McLuhan. Through its instantaneous communicability, video was celebrated in terms of its global consciousness. Like video art, but without the same success, computer art was attempting to define its inherent characteristics as a way to legitimize itself. Whereas computer art received minor support, *New York Times* critic Grace Glueck felt that video in the 1970s was "a developing medium in its own right."[170] Following critics such as Gene Youngblood, artists "separated the video medium from the history of film and of film language and theory" in an attempt to "distinguish it from other art forms."[171] Like many exponents of computer art, they stressed the medium's uniqueness as a reason for an exclusive new category. In contrast to computer art, by the close of the decade video became an autonomous art category.

Those working within the computer art project continually desired the validation of the computer as a legitimate medium. To the frustration of many, computer art in the 1970s did not gain this confirmation. While computer art emerged into a climate where the idioms of art were diversifying more than any other time in history—a period when traditional criteria were being discarded—computer art for many was a bridge too far. This is perhaps why the decade was shrouded in an aura of disappointment. In recent histories of computer art, the 1970s has been portrayed as the Dark Ages, a period of decline after a promising start. However, while computer art did not emerge with the same pervasive impact as video, there were a number of important advances made in the decade. Firstly, the central trope of the Renaissance figure materialized in the form of the artist-programmer, which became a key idea in the following decade. The Renaissance figure of the artist-programmer merged with the metaphor of the "frontier explorer" and the early artists became the pioneers of this quest. In the 1980s, with the personal computer and the idea of the "virtual" emerging, this mythology was strengthened. Secondly, images shifted from the unmistakable impress of the machine, such as precision and exactitude, toward the delicate imprint of the human artificer and the beguiling complexities of natural and organic form. And finally, artists began to build their own artistic and aesthetic systems, using the computer as an aid in the production of multigenerational forms, an enduring and important idea that was lost on most critics. In the place of a single definitive form, the artist generated multiple forms and permutations. Subsequently, the metaphor of growth began to surface with increasing intensity in the 1980s. In the next decade, the morphological point of view, under the influence of the new science of complexity, became increasingly important as artists explored form as it mutates and transforms within the art-making system. The open-ended nature of computer art, its perpetual incompleteness and continual growth, provided a precedent for the Web as a medium in the 1990s. Before then, however, popular technoscience paradigms, such as the science of complexity, emboldened artists to explore the unfathomable in ordered and chaotic systems. This resulted in an increased mystification of the computer. The spiritual quest where the power of transcendental Platonic realities—such an important part of 1960s computer art—emerged again as a vital idea in computer art. While mathematics remained a key part of the computer art consciousness, in the 1980s the introduction of the personal computer and commercial software allowed new artists to use the computer without any formal understanding of mathematics or the machine's vast complexities. The virtuoso artist-programmer, now with a stable mythology, came under threat from the influx of artist "users" who employed the computer with the flair of a traditional art tool. So began the rhetorical debate over the correct and most meaningful use of the computer in art.

CHAPTER FOUR

Frontier exploration

Roman Verostko in his seminal 1988 article "Epigenetic Painting" wrote enthusiastically that working with the computer was a world of endless discovery, for "each frontier opens a new frontier."[1] That same year, fellow artist David Em wrote that the computer was a "wonderful and mysterious gift."[2] For Lillian Schwartz, the computer was "never lifeless," for it hummed as if it were "cogitating some primordial secret" that it would reveal if suitably nurtured.[3] Even though it had been the practice from the beginning to privilege the rational within computer art, the mythological element has always lingered near the surface. As shown in previous chapters, the computer's metaphorical link to the mind and its descent from the mysterious Enlightenment automaton meant that computers were continually anthropomorphized. In addition, the computer possessed a mythic link to mathematics through the arcane allure of Pythagorean *harmonia*. Importantly, in the 1980s these narratives combined with Platonic transcendentalism to provide a new mythology that characterized the computer as a portal into unknown, unseen, and unexplored worlds of digital abstraction. For many, the computer was an "infinite machine,"[4] which gave access to a vast metaphysical frontier that was akin to what Versotko described as an "unfolding universe of visual form."[5] Even before the conceptualization of "cyberspace" (the cybernetics metaphor of the "steersman," derived from the Greek term "kybernêtikê," meaning the pilot), the voyager or explorer was a central metaphor for computer artists. The pioneering explorer, intrinsically linked to the idea of the frontier, is traditionally a figure who explores the limits of the known world.

The frontier, which is a central trope within American history and avant-garde ideology, emerges as a crucial mythology in computer art discourse. Those writing in the 1980s look back to the originators of computer art as the founders, the pioneers of a new art form. The early computer artists are celebrated as heroic historical figures who struggled, opened new territories, and pushed the boundaries of knowledge in the unforgiving environment of early computing. The computer artist of the 1980s built on the pioneer/explorer metaphor by incorporating the dream of space exploration, the most potent frontier mythology at the time in American culture. Like the astronaut, the computer artist set forth to explore worlds that were essentially already out there, in the logical realm of potentiality. Emboldened by the new technoscience paradigm of order and complexity, the computer became a micro-universe, an unimaginable new world ready for tireless exploration.

Ever since the 1950s when the computer first entered the cultural psyche, it had evoked a special kind of wonderment. The tendency to both anthropomorphize and mythologize the machine was part of the general public's, and indeed the artists', inability to comprehend the logical complexities of the machine. The artist was often left dumbfounded as the movement from the symbolic and programmatic to the visual created totally unanticipated and novel results. For the computer artists, the appeal of the computer also lay in its ability to configure new visual worlds through Cartesian spatial logic, which expanded at incredible speed due to new computer graphic capabilities. Nevertheless, the creationist mythology was always present in computer art. From the beginning, computer artists were captivated by the power of origination; as technologist Frank Dietrich reminisced, it was like being an "omnipotent creator," creating a "new universe" with "its own physical laws."[6] Charles Csuri, another important pioneer, believed that the power to change the parameters of the logical and spatial realm of the computer gave him the ability to create his "own personal science fiction."[7] Constructing entirely new geometric bodies and architectonic structures which had no physical existence propelled the artist, as Franke described, "toward new domains."[8]

Part of this fascination with new spatial worlds was predicated on the rapid accomplishments in computer graphics. In the 1970s, there was a shift from vector graphics orientation, with its linear configuration, toward the continuous tonal imagery of raster graphics. These new techniques allowed for far greater realism. Three-dimensional modeling and rendering systems spawned a new genre of futuristic inspired computer imagery based on the popular scientific themes of the day, which were primarily space travel and exploration. The rudimentary linear forms of the 1960s and 1970s, which mirrored modernist hard-edge abstraction, gave way to totally new images that were both complex and highly vibrant. These synthetic images, mystical and imaginative as they were, became emblematic of the new computer age. This type of computer-generated image graced the myriad of computer graphic publications of the day. Overall, the images were futuristic—from galactic images of space to the newest product design—and typified the future like no other form of representation.

David Em's highly synthetic artwork best epitomizes the new futurist-space thematic that emerged within the computer art movement. In 1975, Em was fortunate to gain access to the Jet Propulsion Laboratory (JPL), which had some of the most sophisticated and powerful computers in the world (Figure 4.1). No

FIGURE 4.1 *David Em at the California Institute of Technology's Jet Propulsion Laboratory, 1983. Photograph by James Seligman. © David Em. Courtesy of the artist.*

previous artist had gained access to supercomputers. Em had at his disposal new software interfaces, paint programs, and the electronic stylus, which had been developed by the famous computer graphics pioneer James F. Blinn. Blinn developed, for scientific purposes, new techniques for representing surfaces within computer-simulated models. The new techniques of texture mapping and curved light surfaces created synthetic three-dimensional realities. JPL had been closely involved with the growth of American space exploration through its critical astrophysics and rocketry research. It soon became apparent that NASA would require enhanced graphics capabilities to process video imagery received from deep space probes and also to develop graphic simulation models to help build an engaging visual narrative of space exploration. In 1979, Blinn created a sensation with his computer graphic simulations of the historic Voyager probe. The computer-generated animation showed the craft moving past Saturn and far into the solar system. The graphic simulations ignited the public's imagination more so than the Voyager's actual visual transmissions from space. Like Blinn's simulations, Em's art was often seen as promotion for the latest graphic techniques, which increasingly sought ultra photo-realistic modes. Influenced by JPL projects to visualize space phenomena unseen by human eyes, Em generated fantastic 3-D spacescapes. *Persepol* is a prime example where Em, employing the latest graphic rendering software on the most powerful computers, combined ancient iconography with the symmetry and recursive patterning of previous computer art to create unearthly landscapes (Figure 4.2).

The impact of space exploration and notions of exploring the outer limits of the known universe is also embodied in the work of the nuclear physicist Melvin Prueitt.[9] Prueitt produced the popular publication *Art and the Computer* (1984), which, as the author outlined, demonstrated the "fine works of art being produced by artists using computers."[10] The book follows many of the computer graphic publications of the period, which outline the different techniques and their application in science, business, and entertainment. Although Prueitt's publication was concerned mostly with art, scientists and technologists produced much of the work, and the publication had a tendency to view the imagery through scientific paradigms and metaphors. For Prueitt, the arrival of the computer allowed him to materialize his inner visions, to transfer his imagining from the mind to the screen without relying

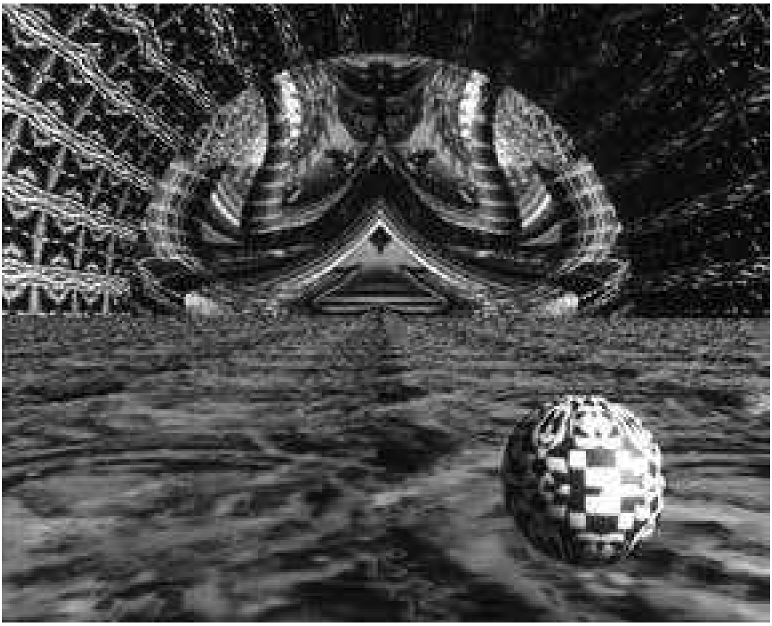

FIGURE 4.2 *David Em,* Persepol, *1980. © 1981 David Em. Courtesy of the artist.*

on any artistic training or innate ability. Effectively the computer allowed him—a scientist—or anyone else to become an artist. With the advent of the computer, as Franke suggested as early as 1971, manual skill was "no longer a precondition for engaging in art."[11] Like Em, Prueitt used the latest modeling and texturing techniques from the graphics field to realize strange imaginative and surreal landscapes. Simulating the natural phenomena of accretion in cave systems by using exponential functions to create the stalagmite form, Prueitt produced the novel computer artwork *Bright Caven* (Figure 4.3). Both Prueitt and Em responded to the technoscience fantasies of the period. The computer was evoked as an instrument that assists the artist in imagining mystery worlds and future scenarios. Though the images were interesting in their novelty, the critics found them to be trite by-products of the commercialization and cultural expansion of the computer graphics industry.

Yet computer art, though criticized for its recourse to the latest science-inspired visions, had its own dynamic, a strengthening

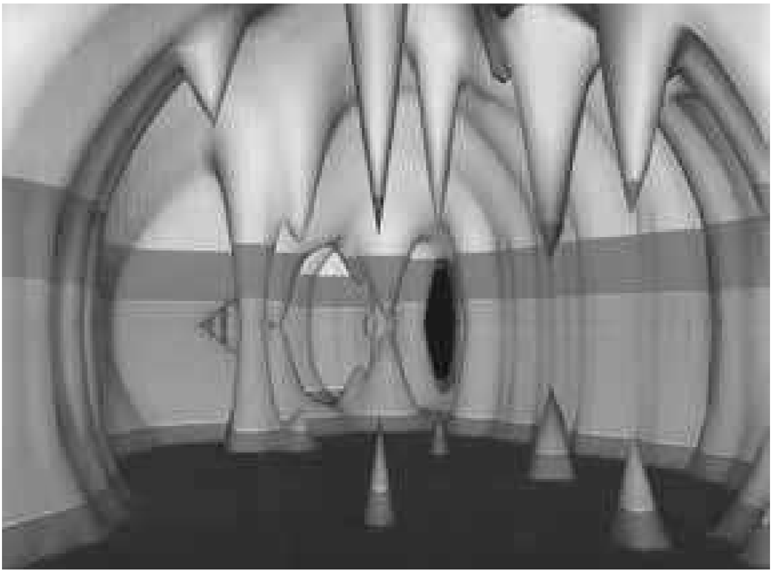

FIGURE 4.3 *Melvin Prueitt,* Bright Caven, *1982. © 1982 Melvin L. Prueitt.*

discourse in chaos and complexity theory. Although the subject of order and disorder had been central to 1970s computer artists such as Noll, Nake, and Molnar, the science of complexity as a cultural phenomenon did not emerge until midway through the 1970s. Not until the 1980s did it become a significant metaphor in the visual arts. As the decade developed, the field of complexity emerged as a highly mythologized scientific discourse. The scientist appeared as a heroic explorer probing the mysteries of the age. The popularity was due in part to two significant texts: Ilya Prigogine's and Isabelle Stengers' *Order Out of Chaos: Man's New Dialogue with Nature* (1984) and James Gleick's *Chaos: Making of a New Science* (1987). These texts portrayed the new paradigm as revolutionary and a threat to traditional orders and ways of thinking. In his history of chaos theory, Gleick lionizes the scientists as "genius" figures penetrating the deep dark secrets of the unknown through the butterfly effect, strange attractors, and Mandelbrot sets.

Emerging from the field of mathematics, the science of complexity was popularized under the title of chaos theory. Like cybernetics, chaos theory was applied to a variety of fields and modes of investigation. Its popularity was in part due to its wide application. Common experience and everyday human scale phenomena became valid fields for inquiry. Any complex natural system was emendable: the unstable atmosphere, turbulent seas, fluctuating populations, and irregular physiological phenomena. Likewise, cultural structures, such as the variability in the world stock markets and traffic flows, received new emphasis. As Gleick noted, chaos was applied to the "universe we see and touch," which was in contrast to "glittering abstractions" of theoretical physics, which had "strayed far from the human intuition about the world."[12] Culturally, chaos theory promised to explain some of life's uncertainties—those complexities and periods of chaos that seemed part of modern life.

After continual reinterpretation through the ages, in which the term "chaos" has acquired multiple meanings and varied signification, it underwent radical revaluation in the twentieth century. Historically, theories of chaos played central roles in most creation myths: the most common being that a divine power imposed form or order on primordial chaos. Since the scientific revolution, chaos had been envisioned as the antagonist to order, a perception that dominated the early nineteenth century. The irregular, disconnected, and erratic dimension of nature had come to be viewed by science as murky and unfathomable. This binary opposition between order and disorder was reinforced by the popularization of thermodynamics in the late nineteenth century, which foretold the cosmic dissipation of all heat sources and the ensuing so-called "heat death" of the universe. However, in the nineteenth century, the scientist Henri Poincaré began recognizing the potential of disorder within dynamic natural systems. He effectively became the originator of the modern science of chaos and complexity. The first half of the twentieth century was characterized by totalizing theories that established unequivocal relations between theory and observation in physics and mathematics. Following the two world wars, however, there was a questioning of this rising cult surrounding order. Universalizing theories became "associated with the mindless replication of military logic or with the oppressive control of a totalitarian state (or state of mind)."[13] When various disciplines started to engage in the exploration of disorder in the second half of the century, chaos came to be seen as an emancipating force. Exploring the difficulties of nonlinear systems, the scientist of complexity began where classical science ceased. While relativity and quantum theory had disposed some of Newton's tenets, chaos eliminated the certainties of deterministic predictability. Soon chaos theory, positioned alongside relativity and quantum mechanics, was viewed as the great twentieth-century revolution in thought.

The science of complexity also had far-reaching consequences for philosophy. The cultural interest in scientific theories of complexity had been on the rise since the 1960s. Literary critic N. Katherine Hayles identified the "crucial turn" when chaos was envisaged not as an absence of order but as a positive force.[14] The concept of atomism, the rigid framework for a schematized reality, was replaced by a structure with morphologic process at its core. This precipitated a variable collapse of established worldview, whereby randomness or chance was now fundamental to knowledge production. In the 1970s, the countercultural figures in the computer world became interested in chaos and complexity as a new world order.[15] For these figures, complexity theory represented a particular holistic, even mystical, approach to ecology. At the same time, chaos entered the cultural matrix and was manifested in theories of post-structuralism and then postmodernism. The discourse of chaos was employed to explain a raft of different cultural and theoretical phenomena. Under the influence of Jean-François Lyotard, who would become an influential theorist of postmodernism, the field of chaos theory was an affirmative premise. According to cultural theorist Stuart Sim, Lyotard was attracted to this new scientific practice because there was a "perpetual search for instabilities" and "paradox" rather than being concerned, as modern science had been, with "logical proof."[16] In the early 1980s, Lyotard forecasted the emergence of postmodern science in his influential publication *The Postmodern Condition*:

> Postmodern science—by concerning itself with such things as undecidables, the limits of precise control, conflicts characterized by incomplete information, "*fracta*," catastrophes, and pragmatic paradoxes—is theorizing its own evolution as discontinuous, catastrophic, nonrectifiable, and paradoxical…It is producing not the known, but the unknown.[17]

The image that most embodied visual complexity and nature's imprint was fractal geometry: it became the icon of chaos. Lyotard cited

Benoît Mandelbrot's fractal geometry as evidence of our incapability of reaching exact measurement. The word "fractal," coined in 1975 by IBM scientist Benoît Mandelbrot, described a set of curves which possessed complexity through increased dimensionality (Figure 4.4). Mandelbrot fractals were, as the mathematician asserted, "meant to be mathematical diagrams drawn to make a scholarly point."[18] Importantly, fractals showed that many phenomena are intrinsically indeterministic. The Mandelbrot Set, identified as the most complex object in mathematics, transformed the application of geometric constructs within science and drastically changed the image of mathematics. By the mid-1980s, the phenomenon of "chaos culture," as it was often termed, had taken hold with a dramatic increase in the number of publications dealing with both chaos and fractals. Unlike cybernetics, which had a limited impact on the mainstream art world, chaos theory and fractal geometry permeated some parts of the fine art world. Such was the cultural ubiquitousness of chaos theory that theorists and artists began to describe contemporary art in terms of this new paradigm. Even artists from traditional genres

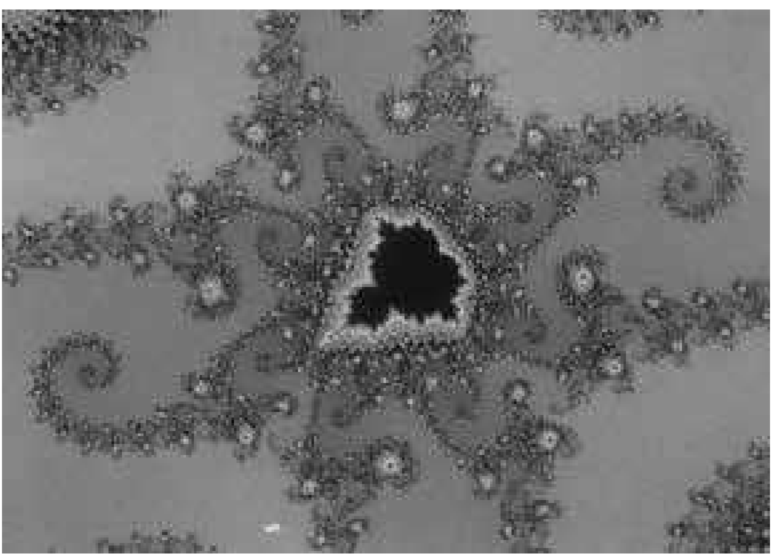

FIGURE 4.4 *Heinz-Otto Peitgen and P.H. Richter,* Map 48, *ca. 1986. Mandelbrot set from* The Beauty of Fractals, *1986. Courtesy of Heinz-Otto Peitgen.*

began exploring the key ideas flowing from chaos discourse. Heroic figures of this new geometry, Mandelbrot and Feigenbaum, were represented in the postmodern painting of Mark Tensey. The new multidimensional imagery seeped into the contemporary painting of Roberto Azank, who completed large fractal murals. Sculptor Rhonda Roland Shearer also worked with the concepts of chaos and fractal geometry. For Shearer, "new geometric views in the world," such as influential non-Euclidian geometries within early twentieth-century practice, became a "key catalyst for artistic developments."[19] "Within this context," the artist and journalist Shearer wrote in 1992, "the new geometric models of fractal geometry and chaos theory may signal another major innovation in art."[20] This new interest in technoscience paradigms also coincided with the 1986 Biennale of Venice, which was entitled *Art and Science*. The exhibition's purpose, like previous conciliatory exhibitions, was "to try to bring together modern art and science after the division that had taken place between the humanistic and scientific cultures."[21]

Although chaos and fractal geometry had garnered wider cultural and artistic significance, the real impact was in experimental mathematics and the generation of natural patterns in computer graphics. Computer art was intimately connected to these ventures. The rise of computer graphics as an integral part of scientific practice coincided historically with the emergence of chaos theory as a cultural force. In the West, the study of complex dynamics did not come into its own until computers became widespread and readily accessible. It was realized in the 1970s that simple sets of mathematical instructions carried out by a computer generate extremely complicated and strangely ordered effects. It meant that complex systems follow predictable paths to randomness, and through the computer one could perceive orders hidden within chaotic systems. Because studying the subtle structures underlying chaos and order was a visual process, visual images became crucial to understanding complexity. Thus, with the advent of the computer, experimental mathematics became increasingly visual. Progressively within the scientific world, the computer was employed to produce representations of data. This allowed the scientist to examine the data from a number of perspectives. The test tubes and microscopes of laboratories were often replaced with computers and their graphic applications. A caption in a popular scientific magazine captured the belief of the time: "Mathematicians couldn't solve it until they could see it!"[22] Within the sciences, many believed that the rise to prominence of fractal geometry assisted the reunion of pure mathematics research with both natural sciences and computing. For those interested in computer art, such as artist Judson Rosebush, fractals were seen as procedural breakthroughs because they "introduce an entirely new class of parameters and an entirely new class of images."[23] Fractal geometry depended upon computers as nothing else previously had done. For many, this was something truly unique, a world inconceivable prior to the invention of the computer. For some, the ho-hum novelty of computer art had now turned to incontrovertible originality.

Fractal sets, however, were not the first to capture the attention of mathematicians interested in complexity. In the 1950s, through the development of cellular automation, John von Neumann recognized the computer's ability to generate visual complexity. In his rule-based scheme, a single change in the automaton's condition prompted a cascade of changes throughout the system. In the early 1970s, a more renowned cellular automaton was developed by the British mathematician John Conway. Called "Life," this program with its simple determined rules generated an infinite variety of patterns. Importantly, it became apparent that when simple rules are applied recursively, the computer produces complex patterns which, curiously, reflected patterns in the universe. Computer art was directly affected by these discoveries and with the development of fractal geometry. The conflation of nature and computer systems continued to be pursued.

In the 1980s, fractal geometry demonstrated the computer's ability to recreate nature's hidden forms. Fractal geometry provided both a description and a mathematical model for many of the patterns and multifarious forms in nature. It was for Mandelbrot a "profound irony" that fractal geometry, which was described as "baroque" and "organic," should "owe its birth to an unexpected but profound new match between the two symbols of the inhuman, the dry, and the technical: namely, between mathematics and the computer."[24] For computer graphics, fractal geometry now played a crucial role in the rendering, modeling, and animating of natural phenomena. By the 1980s, fractals were a key paradigm in computer graphics, playing a crucial role both in its development and increasing popularity. The new science of complexity would spawn a raft of fractal-related art forms, such as chaos art, fractal art, and map art. Reaching a zenith in the mid-1980s, these new visual forms received extensive exposure through international exhibitions and media attention, only to fade as quickly as they surfaced.

By 1989, Mandelbrot confidently announced that in fact fractal geometry had "given rise to a new form of art."[25] This statement was a result of fractal geometry's cultural popularity. For Mandelbrot, the success of fractals was assured because "nobody" was "indifferent to fractals" and because the viewer's "first encounter" with fractal geometry provided a "totally new" aesthetic experience along with a changed perception of science.[26] Like the computer art of the 1960s and 1970s, fractals relied on the Pythagorean conception of beauty—the appeal to recursive symmetry and pattern—which, for Canaday and others, was the basest of all aesthetic responses. Also, like computer art's perceived role in the 1960s, scientists involved in fractal geometry and chaos theory felt that the new paradigm provided a unifying concept that bridged the boundaries between science and art. Hence, in the 1980s, the computer again became a symbol of the unification of the cultural fields. In addition, fractal imagery, with its somewhat tenuous connection to visual art, had the role of effectively popularizing mathematics. In the mid-1980s, Franke employed random number generators, iterative techniques, and fractals to produce a number of visually innovative color computer artworks (Figure 4.5). The fractals' popularity provoked a burgeoning of mathematically related art from the mid-1980s well into the 1990s. Like the visual by-products of computer-based scientific and mathematics research in the 1960s, fractal geometry was often exhibited under the rubric of computer art. Like computer art, fractal art emerged autonomously from the science world and had no direct reliance on the mainstream art world. Moreover, mirroring the beginnings of computer art, mathematicians and technologists were the first to popularize fractal imagery.[27] Consequently, the hegemony of technoscience and mathematics remained central to computer art and its discourse, leaving it remote to mainstream art's central concerns.

Fractal geometry shared much of computer art's original mythological appeal. The mathematicians and scientists of fractal geometry were engrossed by the same unpredictability as the computer artists: consequence cannot be predicted, because as mathematician Heinz-Otto Peitgen and P. H. Richter explained, each "decision has the character of an amplification."[28] For scientist and author Clifford Pickover, creating fractals was like fishing for

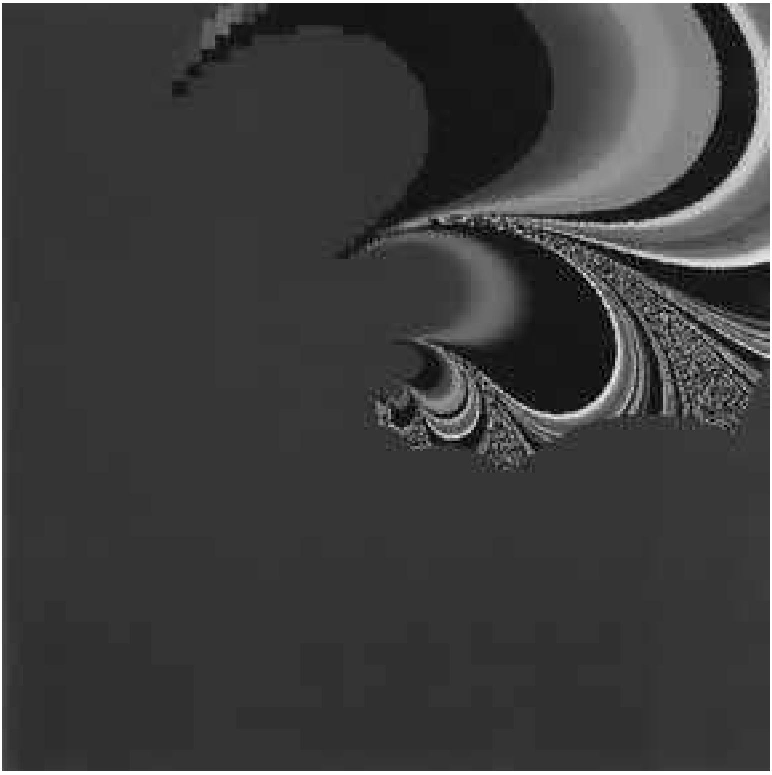

FIGURE 4.5 *Herbert W. Franke and Horst Helbig,* Konforme Abbildung, *1986. Courtesy of Herbert W. Franke.*

"unexpected pleasures," a sentiment that was first expressed by early computer artists.[29] Increasingly, the nature of computers was seen in terms of territory, a visual sphere that invites discovery of a hidden world.

The new fractional dimension, the infinite self-embedding of complexity in the computer, gave the machine the feeling of boundlessness. The computer appeared to expand the range of human senses, becoming like the microscope or telescope, making visible for the first time what appeared to be a limitless realm. Exploring the infinitely magnifying borders of the Mandelbrot Set was likened to plunging the viewer into, as science journalist John Horgan described, a "bottomless phantasmagoria of baroque imagery."[30]

Like previous computer art, Neo-Platonic language was employed to describe the creation of fractals. Computer artist F. Kenton Musgrave, later to become a founding member of the Algorists, communicated the new-Platonic sensation and how fractals can be associated to Duchamp and his impact on contemporary art:

> [T]hey have an ineffable sense of having existed *a priori*; of somehow being inherent in the timeless, universal formal procedures that specify them and of always having existed there as an aspect of Nature, or at least Mathematics, just waiting to be discovered. As an artist, I simply interpret these forms visually. Thus they may represent, at least in part, "found art."[31]

The biggest impact fractal geometry had on computer graphics was the representation of nature. Musgrave, a programmer for Mandelbrot at Yale, was the first to include fractal geometry persistently in his art. Mandelbrot credited Musgrave with being the "first true fractal-based artist."[32] Placing fractal imagery within a historical schema, Mandelbrot referred to three eras of fractal landscapes: the Heroic Era, the Classical Era, and the Romantic Era. The last era was characterized by Musgrave, whose "aesthetics and artistic self-expression come to the forefront in fractal landscapes."[33] Rather than to produce abstract geometric fractals which had dominated since the early 1980s, the artist used fractal geometry and stochastic generalizations to generate coastlines, oceans, and mountains. Much of the previous fractal imagery was generated by deterministic processes; however, when stochastic procedures were formulated, the imagery had a far more naturalistic impact. As a result, random fractal procedures were used to model landscapes and other natural phenomena in computer graphics. Calling on fractal geometry to render the surface appearance of nature, Musgrave's landscape *Blessed State* exhibits all the trends of fantasy and otherworldly landscapes of the era (Figure 4.6).

For the computer artist, the discourse of complexity was attractive because it was another step in breaking the overt determinism of the machine. Culturally, chaos gave the machine a sense of mystery, overcoming the previous austere and rigid mechanistic perception of the computer. As had happened for the pioneers of computer art, the unpredictability of random procedures and the ability to generate sophisticated patterns from a simple

FIGURE 4.6 *F. Kenton Musgrave,* Blessed State, *1988. Courtesy of the artist.*

deterministic system became a central attraction. In the beginning, computer art emphasized stability, order, and uniformity. This was characterized by classical geometry with its lines and planes, circles and spheres, and triangles and cones which inspired a powerful sense of Platonic harmony. However, in the 1980s a metaphorical shift took place. Once the computer could model highly complex forms, the pictorial equilibrium of exact symmetries was broken. The new geometry mirrored the complex universe in its irregularities, unevenness, and distortion. Under the influence of the science of complexity, which started in the 1970s, computer art moved toward disorder, instability, diversity, and nonlinear relationships. Rigid aesthetics began to give way to organic and natural forms.

One of the most significant and celebrated computer artists Roman Verostko viewed his practice as a "dance between order and chaos."[34] Not since Lloyd Sumner had an artist brought such a strong spiritual and mystical dimension to his work.[35] Like most of the pioneers, Verostko was deeply influenced by mathematics and publications such as Douglas Hofstadter's influential book *Gödel, Escher, Bach: An Eternal Golden Braid* (1979), which explored the new trends in the abstract sciences. Even prior to his engagement with the computational medium, Verostko investigated the "visual dialectic" between what he called "control and uncontrol."[36] In fact, Verostko's exploration of order and chaos preceded much of the literature on the new theories. The artist's early paintings presented visual opposites in a "kind of dialectic between order and chaos."[37] Painting wooden panels with both ordered, formal shapes and spontaneous, gestural marks, Versotko attempted to represent the rational and irrational (or nonrational) within the same field, as in his pre-computer work *New City 2* (Figure 4.7). Remarkably, other

FIGURE. 4.7 *Roman Verostko,* New City 2, *ca. 1966. Acrylic with crayon and gesso on wood. Courtesy of the artist.*

artists yet to make the transition to computers were also exploring the relationship between determinism and free will, formal shapes, and gestural marks. When one places Verostko's and Mohr's pre-computer paintings side-by-side, they exhibit striking similarities. In his painting *Bild 1712/65*, Mohr distributed over his pictorial surface a combination of gestural and abstract mobile signs to create abstract visual tension, a method resembling that of Verostko's (Figure 4.8). In their investigation of order and disorder, both artists would make the transition from painting to the digital medium.

Verostko also shared Mohr's attachment to the constructivist tradition. More than any other computer artist, Verostko was acutely aware of the tradition in which his nonrepresentational art was situated. Verostko, who taught art history and who had been at one time an encyclopedist, often included the writings of modern abstract artists such as Piet Mondrian and Wassily Kandinsky while discussing his own work. The move toward nonobjective and

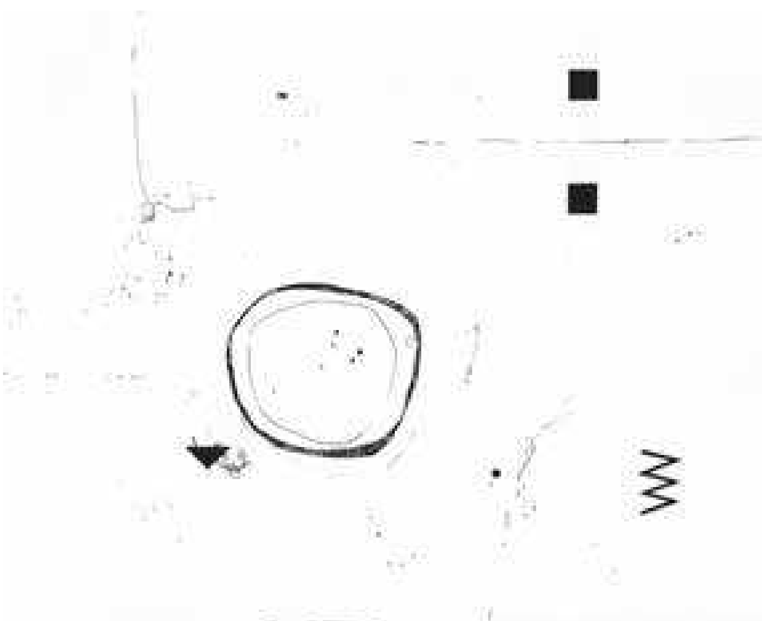

FIGURE 4.8 *Manfred Mohr,* Bild 1712/65, *1965. Acrylic painting, 40.2 × 49.2 in. Courtesy of the artist.*

nonrepresentational art was for Verostko the most important legacy of twentieth-century art. Verostko viewed himself within the purest tradition of abstraction, which looked to construct art with an internal structure independent of any reference to objective reality. In this sense, Verostko was very much an orthodox modernist abstractionist. He also evoked the spiritual and mystical of much early modernism. For Verostko, art, like music, could be untethered from the "bonds of the material object," which might provide a path to the spiritual.[38] Kandinsky and Mondrian influenced Verostko's thinking in this regard. It was Mondrian's efforts to "create a visual dynamic equilibrium that could be viewed as a sign of an ultimate resolution of tensions between the vertical (the spiritual world) and the horizontal (earth, material world)" that produced the early dialectical paintings.[39] Verostko was intending in his pictorial composition to balance the oppositional forces of chaos and order to create, as Mondrian described, "dynamic equilibrium."[40]

The computer, with its mathematical basis, was a perfect instrument for unearthing a world of pure forms without reference to the visual vocabulary of the everyday world. The computer allowed the computer artist to treat abstract relations as visible, workable things. With the computer, the artist could explore visual abstraction in a dynamic, imaginative, and generative way. For Verostko, the computer expanded the capacity to visualize abstract structures as physical images. He saw the probe into visual abstraction as an inherited project from Klee, Mondrian, and Kandinsky. Like the modernists, Verostko viewed his experiments as crossing a "new threshold" in pursuit of the "unseen."[41] The artist explained:

> These procedures opened a vast array of pure form, an uncharted frontier of unseen worlds waiting to be discovered and concretized. My ongoing work concentrates on developing my program of procedures, the score, for visualizing these forms. By joining these procedures with fine arts practice I create aesthetic objects to be contemplated much as we contemplate the wondrous forms of nature.[42]

Through his early exploration of stochastic behavior and free association within computing, Verostko decided to formulate a drawing/painting program that incorporated all that he had learned in his exploration into the visual dialectic. He went about embedding stochastic and formal elements within a prescribed system for art-making. Verostko's *tour de force* was a drawing and painting program called Hodos (meaning "path" or "road" in Greek) which could be continually modified by integrating and refining new programmatic routines. The "control and uncontrol" pictorial elements of his pre-computer painting are evident in the random lines and formal shapes of the *Carnival* from the *Pathway Series* (Figure 4.9). Here, ordered geometric shapes share the pictorial space with random lines and painted marks. Verostko's most unique contribution to digital mark-making—his plotted brush stroke—makes its appearance in this work. This breakthrough, a result of his highly experimental work with the pen plotter, came when the artist attached a Chinese brush to the machine's drawing arm and developed a sophisticated software routine to activate it. For the first time, the artist, who had studied the intricacies of Chinese and Japanese calligraphy, was able to achieve a stroke with a certain expressive energy, the dynamic form of the hand-drawn mark. Finally the cool rhetoric of the mechanical line with its exact precision gave way to a more organic, human sensibility. The line has the temperament of a human creator, a line of pure energy and freedom.

Verostko, in his spiritual quest, would continue to harness the power of the algorithm and its generative and harmonizing force. The computer, providing a "new pathway to making visible the invisible," allowed one to probe the mysterious visual domains of nature's underlying pattern, perhaps echoing the "processes lying at the core of the unfolding universe."[43] In the 1990s, the computer continued to be a vehicle for exploration; a machine that reached those inaccessible forms beyond the artist's imagination.

Through the technosciences, the computer was imagined as a machine for designing worlds, an instrument for probing nature's secrets, and a window onto new visual territories. The artist-programmer paradigm developed along with these metaphors and mythologies. However, the computer now defied any single understanding and began to facilitate other expanded understandings. Shedding its aura of exaltation, it came to be understood as merely a tool among others—an instrument to be bent to the will of the user. Consequently, in the 1980s the computer entered the cultural field in a very different manner from the way it had been previously received. It became a personalized object, and perhaps more importantly it became a manageable medium for the neophyte.

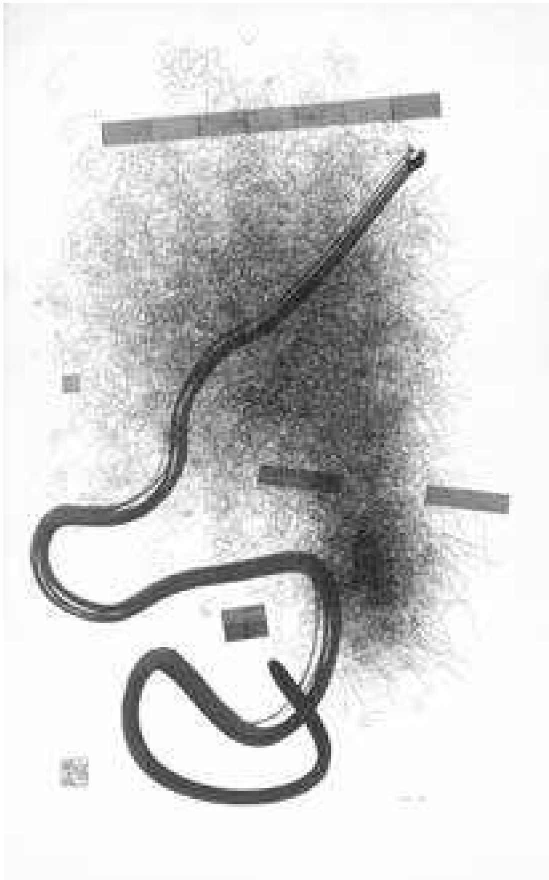

FIGURE 4.9 *Roman Verostko,* Carnival, Pathway Series, *1989. Algorithmic pen and brush drawing, 24 × 40 in. Courtesy of the artist.*

Apart from the cultural populism of fractal geometry, the computer-generated image in the 1980s was entering popular culture through television, video games, print advertising, and feature films.[44] It seemed as if overnight there was a proliferation of new dynamics and color computer graphics in the household. The general appreciation of the computer and its visual products contributed to a wider interest in computer art. Even though computer art lacked critical endorsement or a general acceptance within the fine art establishment, the computer art project managed to generate a substantial amount of interest in the field of visual culture. In 1987, the year the major exhibition and publication *Digital Visions* was staged, Cynthia Goodman wrote that the "enthusiasm and interest with which fine artists are just now responding to the mention of computers is as profound as their disinterest and antagonism only a few years ago."[45] Although computer art expanded in the 1970s, its relative growth compared to video art and photography was small. While the 1970s were viewed as a negative period in computer art's history, during the 1980s there was renewed optimism. Some reacted as if the computer had only recently arrived on the art scene. Jennifer Mellen called the computer an "astonishing new art medium," one with "unprecedented promise."[46] Likewise, Prueitt, echoing the sentiment of the early 1970s, believed that there was a "revolution breaking" within the art world that may be as "profound" as the Renaissance.[47] Prueitt felt that "someday the computer [would] be considered humanity's finest artistic tool."[48] Apart from Prueitt's overly celebratory publication *Art and the Computer* (1984), there were several publications reflecting the newfound optimism in computer-based art, as well as a number of books published that outlined different methods people could use to create their own computer-generated artwork. Styled as manuals, the publications gave artists, who now had access to individual computers, information on the range and possibility of computer technology.

The enthusiasm for computer technology precipitated a growing tide of international exhibitions in galleries and museums. Another factor that increased the exposure and popularity of the computer was the number of mainstream artists flirting with the computer. In the 1980s, artists like Andy Warhol, David Hockney, Jenny Holzer, Keith Haring, Les Levine, and Bruce Nauman employed the image-making and manipulating power of the computer. This factor for Margot Lovejoy went some way in legitimizing the medium, as it proved that computers had "entered the studio of mainstream artists."[49] However, this point is often overemphasized, because the artist's liaison with the computer was only brief for self-serving ventures. Technical difficulty saw many abandon the machine-based art for more reliable methods. The ones who persisted with computing technologies most often enlisted the help of technicians and programmers to construct the computational aspect of their work.

The most significant factor in the rejuvenation of computer art stemmed from the popularity of computer graphics and the growth of interest in computer science, which emerged like Hercules from its cradle. By the 1980s, computer science had become one of the most popular undergraduate majors in the United States. Computer graphics, by then a burgeoning field within computer science, also expanded dramatically. The growth of computer graphics had accelerated to the point where it was ubiquitous in visual culture, leading one commentator to suggest that it was "one of the most pervasive, influential forces in society."[50] The graphics community, which had swelled substantially since the mid-1970s, gave significant support to computer artists and their projects. There was a marked increase in research relating to computer art through the 1980s as well. At Ohio State University, one of the emerging centers for research in computers and art, there were many graduate projects investigating computer art issues. Previously the scientific and engineering community had given only partial acceptance to the computer art project. While computer artists in the 1970s found sympathy among scientists and technologists, people with whom they often closely worked, the scientific community was "often disinclined to regard art as a serious activity."[51] In contrast, the graphics community welcomed artists, primarily, as Mark Resch from SIGGRAPH suggests, for the profound "changes in perception and communication that result from artists using computers."[52] For Resch, computer graphics would not, however, impulsively support an "art for art's sake" approach.[53] The artist needed to provide tangible results for further graphic application. Under SIGGRAPH exhibition conditions, there was no delineation between images produced by fine artists and those produced by computer scientists researching computer graphics. It was, and is still today, an exposition of new work emerging from the latest graphic engineering research. Much of the art pieces demonstrated the capability of new graphics software. As already mentioned, it was difficult to distinguish the computer artist from the computer scientist at many stages in the history of computer art. In the 1980s, the trend would continue with the graphics community securing members who were a blend of technologist and artist.

As the 1980s progressed, it became a commonly held preconception that computer artists found more "acceptance from the computer community than from the art community."[54] In the 1980s, SIGGRAPH, which saw itself as a graphics technology organization, became the most consistent supporter of computer art. In 1981, SIGGRAPH sponsored its first exhibition of computer art in combination with its annual computer graphics conference. Because of a limited budget and scope, the first exhibition, which mirrored the scale of previous computer art exhibitions, showed two-dimensional works that were easily transportable. While the first exhibition was a modest affair, existing as a minor sideshow to the latest research presentations, it allowed artists to develop the *esprit de corps* of a relatively coherent group. From the perspective of the mainstream art world, however, the developing community appeared, as artist Rebecca Allen wryly described, to be the "computer art ghetto."[55] Although other groups emerged and provided new exhibition spaces, such as Ars Electronica and ISEA, segregation from the orthodox art world continued to plague digital artists. Beyond becoming a kind of *Salon des Refusés* for digital artists, these organizations continued to play a crucial supportive role, one in which a confederate of likeminded artists could share their abiding interests in emergent technology. Eventually, however, those institutions, along with the digital arts as a whole, emerged as a microcosm of the larger art world, reflecting similar hierarchical structures and modes of exclusivity.

Nevertheless, the annual SIGGRAPH conference was a crucial venue for computer artists. Because the "door to the art world was closed," Allen explained, artists were required to "seek other venues" to show their computer art. By 1983, the computer art exhibition evolved into a traveling show. Over a two-year period, it was exhibited at 33 sites in America, Europe, and Asia. The importance of the exhibition was guaranteed by the overall popularity of the conference. Coupled with the intense interest in the new graphic imagery, the SIGGRAPH Art Show in 1987 attracted 23,000 over the weeklong conference. As a result, the art show became a major site for the exhibition of computer art and a place for the artist to gain new insight into current technical achievements in computer graphics. However, as outlined in the last chapter, computer art's close relationship with the graphics industry was also a key factor in its marginalization.

Beyond the support of the computer industry, the most important factor that contributed to new interest in computer art was the arrival of the personal computer. With the advent of the powerful and affordable microprocessor, the computer was available on an individual basis. Peripheral output devices also fell in price. This meant that printers and plotters were also personally available to the aspiring computer artist, though still costly investments. Artists now had a fully contained image-making machine which, importantly, was not linked to any large institution. In the early 1980s Mark Wilson was one of the first traditionally trained artists to purchase a microcomputer with the intention of generating computer art. With personal computers, other artists such as Edward Zajec and Jean-Pierre Hébert began working outside large institutions. Earlier, computer artists had been required to work within the confines and restrictions of large institutions, which became problematic as the corporate environment was often at odds with the artists' vision.

With the increasing processing power of the computer and its color graphic capabilities, computer art became visually more sophisticated. Nevertheless, while there was new, more synthetic 3-D imagery produced, the computer art's traditional idiomatic form of linear graphics remained popular, as in Melvin Prueitt's work. Paralleling the elemental line drawings of the original computer artworks, Prueitt's *Roadway to Somewhere* (Figure 4.10) generated

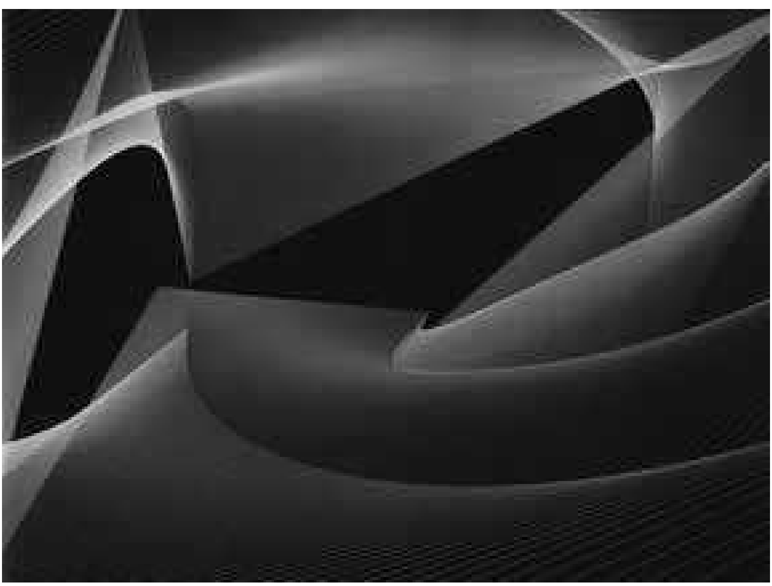

FIGURE 4.10 *Melvin Prueitt,* Roadway to Somewhere, *1981. © 1981 Melvin L. Prueitt.*

subtle spatial relationships and planar effects with recurring lines, soft curves, and, now, color. As the title suggests, computer imagery was conceptualized as an unexplored universe. Increasingly through the 1980s, figures and landscapes of computer art are set in a vacuous black space akin to the spatially immeasurable universe. In addition, the preoccupation with symmetry, which had been an adjunct to the work of the pioneers, was also evident in Prueitt's *Involution* (Figure 4.11). The figure was generated by joining together a number of quadrilaterals and triangles and then filling in each shape with linear spirals. Again, the appeal to Pythagorean and Platonic ideas of beauty remained a constant element within computer art aesthetics.

The spatial register, or vector space, continued to underpin the geometric abstraction of the 1980s. Linear and geometric figuration became a sort of "classical" computer art. Likewise, the constructivist movement, which remained a central influence for the artists of the 1960s and 1970s, continued to influence computer artists well into the 1980s. Mark Wilson, who had been an active painter in New

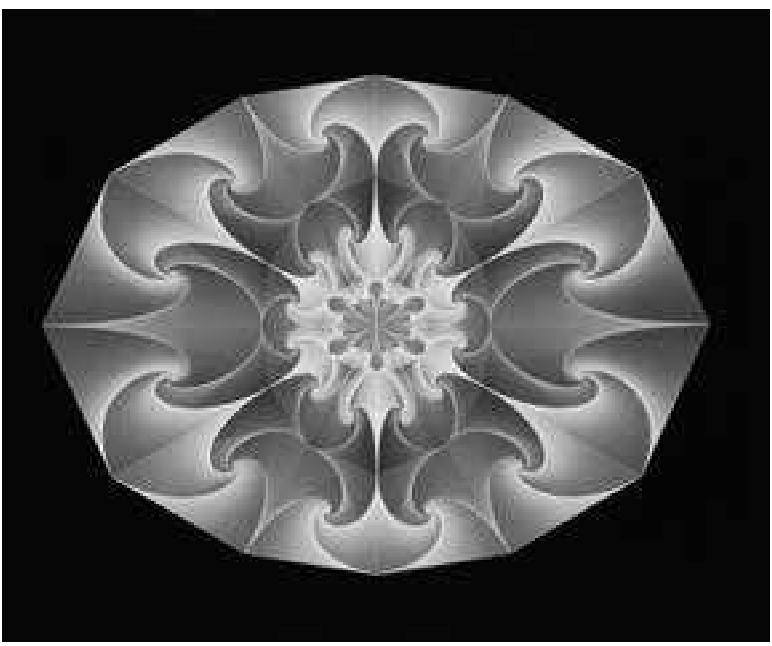

FIGURE 4.11 *Melvin Prueitt,* Involution, *1978. © 1978 Melvin L. Prueitt.*

York in the 1970s and had exhibited widely in the United States and Europe, maintained a connection with constructivism. Beyond generating constructivist characteristics of line and plane, Wilson hoped to discover a wholly original style from the use of computers. As with Mohr, Cohen, and Molnar, Wilson's pre-computer paintings bear a distinct resemblance to his computer art. In his pre-computer painting *Untitled* (Figure 4.12), the abstract formation has the appearance of an electronic or digital circuit board. Wilson was intrigued by the visual beauty and complexity of chip diagrams and circuit boards. Although his paintings represented the interiors of technological artifacts, when he employed the computer, his work—paradoxically—evolved toward a more neutral and abstract position, as seen in his *Skew J17* (Figure 4.13). Floating circles,

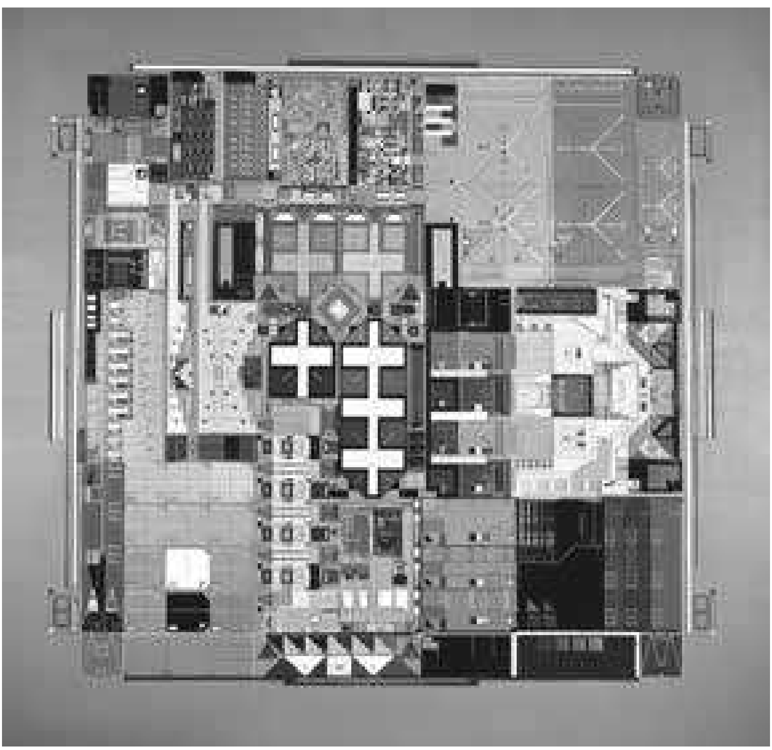

FIGURE 4.12 *Mark Wilson,* Untitled, *1973. Acrylic on canvas. Courtesy of the artist.*

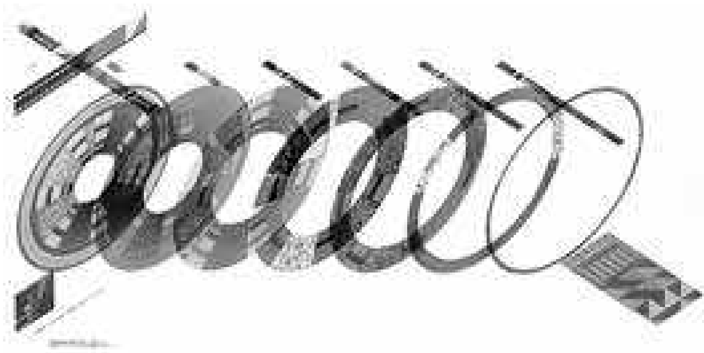

FIGURE 4.13 *Mark Wilson,* Skew J17, *1984. Plotter drawing, 22 × 38 in. Courtesy of the artist.*

with intricate radial lines moving from the circle's center to its perimeter, overlap with similar forms in space. The segments in each semicircular shape remind us of the wedge-shaped sections, the *cunei*, of ancient Greek amphitheaters or maybe they mirror the schematics of data segments on a computer's hard-drive disk. The artist's colors, all generated randomly, burn with a plastic intensity, fully resonating the artificiality of synthetic forms.

By the 1980s, the plotter, like the vector-based graphics, had become the orthodox imaging tool for artist-programmers. Wilson called the plotter the "most venerable device" to have been used in the service of computer art.[56] The plotter's significance was its embodiment of automatism in the art-making process. Because plotters follow vector graphic instructions directly, which means that lines are drawn from one point to another simulating hand drawing, the plotter possessed the mystical dimension of the Enlightenment automata. Once the algorithm was initiated, the artist could retreat and watch the machinery create the artwork (see Mohr, figure 3.8). As with Mohr's and Cohen's exhibitions, the audience was captivated by the manner in which the pen executed the lines in the same way that the human hand draws.

In contrast to the other display peripherals, the plotter enabled the artist to introduce traditional media into computer art. The plotter had the ability to accommodate high-quality traditional fine art materials like Arches paper and Indian ink. The traditional rag paper had desirable textures and, importantly, was archival. Having an advantage over other computer art forms, plotter drawings could be easily identified and assimilated by art historians, critics, and gallery owners into traditional art structures. As Franke suggested, the easiest method of acceptance within the modalities of the gallery was to produce editions of static pictures on paper.[57] The plotter finally gave the computer a sustained form of representation, while conversely previous computer art had required other modes of technology for representation, which had physical and financial limitations. Even the new raster screens within CGI graphic format had limited the quality of the image. In contrast, the pen plotter allowed 1,000 increments to the inch, which had a higher resolution than the computer monitor. With their superior resolution, the plotters allowed for those subtle nuances and tempered qualities achieved only with human hand movement. Importantly, for artists like Verostko, the plotter could build color tones and drifting fields through multiple layers of lines (Figure 4.9). A single layer of pixels in raster graphics could not achieve Versotko's unique glazing effect and visual drift, which was formed by the physical overlapping of colored inks.

Perhaps the greatest exponent of the intricately complex plotted line is Jean-Pierre Hébert. In 1959, Hébert, who was studying engineering at the time, began using the first IBM computer installed at the company's headquarters in Paris, France. While Hébert became one of the earliest computer consultants, moving to the United States in the 1980s to be at the cutting edge of the computer industry, he remained committed to the visual arts, eventually dedicating his life to computer arts. His love of art was nurtured early. Seeking refuge from the war and Nazi persecution, Hébert's mother took her son to live on his grandfather's estate in the Vence, the medieval-walled village at the foothills of the French Alps. Vence had a rich artistic heritage, particularly for modern art. The town is commonly known for the Matisse Chapel (Chapelle du Rosaire de Vence), which was built and decorated by Matisse as a gift to the Dominican nuns who helped the artist recuperate after illness. At different times, modern masters made Vence their home, including Marc Chagall and Max Ernst. Picasso's Madoura pottery studio in Vallauris was nearby, and because the town was in the orbit of Picasso's playground, the French Riviera, Hébert would often see Picasso on the beach. Many of the modernists showed their art in the famed Galerie Chave, a gallery named after its founder

Alphonse Chave, a figure who became prominent in Hébert's life. Pierre Chave, Alphonse's son, held Hébert's first solo show at the Chave Gallery in 1989. Entitled *Sans Lever La Plume* (Without Lifting the Pen), the exhibition showcased some of Hébert's most finely rendered computer-generated plotted works.

Works like *Vent Noir II* (Figure 4.14) illustrated the power of Hébert's programming and the subtly to which the artist was able to apply the unique capabilities of the computer-guided plotter. In the late 1980s, quite divorced from the computer art movement and more remote from the mainstream art world, Hébert began completing some of the most exact and complicated single-line drawings ever completed. Like much of Hébert's art, *Vent Noir II*

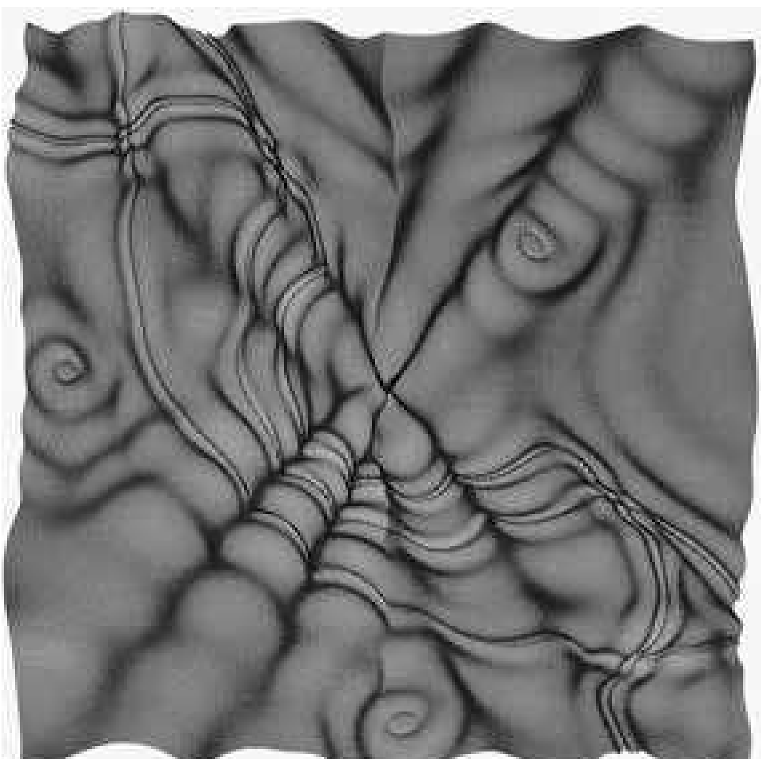

FIGURE 4.14 *Jean-Pierre Hébert,* Vent Noir II, *1987. © 1987 Jean-Pierre Hébert. Courtesy of the Artist.*

is made up of one finely rendered line that when viewed in total creates an intricate tapestry, a kind of translucent topology that mirrors the effect of light passing through a permeable membrane. To generate this linear configuration required years of painstaking work in which the artist, through trial and error, found the most suitable plotter, pens, and inks to support the process. Some of his larger more complex works would take over 60 hours to plot, which, for the artist who remained without sleep, became mentally and physically exhausting. Any impurity in the ink could clog the pen, or the risk of a power outage was ever-present. If a problem arose the printer would fail and because the design was reliant on the single, unending line, no retracing or starting from the same point was possible. Three weeks of preparation would be for naught, and the artist would need to start again. While the process of watching the plotter plot was "magically rewarding," the whole thing being a "fascinating performance," the mental exhaustion from knowing that "at any second, the whole thing could collapse" transformed the artist, as he said himself, into a "nervous wreck."[58] Art critics were largely oblivious to such technical hardships.

For most of the artist-programmers, the plotter—though difficult to master—embodied the most important features of computer art. Beyond its essential link to programmatic automatism, the plotter had associations to fine art through the traditions of drawing, printmaking, and general materiality. However, just when computer art seemed on a solid foundation, computer technology rapidly transformed. The most fundamental shift in computer art production was the development, then refinement, of the computer interface. The Graphical User Interface (GUI), which was developed in the late 1960s, humanized the computer by allowing the individual (now called "user") to navigate the computer's systems using familiar art metaphors and icons. Importantly, the user did not have to wrestle with the internal structures of the machine, such as its complex symbolic and command-line system.

Since the late 1960s, computer scientists had been developing systems that hid the complexities of the computer—to essentially free the artistic elements from the mathematical and programmatic components. In the 1970s, many software engineers and artists worked on art-based graphic programs and interfaces that would evolve into the paint system, electronic palettes, and image synthesizers of the 1980s. Effectively, the new interfaces within painting software rendered the computer monitor a window onto a simulated canvas. For the first time, the computer now embodied traditional media and its processes. Therefore, artists could approach the computer with their visual arts training intact without requiring recondite computer programming knowledge. For the first time, the computer artists would not necessarily need to script or prefigure their art ideas into algorithmic form.

This precipitated two methodologies within computer art: the conceptual basis for the artwork with its traditional algorithmic imperatives and the operational process, which used the computer as a tool for specific results. While many of the artist-programmers preferred to draw and modify pictorial elements by scripting changes in a nonvisual form, the new breed of computer artists employed all of the gesture-based activity innate to traditional media. The artist, by using the computer as a physical tool with all of the real-time virtuosity of traditional media, was involved closely in the visual production of the work. Yet the consequences of the interactive visual interface were that the artist had little conscious understanding to the underlying structure of the computer and its processes. The interface allowed the artist to work in a nonlinear fashion; effectively intervening in the visual data at any point in the process. In contrast, the abstracting methods of the programmer distanced the artist from the visual outcome.

With this new development, the computer became a creative partner rather than an autonomous art machine. In part, the shift was due to changing perceptions of the computer as a universal and protean machine. Apart from the change in interface and the move toward screen-based information, the 1980s witnessed digital technology that combined sound, text, and image. Previously, the fields of computers, telecommunications, and audiovisuals developed independently. However, in the 1980s, areas of high technology converged through different multimedia formats that allowed the processing of visual information in a number of ways, including an interchange between analog and digital systems. Increasingly, art was understood in terms of a database or data structure that was permanently flexible. For the new computer artists, the computer's power lay in its ability to make the image infinitely malleable. For Joan Truckenbrod, the computer represented a multidimensional imaging system that opened up the possibilities of a rich variety of artistic activity through a convergence of media: the "computer becomes the hub of a multifaceted imaging network, involving visual, acoustic, performance, and experiential 'images.'"[59]

The idea of the computer as an "expanded medium" had been implicit in Schwartz's practice since the late 1960s when she was a pioneering artist at Bell Labs. By integrating both digital and analog media, traditional practice and advanced technology, Schwartz employed the computer as a polymorph of tools. Her achievements and awards in computer animation are well documented. Her role in promoting a new kind of artistic intentionality—a direct approach that manipulated the image at the level of the pixel—led in new directions. Now computer art was not just a cerebral exercise, but became a bodily ritual and a sensory experience. Having formal training in art allowed Schwartz to see the computer's potential as a universal image machine: a consortium of tools that could mimic traditional media. Expanding the medium beyond specialized programs, Schwartz "inputted" her ideas through the mouse, joystick, and keyboard. Her desire to move beyond the linear process of programming and manipulate the image at the level of the pixel led her to a remarkable career in the computer-aided analysis and electronic restoration. Her research into perspectives in Leonardo's *Last Supper* and her analysis of the continuity of proportion between the Leonardo self-portrait drawing and the painted *Mona Lisa* were both widely acclaimed. The now iconic computer art piece *Mona/Leo* (Figure 4.15) matches (in a postmodernist act of appropriation reminiscent of the work of Sherry Levine and others) the same frame half of Mona Lisa's face with that of Leonardo's. The digital alteration commented on the irony and hidden meaning of the two figures' physiognomic similarities. The irony is doubled upon when considering both the role of Leonardo as an icon in computer art and the often obscured role of women in the computer art field.

Schwartz's combinations of different media technologies and her successful intermixing of different artistic techniques made her practice a model for future new media art. Schwartz effectively ignored computer art's modernist impulse to rigorously delimit and define the art form. The trend toward the computer as a multifaceted, dynamic, screen-based medium was confirmed by technology-based international art events. The SIGGRAPH art exhibition became more complex as it included environmental, interactive, online, and traditional computer artworks. From the mid-1980s, international art and technology exhibitions became

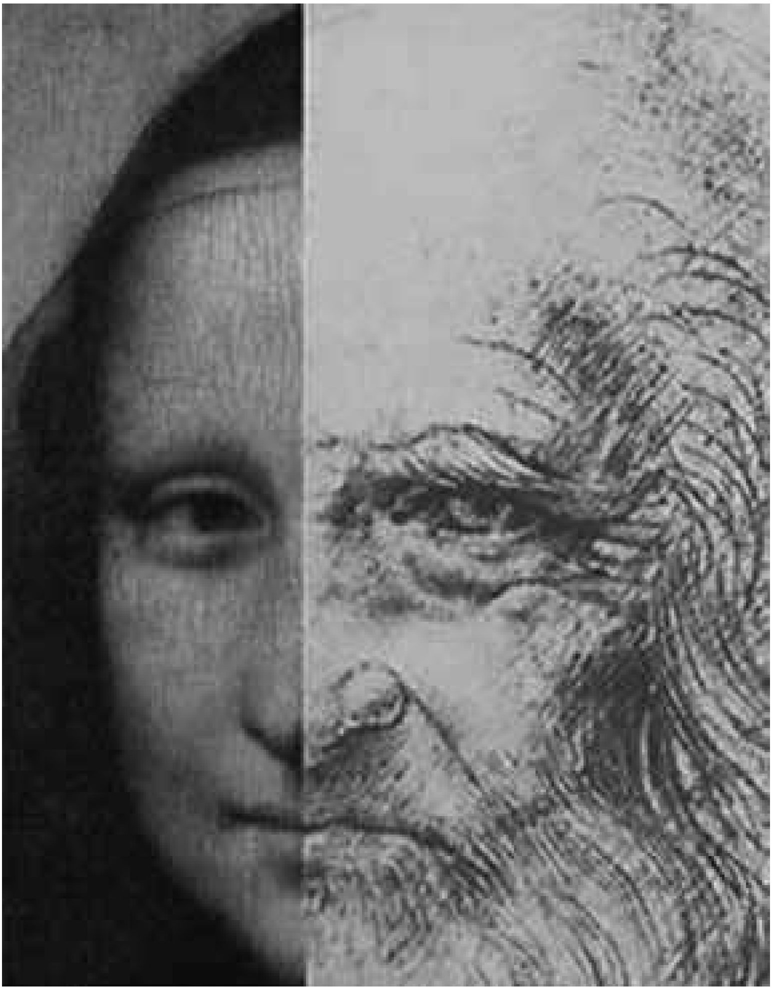

FIGURE 4.15 *Lillian Schwartz,* Mona/Leo, *1987. © 1987 Lillian F. Schwartz.*

ever more ambitious with exhibitions presenting live performances coupled with the latest technologies such as 3-D laser projections. By 1987, the SIGGRAPH exhibition had grown large enough to warrant five categories: abstract, visual research, human image, graphic design, and landscape.

For Schwartz, the "qualitative sensations of the creative act remain the elusive domain of the artist."[60] Even though the computer was a powerful tool in the analysis of art, the artist, as author and originator, held the primary position. Although we can employ the computer to gain insight and improve our comprehension of artists' methodology, Schwartz asserted that "we will never parse [the artists'] inspiration into a set of rules or an algorithm."[61] Here, Schwartz warns against the narrowness of the conceptual programming approach:

> Knowing a programming language and then writing a program using that language can lead to a creative isolation for an artist, because the birth of the program (often followed by the need to tinker with it over the years) displaces the artistic act. The program becomes the artwork, and the fontanelle through which creativity has previously surged unimpeded becomes impenetrably blocked…I did not have the desire to write a program from scratch or to spend time afterward scrutinizing each line of code to make it more efficient.[62]

For the nonprogramming computer artists, the immediate nature of the computer interface, with its direct link between the artist's hand and the screen, increased experimental interplay. Using a combination of tools and filters, the artist could perform nonlinear actions on the image. The flexibility and universality of the medium is what attracted the Pop artist Andy Warhol to the commercially available Amiga system. One of the main features of the metaphorical interface was its multifunctionality, which for Warhol meant artists did not need to alter their own style. Software programs effectively established continuity with the artists' previous way of working. The computer's power of allure, which had once been closely coupled with the seduction of programming, became tied to the appeal of the interface. As Sherry Turkle suggested, the artist as a "user" was involved with the "machine in a hands-on way" and was not interested in the technology, "except as it enables an application."[63] The artist-programmers were the antithesis of users; they, like the computer hacker, were "passionately involved in the mastery of the machine itself."[64] Their intimate relationship with the machines was sustained by the joy of fully comprehending a complex system and being able to reconfigure it at will. As Turkle proposed, the new user-friendly interface "encouraged users to stay at a surface level of visual representation," effectively working in ignorance of the underlying digital system.[65]

Although Cohen's autogenic practice was still gaining widespread popularity, the days when the program was merely set in motion were long gone. With real-time interfaced art-making software available, the interactive and intuitive engagement began to dominate. Not all welcomed the computer interface and screen-based practice made possible by new commercial software systems. Many from the artist-programming tradition resisted the new technological transparency, which the computer world increasingly celebrated. While many traditionalists had predicted the further expanding of the medium, many could not foresee that computer systems would facilitate the integration of sound, images, and text through multimedia interface. As these new modes developed, interaction became one of the primary paradigms through which to understand computer art. The interactive mediation between medium, artist, and participator, which the computer facilitated, was trumpeted as the new progressive form. Many believed that if computer art had a future it would be dynamic and interactive.

As early as 1976, Edward Zajec felt that the current static computer art was a discrete element in a transition stage: "they stand as stills in a process in motion and fall short of realizing the full potential of the medium."[66] Others also believed that all static art, including art produced by computers, left the audience "unsatisfied" and was somehow "incomplete."[67] Zajec felt that computer art was moving away from object-oriented art toward "direct interactive exchange."[68] This trend was confirmed by Franke's article "The Expanding Medium," in which he saw computer art moving from the "small, limiting frame of a picture" to a "comprehensive image of an environment or world."[69]

The movement toward a more sensual, interactive, and synaesthetic environment diverged increasingly from the normative paradigm of the artist-programmers, who had been preoccupied with mathematically configured spatial form and pattern within their individualized art-making systems. As the 1980s developed, critics and artists alike were beginning to delineate the different modes of computer art practice. By the mid-1980s, computer art began to splinter into two competing approaches. The schism that emerged was, as Donald Michie and Rory Johnston described, "every bit as vehement as the rivalry between painters and sculptors in Titian's day."[70] Although this appears to be an exaggeration, the disjuncture was clearly visible in computer art discourse. The artist-programmer paradigm was under threat from the now ubiquitous software applications that allowed the artist to employ the computer in the manner of a traditional medium.

As computer art dichotomized into competing paradigms, hostilities began to surface from the old order. For the traditional artist-programmers, the prefabricated software had a number of disadvantages. Artists who worked with commercially available computer software had to accept the limitations of the system, adjusting their style to the machine's capabilities. This required no change in perception or method to use the system, and thus no new understanding of the computational potential. Artist-programmers felt that the new computer artist was using the computer for the "sake of novelty" rather than exploiting the "unique visual characteristic" of the computer, as Preusser described it.[71] For Roger Malina, compared with the works of artists who designed their own programs, such as Cohen and Verostko, commercial software and particular hardware embedded a recognizable "signature" in the artist's work.[72] Likewise, the aesthetician and computer art theorist Mihai Nadin felt that commercial software left a diminishing mark on the art. He believed that computer software controlled the artist by its specific parameters, which resulted in what he deprecatingly termed "canned art."[73] In addition, the computer's ability to simulate other art styles and processes with relative ease and speed produced a fast substitute for art, which he called "MacDonald art."[74]

Purism developed among the artist-programmers, who saw their programmatic technique as the only possible path for generating computer art. For Musgrave, the algorithmic imperative was the purest form within computer art. Programmed computer art is different from traditional art mediums because details cannot be manipulated in isolation from the whole. In contrast, programmed art "changes the global parameters immediately and directly affects everything."[75] For Michie and Johnston, the "tool" approach, exemplified by David Em, was dismissed as "painting by numbers."[76] For Nadin, the commercial computer program gave a "prefabricated, general solution" to the process of art making.[77] The artist was a mere user confined and determined by a program constructed by others, and the only way to overcome the governing aspects of the commercial program was to construct the program oneself, to have in effect a blank computer. This, Nadin felt, was necessary to make distinctions between personally programmed computer art and art created through the commercial programs. One needed to establish the emerging aesthetics in terms of the idiomatic visual form of the computer: “It is in the realm of what was not before possible that one can see the assets of this artistic involvement with technology.”[78]

Under this conception, the program was the work of art. This echoes the previous emphasis on the program by Franke, who in 1971 commented on the copyright problem of computer art, reiterating that it was not the “individual productions but the programs that are the real results of creative activity.”[79] For Nadin, there was no such thing as a “computer artist who is not the author of his or her program.”[80] “The very few successes we know of are,” he said, “the result of authentic mastery of the programming and the result of the attempt to create a legitimate alternative medium.”[81] The high profile artist Harold Cohen had also insisted publicly on the need to program.[82] For most of the orthodox, the program constructed by the artists would evolve over time and have in it the embedded recognizable characteristics of the artist, which commercially available art package programs lacked. Mirroring previous mythology surrounding the priesthood of the machine, Prueitt believed that “only the programmers can fully see the beauty of their work,” and computer art had a secret depth that could only be perceived by those with deep knowledge of computation.[83]

The purists felt that the new software failed to bring anything new to computer art discourse, settling instead to simulate traditional media. While there was a preoccupying attempt to define what computer art was, the significant factor in the antagonism was the mind/body duality that ran through computer art discourse. The artist-programmers privileged the cognitive faculty and rationality, while the artist using painting software injected the body, via movement and manual dexterity, into computer art. For scientists like Prueitt, the computer was significant because it dispensed with the need for the body in art. Overcoming the need for manual dexterity, one could extract any vision from the mind. The computer enabled the virtual embodiment or visualization of embedded mental forms because within the “soul dwell masterpieces of artistic creation that cannot get out.”[84] For these scientists, the body is an impediment and barrier to the forms of the mind.

With the inundation of off-the-shelf software and the new dynamic, interactive digital modes emerging, the computer art project began to fragment. Computer art came under attack from both external and internal figures. In 1983, art critic Grace Glueck wrote in the *New York Times* an article entitled "Portrait of the Artist As a Young Computer," again a reworking of James Joyce's title as well as a parallel to the first article that pushed computerized art into the realm of popular culture: John R. Pierce's 1965 *Playboy* article entitled "Portrait of the Machine As a Young Artist."[85] She opened her essay with this salvo:

> Given what we've seen of it to date, it's small wonder that when we hear the term "computer art" our attention begins to wander. By now we've developed an understandable resistance to the boring optical shenanigans that result when computers are programmed to make drawings by technicians who lack the imagination of artists.[86]

Critics were still highly uncomfortable with the technologist as creator. Yet the term "naïve practitioner," which was employed to deride the scientists and technologists since the 1960s, ironically became a term used to describe the new computer artists who had a superficial understanding of the computer and its internal systems.

Like his fellow programming artists, Cohen expressed a passionate disdain for what he referred to as "off-the-shelf" software. Cohen could see that the production of this software and its particular technological mode, which confirmed quick-changing and new characteristics, resulted in an overt attraction for the superficial and the novel. Inevitably the artist would be associated with a product inexplicably linked to the future-oriented economy of new digital technology. Even so, Cohen did not spare artist-programmers from his criticism. For Cohen, computer art more generally lacked any inspiration or ingenuity. This was the reason why, as Cohen suggested, computer art had "failed to stir the imagination of serious critics … [or] … any part of the serious art community."[87] He went on to conclude that he had "never met a computer artist who didn't think that most computer art has been extremely dreary."[88] For Cohen, computer art was "old-fashioned … simple-minded and boring."[89] This sentiment reflects a common preoccupation among computer artists who exhibited a propensity to dismiss the majority of computer art as insipid and aesthetically repetitious. Art theorist Rudolf Arnheim also noted that contemporary computer art seemed surprisingly unsophisticated when one considered the effort, knowledge, and techniques required to produce it. As Arnheim noted, there was "frequently a pathetic discrepancy between the sophistication of the program fed into the computer and the simplism of the visual results."[90]

Apart from the continuing debate over computer art's questionable aesthetics, the computer remained a target of technophobes. Even though the computer had been accepted culturally as a symbol for a new technological liberation, the art community, which was incessantly humanistic, found the computer and the art produced by it irreconcilable. In many respects, little had changed since the emergence of the computer as an art medium in the late 1960s. Traditional artists, like the early critics, were still "suspicious of technology," finding it perpetually "cold and hostile."[91] Glueck, who seemed to praise the work of Harold Cohen, asked the question that had dogged computer art since its inception: "Doesn't the idea of a technical apparatus doing the work vitiate the whole concept of art as a unique product of the creative imagination?"[92] Prejudice was also widespread in art educational institutions, which offered only limited educational options in the visual arts for those who wanted to explore the computer as an art tool or medium. Computer artists who became educators constantly expressed the resentment that colleagues from traditional art departments exhibited. Within commercial galleries and museums, too, the practice of ignoring computer art was still in effect. Many curators and gallery directors were still, as Timothy Binkley described, "skeptical" about the validity of computer-assisted art.[93] Even in West Germany, one of the originating computer art countries, resistance to computer art remained in many quarters. In 1985, an application was filed with the exhibition commission of the BBK in Munich to exhibit computer art. The exhibition was to address some of the theoretical issues concerning the art form. The published catalog brought together a number of important essays by both contemporary artists and the founding scientists, such as Bense and Franke. In spite of this, the original discussion concerning the application "exposed prejudices and uncertainty with respect to new [computational] media."[94]

Support from the computer industry itself was conditional and rather limited. Even IBM, which established a research and development center in La Gaude in southeastern France, only offered limited support to Hébert, an individual who had worked at IBM in the very first stages of the computer industry in France. While they allowed Hébert to exhibit works at the research center at La Gaude, which was organized by Pierre Chave, IBM did not buy any of the works. Describing how tough it was in the 1980s, Hébert reflected that not only was there resistance from the art community toward the computer, but those who did support computing, such as IBM, did not "respect computer art" enough to support the career of artists.[95]

In the 1980s there was still a prosaic technophobia running through the arts community. As Franke attested:

> One of the reasons for the rejection of computer art could be that it is being produced with the help of a highly technical medium, a medium very much under cross-fire today. Interceding in favor of technology as a legitimate means of creating art, means confronting the question of whether or not, in a world where technological progress itself has become dubious, art at least should be kept free of machines.[96]

Even though there was a proliferation of futurologist publications advocating the positive impact of computing on society, a number of humanists attempted to describe the technological inspired writing as utopian fantasy. Social commentators such as Theodore Roszak wanted to debunk "the cultlike mystique" that surrounded the computer.[97] In *The Cult of Information* (1986), Roszak concentrated his critique on the "folklore" regarding the "images of power" and the "illusion of well-being" that had "grown up around the machine."[98] His principal target was the concept of information, which had become inextricably linked to technology in the public mind. While Roszak freely admitted that there was an "obvious humanist agenda running through the critique," he found it necessary to urgently investigate the politics and technology of information against what he had called in previous publications the technocratic political agenda and the position of doctrinaire technophilia.[99] Even so, Roszak's vocal criticism was a distant voice among the flood of futurist publications of the era that trumpeted the immense power of the computer. The humanist critiques of technology, which reached an apogee in the 1960s and 1970s, declined in the conservatism of the 1980s. Culturally, the world had come to terms with the computer's ubiquitousness.

Even with cultural acceptance of the computer, computer art failed to flourish. The predominant belief was that the computer and its art form were immature, even though in the mid-1970s a number of commentators felt that computer art had emerged from its experimental stage and approached a phase of maturity. A decade later, Franke believed that computer art was still in its initial stages of development, a sentiment that Youngblood also shared. Many believed, as with the history of photography, that there would be a significant period before legitimization. Even by the late 1990s, the computer as an artistic medium had, according to many commentators, not reached maturation. The artist and writer Paul Brown constructed a historical model to predict the time it would take before the computer as a medium matured: "Forty years is precisely the time it takes for a technology to mature and, more importantly, for a new generation of artists to develop who haven't been influenced by the previous paradigm."[100]

Some believed that the rapid and continual progress of digital technology and its essential protean character prevented the artist from reflecting on the subtleties of the process. The technology was simply evolving too fast for an artistic tradition that could only change slowly and in relation to broad social and cultural movements. Also, as Franke suggested, the graphic software of scientists and engineers had been the "pacesetter for art," and the position was now progressively being taken over by commercial interests in entertainment and marketing.[101] Csuri and other artists such as Rebecca Allen had already developed important graphic applications that were increasingly employed in television, advertising, and filmmaking. At the close of the 1970s, Negroponte anticipated the changing trend toward ubiquitous computer-generated graphics. With predictive acuity, he wrote that the "major impact of computers in the visual arts will be on our daily lives, not necessarily on high and fine art."[102]

Indeed some of computer art's problems were associated with the common belief that it was merely an adjunct to computer graphics. In the early 1980s, computer art was, as Noll wrote, still "tied to the computer community."[103] Youngblood believed that the "full aesthetic potential" of computer art would be realized "only when computer artists come to instruments from art rather than computer science."[104] Many believed that artists were seduced by the race to develop realistic simulation, what Franke called "illusion technology."[105] The challenge to generate images that appear realistic became the holy grail of computer graphics. Franke felt that the development toward a perfect simulation of reality was related only "marginally to the problems of art" and that graphic realism was associated with "problems of leisure time and entertainment."[106] Roger Malina agreed with this trend, adding that "the fantastic landscapes produced using the most advanced computer graphics systems reveal the use of no new tools by the artists and no visual languages that were not already available to the surrealists over half a century ago."[107] Although Em's images met with initial success, expressing the novelty of synthetic realities, some felt that they lacked semantic meaning. For example, Philip J. Davis and Reuben Hersh believed that computer art was far too intertwined with the emblems of popular science:

> Sometimes an initial reaction of elation, shock, mystery, whatever, comes from the unusual texture or color, from the juxtaposition of elements, or from the creation of superreal objects. Often the underlying iconography hints at a strange and wonderful world of the future that will be brought about by science and technology, a message which after two hundred years is rather trite.[108]

As the 1980s progressed, the term "computer art" came under increasing attack. For Mark Wilson, the problem was in the term's inclusiveness: any image made via the computer was termed art. Wilson felt that the "semantic confusion" persisted into the 1980s.[109] Many computer art exhibitions and organizations (such as the Computer Art Society) had an inclusive policy that made no distinction between artist, technologist, and scientist. There was a tendency, as Nicholas Lambert suggested, "to treat everything claimed as 'Computer Art' too reverentially" through "fear of dissuading further experiments with adverse criticism."[110] The result was that "mediocre pieces of graphical work" were "promoted as art regardless" of conventional understandings of art.[111]

Equally, many had questioned the legitimacy of trained scientists and technologists calling themselves artists. Scientists, although having no training in the arts and deriving no income from their artistic practice, comfortably assumed the title. The legendary computer scientist Blinn declared "he could now term himself an 'artist' because that term was effectively bestowed upon him through the artistic recognition of his work."[112]

The term "computer art" also became incompatible with the current diversity of technology. Finding the term too narrow, Truckenbrod preferred the term "computer-aided" art.[113] Increasingly the term "computer art" was exchanged for others, such as "computer-assisted art" which, like "computer-aided art," shifted the computer from the center of practice and oriented it toward its secondary place as a mere tool. The computer assisted in production and became a facilitator, rather than being the intrinsic element of production. Likewise, artists themselves increasingly resisted being termed "computer artists." Mohr, Cohen, and Em felt that the term unnecessarily stereotyped them in the eyes of the art community and public.

As early as 1981, the Japanese artist Yoichiro Kawaguchi started to designate the products of his practice as "digital art."[114] In the 1990s, this term became ascendant, but before then, there was a raft of substitute terms that gave a more descriptive account of computer art methodology. What triggered the splintering of computer art into a myriad of terms was a crisis of confidence in the closing years of the 1980s. The new perceptions and designations that emerged during that time constitute the central theme of the next chapter.

In the mid-1980s, computer art historian Goodman stated that: "Before being accepted unquestioningly as a legitimate artistic medium, some of the challenging aesthetic and philosophical issues raised by computer-generated art must be solved."[115] Yet by the second half of the 1980s there were was no definable consensus on what theoretical approach should underpin computer art. Although computer art continued to grow in the 1980s and reach a populist audience, boosted by a nascent graphics industry and the enculturation of the computer-generated image, there was simmering discontent among computer artists. To compound problems, computer technology had significantly shifted toward universal and mainstream users, which effectively rendered the orthodox artist-programmer redundant. Bemoaning the commercialization of computer art, orthodox computer artists found new ways to define their art and add to the rhetorical debate over what constituted computer art. The irreconcilable differences between two computer art paradigms, the rise of critical postmodern theory, and the further expanding of the computer as a medium contributed to unprecedented instability within computer art discourse.

Nevertheless, critical theory brought a new understanding of technology, one that envisaged the computer as a democratic instrument and subversive of modernist conventions. The computer as the ultimate manipulator of the image would no longer be an anathema to artistic values. Nevertheless, configuring computer art according to postmodern criticality had its contradictions. With extensive links to modernist ideology, computer art naturally resisted reformulation. The next chapter explores computer art's search for theory and content from the different discourses operating at the close of the 1980s. It will show how competing ideologies extracted various themes and histories from computer art discourse and used them to construct newer more palatable narrative. For example, the postmodernists applied the history of computer art to the formation of the digital art paradigm, and the exponents of technoscience removed essentialist concepts such as the algorithm from their new art forms. As the following chapter argues, this effectively left computer art as an amorphous and fragmented movement.

CHAPTER FIVE

Critical impact

The year 1989 was pivotal in the history of computer art. Two crucial proceedings took place: the annual SIGGRAPH conference and College Art Association (CAA) meeting. Together they provided the genesis for a number of wide-ranging and ideologically diverse journal articles.[1] These texts, which carry strikingly divergent opinions, were the first major attempt to bring critical focus to computer art. Subsequently, these articles reframed the reception and understanding of the computer and its future role in the arts. The conference proceeding and the articles which followed responded to the crisis of confidence surfacing within the entire computer art project.

This final chapter charts the new analytical temper that entered computer art in the mid-1980s and the gradual intensification of rhetoric as criticality impacted computer art discourse. At the close of the decade, commentators and critics began a comprehensive evaluation of computer art in the face of what appeared to be computer art's abject failure. Antagonism and frustration surfaced among artists and theorists as the modernist ethos of conservatism and technological utopianism that was such a dominant part of computer art discourse came under attack.

The diverse ideologies encountered at the close of the decade were the result of the changing critical environment within visual art, especially given the dominant position of postmodern philosophies. Postmodernism and a number of other strategies were called on to validate computer art, even when the new paradigm was largely ill-suited. Although postmodernism was unable to penetrate the hegemonic technoscience paradigm of computer art, the postmodernist discourse does affect the widespread understanding of technology in the arts. The computer, as it became increasingly accepted in its new pluralistic form, proved a valuable postmodern art tool. This had profound effects for the 1990s, especially in discourse surrounding new media art. As computer art became increasingly contested, the term effectively became nebulous, prompting artists and critics to invent more descriptive terms. This fragmentation meant that computer art never again held the exclusive position it once enjoyed. The discourse lost much of its historical importance to the new paradigms, such as digital art, which co-opted computer art's history for its own genealogy.

This chapter focuses on the impact of postmodernism and how its critique of modernism fractures the genre of computer art. The most obvious outcome for computer art was the collapse of the term, as it was unable to accommodate conflicting interpretations. Divergent understandings of the ever-evolving computer remained the central problem in the schism. The abstract-generative paradigm of the artist-programmers, with its media specificity, fostered a modernist understanding of the art form. As the decade progressed, the technology shifted toward the new screen-based, multi-modal, pluralistic approach, which allowed the influential postmodern paradigm to become more dominant.

The critical situation that emerged at the close of the 1980s centered on, as Mark Resch pointed out, the "relationship between computer art and the mainstream art world."[2] Continually disenfranchised by the wider artistic community, computer artists felt frustrated that acceptance and legitimacy had not yet eventuated. Even by the close of the 1980s, computer art discourse remained haunted by illegitimacy. In the mid-1980s, according to Donald Michie and Rory Johnston, the general consensus was that the computer had not met original expectations, acquiring on the whole a "bad reputation."[3] The authors saw no "serious contribution by computers to the arts" and speculated that if any significant addition were to be made, it would be in the distant future.[4] Roger Malina believed that in the "larger context of the history of art, computer art of significance is imminent."[5] Once again the continual deferment of success is apparent in the narrative of computer art. Ken Knowlton in a 1986 SIGGRAPH art show paper asked "Why It Isn't Art Yet?"[6] The frustration of not having curators and directors who took technological art seriously even produced angry responses in publications such as *Leonardo*. In 1986, there was a series of exchanges in the journal over the lack of acceptance for this type of art form in the mainstream.[7] By 1989 the editor of *Leonardo* David Carrier announced in a somber tone: "it is genuinely unclear to me whether any art using computers is truly significant."[8] Many artists and theorists such as Nadin were expressing a similar disappointment in the computer–art alliance.[9] Nadin felt that it was time to examine "what we address as computer art and to try to understand why, despite expectations (some very high) and tedious work, despite major investment (easily approaching the billion dollar mark and exceeding any other investment made in art) and despite enthusiasm, the result has been rather minor."[10]

From its inception, computer art had been burdened with a significant weight of expectation that saw exponents continually anticipate a period of maturity in the near future. In effect, the artists were still waiting, as Malina described, for "computer art to be collected by museums and galleries."[11] In 1989, art critic for the *Los Angeles Times*, Cathy Curtis, believed that while computer art had overcome the reputation of the "the nerd at a party," characterized as "too doggedly earnest, too klutzy, too frankly unartistic," there still remained the "'garbage in, garbage out' truism" that had become the maxim of many critics.[12] If it was to find success, Curtis believed it needed to conform to what she saw as the critical framework and sophisticated evaluative systems that defined the mainstream art world.

In an attempt to explore the issue at the core of the artists' discontent, a panel session was organized for the 1989 SIGGRAPH conference. It was fittingly entitled "Computer Art—An Oxymoron?" with the subtitle "Views from the Mainstream." International museum representatives and mainstream critics were invited to "discuss the status of computer art."[13] The speakers came from the Institute of Contemporary Art, the National Museum of American Art, and the San Francisco Museum of Modern Art, among others. At the heart of the debate was the mainstream art world's reluctance to acknowledge computer art. Dorothy Spencer, the session's chair, asked if computer art would, like photography, "take three-quarters of a century" to be accepted by the mainstream.[14] Some, such as Henry Rand of the National Museum of America, believed that the computer, like any other technology in the history of art, would take some time to be integrated into fine art. Computer art also required, as he saw it, an artist who was a "towering figure"—a "Beethoven of the computer" who could "move the spirit of the audience."[15] Apart from the empty calls for a computer art genius, the session was plagued by confusion, hyperbole, and superficial prophecy. Consequently, there was no formal consensus, and the participants left frustrated and dissatisfied.[16] As Delle Maxwell recalled, the mainstream critics did not provide encouragement for the computer art project, nor did they invite artists to exhibit in their museums or galleries. According to Paul Brown, the critics and gallery curators "still felt confident to reiterate their belief that computer art" was "cold, intimidating, and heartless."[17] The artists felt that their questions were "left unaddressed and that they were being written off as insignificant."[18] For Maxwell, the two factions "seemed to exist in parallel worlds, unable to pass through an invisible though palpable barrier."[19]

This animated panel session was one of many critical responses to the perceived crisis. The articles that resulted from this exchange demonstrate the tendency there was to engage new critical discourses as a strategy for giving substance to the computer art project. These influential writings appeared in two periodicals. The first, not surprisingly, was the journal *Leonardo*, the bastion of science and art knowledge and the most prominent supporter of computer art. For the first time, a series of articles, entitled "Computer Art in Context," attempted to bring critical perspective to the field and cement computer art's current position. The most discernible factor in the series of articles was the multitude of ideological perspectives, which ranged from diatribes attacking the apolitical nature of computer art to manifestos calling for the return to modernist purity. The authors contributing to the second periodical, *Art Journal*, shared similar intentions; however, they represented a more unified critical approach. The series titled "Computer and Art: Issues of Content" brought together numerous ideological positions that revolved around current trends in postmodern critical discourse. The title of each series revealed the subtle difference between the contemporary art journal and the specialized science and technology–themed journal. The addition of the "and" between computer and art—although subtle—signaled the changing attitude toward the computer. The distinction between "Content" and "Context" also supported this changing trend: the *Leonardo* series sought to establish computer art's position within the wider contemporary art world, while *Art Journal* attempted to ground computer-based art in social reality. The most significant difference, however, was the appearance of computer art, previously a fringe topic, in a contemporary art journal. Rarely had a mainstream contemporary art journal widened its scope to encompass computer art. Because the number of computer artists increased dramatically in the 1980s, and digital forms were proliferating at great speed, the journals of the mainstream and avant-garde felt they needed to respond.

What the specialist and contemporary art journals illustrated was evidence of a new mode of criticism previously unseen in the computer art movement. The two publications confirmed the appearance of critical discourses within computer art and the expanded field of electronic art. While the 1989 appearance of critical discourse on computer art seemed sudden, there were already a number of trends in contemporary art that affected in minor ways the contextual formation of computer art. The most distinctive indicator of these growing trends was a study conducted by Richard Lucas in 1986.[20] Importantly, this empirical study confirmed a distinctive shift toward contemporary art and its dominant critical discourse.

The study attempted to identify and establish an aesthetic criterion for computer-generated art. The catalyst, as in previous investigations, was the unresolved matter of computer art's aesthetic foundation. Lucas felt that the changes produced by the computer forced "critical analysis beyond 'normal' limits."[21] This in turn resulted in the need for new criteria that incorporated unfamiliar concepts. For Lucas, the "inherent properties of computer art" required at least "some change in our approach to evaluating its aesthetic worth."[22] In establishing or recognizing new aesthetic criteria, Lucas employed a formal study, called the Delphi Procedure, which sought to arrive at a consensus of thought among experts. The international figures—representing a good combination of artists, theorists, and commentators—included Charles Csuri, Frank Dietrich, Hiroshi Kawano, Monique Nahas, Mihai Nadin, Frieder Nake, Lillian Schwartz, and Gene Youngblood.

Since the 1970s, there was a strong impulse to formulate a basis from which computer art could be defined, evaluated, categorized, and judged. In part, this was a response to the continual criticism computer art received. Computer art was viewed as fragmented; consequently, almost all writings on computer art began with a call for formal criteria in the hope that this would have a homogenizing effect. Although the computer art project consisted of divergent opinions and competing ideologies, there had been no systematic attempt to locate overarching commonalities. The study's primary question, central to the ongoing debate, was: "Should computer art be considered a new art form which requires new criteria for assessing its aesthetic?"[23] The consensus up to the mid-1980s was that computer art did require a unique criterion. However, the results from the Lucas study differed substantially from previous positions. Overall, participants responded in the negative. The participants were reluctant to recognize the appearance of, or even a need for, a new aesthetic standard. Surprisingly, there was also a considerable concurrence of opinion endorsing traditional criteria. Reaffirming these traditional aesthetic values—described in the report as the visual basics of harmony, symmetry, and balance—meant that the respondents were confirming the merit of formalist values. Nadin felt that far from overturning traditional modernist aesthetics, computer art mostly "reemphasised" them.[24] The participants, with varying rationales, reaffirmed traditional aesthetics because no "new aesthetic ideologies" had emerged that would give reason for a "departure from traditional aesthetics."[25] Regardless of whether innovative properties emerged, traditional aesthetics, Nadin suggested, would not be rendered obsolete. For Nadin, traditional criteria would remain an integral part of the aesthetic evaluation of computer art. The majority of participants clearly stated that further technological developments would be of little consequence toward the rejection of traditional criteria. Furthermore, they agreed that computer art should be viewed as a pedigree of fine art and should be firmly embedded in its heritage.

While modernist aesthetics was reaffirmed as the only valid and workable criteria among the majority, there was nonetheless a "dissenting faction within the group" who believed "criteria in general are transitory and often short-sighted," therefore of "dubious distinction to a lasting evaluation of any form of art."[26] The idea of aesthetics, like greatness in the canon, had become contested since the 1970s. These artists were responding to the widespread postmodernist questioning of value judgment inherent in modernist orthodoxy. Following current radicalism, the artists claimed that there was no basis for value judgments and aesthetic criteria.

In addition, among these dissenters there was a call for computer artists to engage in the social realities of the day. Historically, computer art, through its emphasis on abstraction and instrumentality, had been isolated and disengaged from social and political spheres. The progressive respondents, led by Youngblood and Schwartz, believed that art should be evaluated "regardless of the medium" and that other factors should come into play, such as how the work "contributes to contemporary society" and how it reflects and challenges "human needs and desires."[27] These commentators sought to define computer art as a historical mode of praxis, socially constituted and in a constant state of flux, in contrast with the impersonal temper and detached abstraction of previous computer art.

Apart from the shift to social contextualization, the study highlights the trend toward the subjugation of the technical dimension of the computer. While there was a willingness among respondents to acknowledge the existence of unique properties within the computer, they found those factors did not justify "new aesthetic criteria" or the title of "innovative art."[28] This is a substantial shift from those previous beliefs that supported the formation of a new criterion based on unique functional attributes. This Greenbergian model looked to differentiate computer art—to claim autonomy from other art forms by defining its central characteristics. Other participants, contradicting previous thinking, sought to separate the production from the product. Youngblood cautioned against confusing a technique with the art form: "The properties of a medium, the techniques that define it, do not constitute the exploration which they may facilitate."[29] The uneasiness over the conflation of process and art was constantly evident in the disdain for the term "computer art," which failed to make that distinction. For example, Nake felt that the term suggested that the "computer adds aesthetic reality to a given piece"—for him this was a "horrible suggestion."[30] For many, the term "computer art" burdened the work with functionalist ideals and the need for esoteric technical understanding.

The anxiety over computer art's accent on production was paralleled by the general concern that technology had often subordinated creativity. For Nadin, the computer was still "controlling the artist."[31] Similarly, for Nake, the medium was "surpassing the message almost totally."[32] Csuri also warned against the overt celebration of "interactivity," because the "novelty of such technology" may "overshadow the aesthetic function of that object."[33] Many of the study's respondents reiterated the point that traditional art also had highly diverse interactive modes. Csuri warned against inflating the potential of artificial intelligence, which had not reached the initial expectations forecast by its proponents and advocates. This skeptical response, widely shared within the study, shows that the attitudes of technoscience and modernist paradigms were beginning to wane. Equally, there developed an increasingly sober view of the endemic futurology that had been such a dominant feature of computer art discourse.

While the study's objective was to provide a consensus, the report reached no firm conclusions. If anything, it restated modernist aesthetic criteria. The study highlighted the many contradictions, paradoxes, ambivalences, and diverse ideologies inherent in the computer art movement. The study seemed to suggest that the former hopes of engendering a new art form with its own criteria (as photography and later video achieved) would never materialize. As the ever-pragmatic Csuri suggested, no "new reality or point of view" or anything that resembled an art "movement" had appeared.[34] In 1989, these views and attitudes surfaced with such intensity that computer art became thoroughly destabilized. Nevertheless, by the time of the conferences and articles of 1989, there was a new attempt at a consensus of opinion. However, this time the new critical discourse, which had reshaped much art theory and history, would have a greater role in redefining art made with advanced technology.

The trend toward criticality, which had been evolving slowly since the mid-1980s, climaxed at the close of the decade. For the first time, writing on computer art contained references to critical and postmodern philosophers. In 1989 Timothy Binkley wrote that the computer was rising from the "sea of Postmodern culture not as a new Venus promising more beautiful art, but as a wily sorcerer taunting us with its cleverness."[35] Suddenly computer art was being theorized through thinkers such as Walter Benjamin, Michel Foucault, Jacques Derrida, Roland Barthes, Jean Baudrillard, and Jean-François Lyotard.

The appearance of critical discourse in the computer art field was part of a larger trend in visual art discourse. During the 1970s, the discipline of art history underwent significant reorientation toward the social-critical. The culmination of this trend in art-historical practice was called by some the "new art history." Like the broad intellectual movement of postmodernism, the new art history had its roots in the political and ideological activism of the late 1960s. During and after this period, class, gender politics, and the nature of capitalism and imperialist nation-states came under intense critical investigation. Art history also came under the influence of these more radical trends. Influenced by the social histories of art written by T. J. Clark and others in the 1970s, historians and critics alike became increasingly interested in the political and social critique of art, art criticism, and art history. Modern art and its histories came under intense evaluation. Traditional aesthetics, connoisseurship, antiquarianism, historical narratives, and the representation of ethnic and sexual identity became the subject of criticism. As the paradigm of social criticism developed, organizational categories and concepts began to surface. A raft of critics and theorists, such as Rosalind Krauss, Douglas Crimp, Craig Owens, Victor Burgin, Hal Foster, and many more, employed a variety of these critical methods. They developed in the 1980s a broad critical art history under the standard of postmodernism. In the late 1980s, these contemporary art theorists were increasingly engaged by computer art commentators in the theorization of art and technology.

In the 1980s, postmodernism in its varied forms had a powerful effect on the contemporary imagination. By the late 1980s, it was the dominant cultural paradigm for a wide variety of cultural practices and theoretical positions. Its critical and descriptive range extended across various disciplinary and discursive boundaries. Once its eclectic, adaptable, and transformative character emerged, postmodernism became, as Stuart Sims described, a veritable machine for producing discourse.[36] It was only a matter of time before postmodernism made a similar incursion into the remote and marginalized field of computer art.

Postmodernism entered computer art discourse relatively late compared with its arrival among other art forms. In the late 1980s, critics began considering the political potential of mass culture through its different technological modes. Beyond postmodernism's new relationship with technology, the driving concept of 1980s cultural politics was the deconstruction of modernism. The critique of modernism and its institutions was the primary critical strategy that postmodernist commentators used in deconstructing computer art and its discourse. Importantly for this new breed of commentators and artists, postmodernism refined, as Lyotard suggested in his seminal text, "our sensitivity to differences" and increased "our tolerance of incommensurability."[37] Computer art had always remained incommensurable. Now finally there was a discourse that recognized, and was receptive to, the marginalized and incongruous. For the new computer artists and theorists, postmodern discourse seemed to possess the means to create a sustainable and firm foundation for the further conceptualization of computer art. Here, also, was the chance to enter the mainstream contemporary art debate by embracing the dominant critical paradigm. Paradoxically, by eschewing the prior dominant paradigm of modernism to which it had been so attached and by joining forces with a new dominant paradigm that advocated listening to the marginalized, computer art could finally function in the expanded field of contemporary art.

The intention of the new postmodernist commentators was to fill the critical and theoretical void that had plagued computer art since its inception. Both the science-orientated and mainstream art commentators had acknowledged the hitherto lack of critical rigor. According to Robert E. Mueller, those who had theorized computer art prior to the 1980s had been mostly "upbeat and reassuring."[38] In the early 1980s, Mueller recognized that commentators were being seduced by the "dazzling new scientific techniques" inherent in computer art production and advocated that those interested in computer art should study art and its histories.[39] Likewise, Harold Cohen felt there was an absence of critical engagement:

> That computer art has lacked criticism almost completely is perhaps the most important reason why I don't want anything to do with it. Computer art exhibitions are like mail-order catalogs: everything marvelous, everything up-to-the-minute or just dressed up, and nothing ever presented or discussed, under any circumstance, in terms of its significance.[40]

Many believed that computer art needed a historical tradition or critical context in which to assess the artwork. For Roger Malina, the shortfall of "adequate theoretical, historical, and critical framework" was the largest "impediment [to] assessing the significance of computer art."[41] As artist and critic Terry Gips noted in 1990, it was "nearly impossible to find informed and thoughtful critical writing about art made with the computer."[42] From the beginning, computer art had a reputation for being uncritical. Indeed, the Computer Art Society, established in London in the late 1960s, had decided against applying "heavy criticism because this would discourage potential artists."[43] One of the main objectives of the new postmodernists was to break the existing stalemate over computer art's position within art. Writing in the 1990 *Art Journal* issue "Computer and Art: Issues of Content," Terry Gips asserted:

> While conferences and journals have over the years provided forums for the fruitful exchange of *technical* concepts, many artists, curators, and critics have bemoaned the lack of a *critical* dialogue…In practical terms then, this issue is an attempt to mitigate the existing condition and, through texts and images, establish a more solid theoretical ground for producing and understanding digital art.[44]

There was a need, said Gips, to "push beyond description" and "grapple with the much more demanding issues of content."[45] Significantly, these quotations, beyond indicating the move toward a perceived need for criticality, reveal the shift toward the use of the term "digital art" instead of "computer art." Gips recognized the different and often superfluous connotations of the numerous terms available. Like many of her contemporaries, she used the terms "digital art" and "computer art" interchangeably, thus forestalling precision and lucidity. Nevertheless, the term "computer art" had a fundamental problem which arose when there was a complex intertwining of traditional analog, electronic, and digital technologies, and when the artist had no desire to proclaim the medium as central to the work. In fact, artist Judson Rosebush proclaimed in 1989 that "computer art has become a meaningless term."[46] That same year, Brian Reffin Smith proclaimed this to his readers: "Let us make an art that does not need the computer to justify it."[47] Positively, for the postmodernist, the term "digital art" suggested a comprehensive process without linking the computer—the hardware itself—directly to the art. The terms "electronic art" and "new media art" also broadened the definition and placed emphasis on an overall technological process rather than a particular medium or machine.

The objective of the new critical stance, besides providing an alternative to the term "computer art," was to identify and if necessary recast the history of computer art. Gips reminded the reader that in the current climate, where artists had a newfound attraction to computers, it was "easy to forget" that the computer had a history in the arts.[48] She pointed out that pioneering artists since the 1960s had "investigated technically, aesthetically, and philosophically" those issues that seemed so "freshly urgent."[49] For Gips, those pioneers, while making a history, have "worked without the benefit of *having* a history of computer art."[50] The computer artists, Gips suggested, "lacked a critical mass with regard to production, audience response, and constructive discourse."[51] She explained:

> As a result, the issues of computer art remained less than fully formed, and the art itself, struggling in an infertile environment, failed to ripen. Through those years, work produced was occasionally a portentous venture into new territory, sometimes an interesting recasting of a former work but too often an empty outburst of technical bravura.[52]

Like Lucas' findings, the previous emphasis on production over content was increasingly disparaged. The technical development of the medium, a product of its close allegiance with the scientific world, had for Gips produced only trivial objects. The "old" computer art, while having a strong technical history, had no art theoretical basis and hence lacked the language and the critical tools that were fundamental to the maturity of an art form. Only now, Gips argued in 1990, wrestled away from the superficial world of functional expedience, could the real history of art and technology be told. Gips and others appeared to be unaware of the experimental aesthetic, along with other technoscience discourses, that had underpinned computer art for more than a decade. Computer art had a theoretical basis, to be sure, just not one that emanated from the arts.

For Gips, the function of the new critical discourse was to address the process of "incorporating electronic technologies into the art-making process," and to prompt a "rethink" of the "definitions of technology and its relation to art throughout history."[53] It was no longer a matter of merely humanizing technology—the highly suspect modernist approach—but of redefining technology in terms of its holistic and disruptive forces. Increasingly, under the banner of postmodernism, technology was politicized.

The important factor for Gips and other postmodernists was that computers "disrupted the agenda of modernism."[54] For Gips, "digital technologies have served as a garish yellow highlighting pen, causing many of the old modernist dilemmas to jump off the page."[55] Following Lyotard in particular, new computer art commentators called for the deconstruction of the meta-narratives of modernity. This method criticized modernist value systems and their claim to authority in the field of artistic activity and theory. Rejecting the pretension of totalizing theories and modernism's perceived authority, the postmodernists became defenders of difference. Postmodernism finally offered a critical mode that overcame the tyranny of modernism. For computer art, modernism had remained an elusive paradigm and it was unable to fully conform to modernism's major tenets.

One common approach taken by the postmodernists was to align computer technology with the history of photographic technology. Photography's history in the arts and its potential as a disruptor or subverter of modernist values became a key trope in the postmodernist position and so proved a useful basis on which to cement computer art's claim as a postmodern practice.

Margot Lovejoy was one of the most significant figures in applying postmodern theory to art and technology discourse. In 1989, as an artist and critic, she published the influential *Postmodern Currents: Art and Artists in the Age of Electronic Media*, which positioned art and technology as part of the larger cultural postmodernist trend.[56] For Lovejoy, electronic technologies were emblematic of the postmodern era. She believed that technological change transformed consciousness, disrupted modernist conventions, and forced a redefinition of representation and its evaluative criteria. She viewed current cultural trends through older technologies and their histories. In her *Art Journal* article, Lovejoy highlighted the "parallel relationship" between photography and electronic media in heralding a new age.[57]

Like photography's influence on the dynamism of modernism, the postmodern shift, for Lovejoy, was being driven by electronic media. She also voiced a common belief that 1980s visual culture was a parallel moment to the "one that arose when photographic technologies posed a threat to the art institutions of the nineteenth century."[58] Following the lead of other postmodern art theorists, she situated Walter Benjamin as the pivotal figure and advocate of new reproductive technologies. He provided a "framework for understanding the forceful impact of technological media on society" as well as "its disruption of the fine arts."[59] Benjamin believed that improvements in the technology of mechanical reproduction would lead to a reduction in the criterion for authenticity, to a deteriorating of the aura of originality, and to a crucial revaluation of technical categories.[60] The postmodernists were not the first to make a connection between computer art and Benjamin's theories. Marc Adrian, in the 1969 catalog *Kunst und Computer*, believed that the practice of computer art would inevitably lead to the "destruction of the prestigious 'aura of the work of art.'"[61] Lovejoy, like other postmodernists, felt that photography had become a primary instrument in the deconstruction of modernist conventions. It had become the "chief catalyst in rendering out-of-date many mythical and mystical notions about art."[62] Following in the footsteps of photography, computer art, with its reproductive capabilities, had partially collapsed the boundaries between high and low art and questioned the aura and the ritualization of the art object. Post-industrial technology, instead of being linked to the Enlightenment idea of progress that characterized early discussions on computer art, was now envisaged as a disrupter of traditional orders.

Since Douglas Crimp's 1977 exhibition *Pictures*, photography had been increasingly identified with the assault on modernist representation and its claims of originality. And by the mid-1980s, postmodernism became the orthodox position for those engaged in writing about photography. Importantly, some critics and art theorists had accorded the status of avant-garde to many photographers. Following a long period of marginalization, photography was considered central to the postmodern shift and, importantly for Lovejoy, it was given a key position in the modalities of contemporary art. Lovejoy also believed that photography had originally been dismissed as an art form for many of the same reasons as other technologically based arts, including computer art. Employing the same critical modes in which photography gained primacy in the mainstream, Lovejoy argued that computer-based arts could also acquire a significant position at the forefront of contemporary art. By discussing the avant-gardist photographers Barbara Kruger, Cindy Sherman, and Robert Mapplethorpe in relation to computer and electronic art, Lovejoy posited electronic art as part of the larger mode of reproductive technologies that had recently been employed to emphasize the pluralistic polemics and cultural imperatives of postmodernism.

The theorist and computer artist Donna Cox, writing in the 1989 *Leonardo* issue, also used photography as a comparative measure and template for the discussion of computer-based art. For Cox, photography had emulated painting until it found its own purity. This corresponds to the history of computer art which, after copying older styles, asserted its essential character through algorithmic and interactive modes. Cox's analysis relied extensively on a quintessential postmodern art text, Brian Wallis' *Art After Modernism* (1984).[63] She somewhat crudely framed computer art within the history and contemporary strategies of photography by merely inserting "computer art" into a quote from the original text:

> Virtually every critical and theoretical issue which postmodernist art may be said to engage in in one sense or another can be located with photography [and computer art]. Issues having to do with authorship, subjectivity, and uniqueness are built into the very nature of the photographic [and computer] process itself.[64]

Postmodernism, for Cox, was the "new systemic cultural norm," and through its success in a wide range of philosophical and social discourses it could become an important instrument in the theorization of computer art.[65] However, for Cox, a shift needed to occur in postmodernism in order to "assimilate such alien aesthetic activities" as scientific visualization and computer art.[66]

Timothy Binkley, like Lovejoy, also applied postmodernist theory to the art and technology field.[67] Writing in the 1989 issues of both *Leonardo* and *Art Journal*, Binkley believed that the computer should not be placed in the modernist context; rather, because of its conceptual orientation, computer art was postmodernist in character. He formulated the influential theory that designated the computer not as a new medium, but as a "metamedium."[68]

To describe it as a new medium is for Binkley retrograde, since its conceptual and simulating properties (correlated to contemporary postmodern strategies) overcame the delimiting tendencies of modernism.[69]

Binkley's *Art Journal* article stressed computer art's theoretical alignment with postmodern discourse by confirming the existence of four common themes or attributes: conceptualism, pluralism, simulation, and metadiscourse. Binkley saw computer art as part of the trend toward the dematerialization of the art object. The inherent abstraction and symbolic mode of computing meant that the art sat easily in the sphere of conceptualism. Like the previous postmodernists, Binkley believed the computer to be radically pluralistic. The digital interactive interface format, its speed and memory, its potentiality, and its interconnectivity meant that there were new modes of experiencing cultural information across diverse fields. Binkley also found that computers fostered a method that was opposed to metanarratives.

While most critics celebrated the postmodern era and posited technological change as emblematic of postmodernity, Beverly Jones, writing in *Leonardo*, chose not to use the term. Nevertheless, like all of the commentators and theorists, she built on the decentering strategies practiced by the postmodernists. She used deconstructionist theory to excavate the ideologies of computer-generated imagery, and believed it was in accord with the broader post-structuralist project.[70] She also felt that post-structuralist strategies would bring a degree of theoretical rigor and historically specific analysis to computer art forms. Like the previous commentators, Jones initially viewed computer art in relation to the "controversies and dilemmas" of photography's history and took a "holistic" view that refused to attach objects to their "disciplinary divisions," which she believed was "arbitrary, valueless, falsifying and obscuring."[71]

The postmodern practice of refusing to categorize was adopted at the 1985 Paris art and technology exhibition *Les Immatériaux*, which made no distinctions between artists' and scientific images.[72] Curated by the postmodernist philosopher Jean-Françios Lyotard, the exhibition "sought to chart the new order of our postmodern condition."[73] Following Lyotard's lead, Jones felt that modernist art focused on categories and boundaries and thus missed the "larger cultural context" of art's praxis, reception, and cultural meaning.

By focusing on formal characteristics and definitions, the analysis failed to reflect the "larger models of cultural reality."[74]

Most importantly perhaps, postmodern critical theory provided a platform to attack computer art for its inherent conservatism. Throughout the climate of political radicalism that characterized the 1970s, computer art remained ostensibly apolitical. Not until the mid-1980s did any computer artist, such as Copper Giloth, reflect the broader changes in contemporary art by making a substantial polemical statement. Even when Giloth in the 1980s approached the controversial topic of abortion in her installation *Clothes Hangers*, she found her peers in the computer art movement to be "uncomfortable," preferring instead to avoid highly politicized topics.[75]

The most forceful written polemic was given by Brian Reffin Smith in the 1989 *Leonardo* issue "Computer Art in Context." A regular iconoclast of computer art and its conservative tradition, Smith wrote what was perhaps the most radical critique attempted to date. The article entitled "Beyond Computer Art" began:

> Let us first agree that most "computer art" is old-fashioned, boring, meretricious nonsense; and then that most of it is done by people whose knowledge of contemporary art and its problems is more or less zero; and then that most of this "art" is actually a demonstration of the power of a few companies' graphic systems; then that most of the "art" is really graphic design, produced for graphic design-like (and thus not art-like) reasons; and finally that there is a sort of "mafia" of people who produce, teach, and write about, judge at competitions and generally celebrate and curate this "art."[76]

With an irreverent tone, Smith told his readers that they should not be surprised that "proper" art galleries critically ignore computer art.[77] Nor should one be surprised that computer art, although having been "around for 38 years," had "virtually no place in the archives of contemporary art, not even in the interstices reserved for phenomena such as video or 'technological' art."[78] With biting satire and parody, Smith derided the amateurism of technologists and scientists who produced "symmetrical whirls and spirals as if from a supermarket drawing toy."[79] Mocking the work as trivial, Smith described pioneering computer art as the stuff their "mothers used to make by banging nails into a piece of wood and stretching thread in between to make patterns."[80]

The problem for Smith was that computer artists were too closely allied to the economy of computer companies, which meant that they were far removed from contemporary art concerns and debates. Computer art was, for this iconoclast, inherently associated with the rhetoric and ideals of technology. For Smith, computer artists—really technologists in disguise—were Robinson Crusoe figures, inhabiting a "kind of conceptual desert island" in which they trudge aimlessly around its fractal perimeter, desperately seeking SIGGRAPH, and far from the concerns and purview of contemporary art.[81]

Smith went on to further criticize the conferences that provided support for computer art by stipulating that if "film is the truth 24 times a second…computer art shows and conferences tend to be lies and humiliation once a year."[82] Lamenting the fact that computer art could have been the "most revolutionary art form ever," Smith blamed those self-deluded opportunists who "hijacked" and transformed "banal nonsense into value-added insults to the intelligence."[83] He added that computer art, in the hands of technologists and their domineering high-tech companies, had become banal and conformist.

Smith believed that there was a need to move beyond computer art so that it could be employed to tackle the important sociopolitical debates of the day. Smith's own politicized work, which attempted to demystify and undermine conservative traditions—the pervasive Thatcherism he saw—in politics and art, functioned in the public domain (Figure 5.1). He believed that computer art should provoke, question, and challenge the body politic and that this should happen to the point where computer companies, which normally collect computer art, would reject it. This could only be accomplished, according to Smith, by not confusing graphic design with art, which had its own critical agenda. In addition, ideas should be taught along with the technical aspect of computers, so technology is demystified rather than deified. At the time, Smith felt that there was too much of an emphasis on the latest computer technology, which blinded the artist to the potential of older technologies and created a situation in which the artist would forever be shackled to those ideologies of technology that supported capitalistic economies. To prevent this, there needed to be a shift in pedagogic strategies—a

FIGURE 5.1 *Brian Reffin Smith,* That Cher Evil, *1988. Photographic reproduction of plotter drawing on billboard, Hamburg, Germany. © Brian Reffin Smith.*

move away from expert technician toward ideas-based tutors. This would precipitate, as Smith suggested, the inclusion of "critical discourse and contextual and productive references *in the artwork itself*."[84]

Smith's call for a critical dialogue contrasted dramatically with the positions occupied by contributors to the 1989 *Leonardo* issue. The *Leonardo* issue revealed a spectrum of ideologies and attitudes, whereas the *Art Journal* series put forward a more homogenous and unified critical position. While the postmodernists in *Art Journal* were devaluing the mainstays of modernism, such as ideals of uniqueness, authorial genius, and formal purity, many computer artists from *Leonardo* were advocating a return to modernist principles. Tom DeWitt, a computer artist, proposed that the term "computer art" should be replaced with "dataism." His manifesto (again a written declaration that was modernist in tradition) called on the computer artists, whom he called dataists, to embrace the "innate formalism" within the programmed procedures of the machine.[85] The aim was to build on the remnants of modernism in order to reverse the iconoclasm of anti-art movements such as Dada and to restate "traditional aesthetics through formal practices."[86]

The dataists were to go forth and "build a foundation for aesthetic structures," to "enjoy an integrity that is possible only when a common language is used to communicate the processes of creation from generation to generation."[87]

Apart from the distinctly modernist rhetoric, other commentators in the *Leonardo* issue reinforced the close allegiance of computer art to technoscience discourses. They stressed the importance of existing scientific paradigms and methodologies. Cox advocated the understanding of postmodernism through the cybernetic paradigm, as it provided a model for complex dynamic systems in which "new levels of organization and creativity emerge."[88] She also posited a "cybernetic approach to art criticism," which would provide a more holistic view than the one put forward by modernism and more recently by postmodernism.[89] In fact, Cox lambasted postmodern critics for their "languid historicism" and their failure to "recognize the real 'new,'" which she saw as the new mode of scientific aesthetics and visualization emerging from the interdisciplinary fields of science and technology.[90] Cox believed the artist's expertise should be put into the service of science.[91] Working at the National Center for Supercomputing and Applications, Cox accomplished important work in the field of scientific visualization. Her participation enriched the process of scientific discovery and revolutionized the way scientists employed simulations. In the late 1980s, scientific visualization was, according to Margaret Neal, in a "hot phase" because it ignited within the scientists and mathematicians "new insights, new directions for research, [and] new knowledge of the subject."[92] Centered on the potential for new knowledge through scientific visualization, a number of artists joined with scientists, computer scientists, and engineers in government and privately funded institutional research groups, including the celebrated Electronic Visualization Lab at the University of Illinois at Chicago. Cox felt that the future of art existed in these collaborations, what she called "Renaissance teams."[93] The collaborative group (art)n founded by artist Ellen Sandor in 1981 at the Illinois Institute of Technology became internationally celebrated.

Many computer-based artists were still deeply involved in scientific research methodology, particularly through mathematics. In the 1989 *Leonardo* issue, Roger Malina (now the executive editor of the journal) reiterated the importance of computer art to science, especially in the popularization of mathematics. Responding to

David Carrier's question of whether "any art using computers is truly significant," Malina answered in the affirmative—especially, he asserts, when one considers computer art's role in the promotion of the abstract sciences.[94] Malina, evoking the writings of Marshall McLuhan, believed that "the conscious role of the artist is to explore and create awareness of the new environment created by new technology."[95] Following his father Frank Malina, who was the founding editor of *Leonardo*, Roger also felt that one of the roles of art was to "mellow the applications of science and mathematics."[96]

The humanization of the abstract sciences and technology had been a continuing preoccupation within the computer art project. Frank Malina had believed, as *Leonardo*'s editor Pamela Grant-Ryan wrote, "artists in particular should be instrumental in developing technology towards humane ends."[97] His son felt that in the current context, with the artist's social role as "humaniser, commentator and coloniser of technology," the computer art project had indeed become significant.[98] He used Cox as an example of a colonizing artist who successfully controled "the most advanced technological tools."[99] This position located art in the service of science and technology, while the opposing postmodern position recognized technology in the service of cultural politics.

Like the artist-programmer puritans, Roger Malina advocated the primacy of the computer's essential character as computer art's dynamic force. In direct opposition to some of the postmodern commentators, he believed that the more significant computer art took advantage of the "unique new capabilities made possible by the computer."[100] Making a distinction along technological lines, this position encouraged judgment to be made on the art's unique production, rather than on aesthetic grounds. Malina, while noting the need for increased contextual and historical understanding, encouraged the new generation of theorists and historians to "pay particular attention to art that could not have been made *without* the use of a computer."[101] Significantly for Malina, the mode of analysis emerged from the computer's specificity. Again, instrumentality and the mode of production were emphasized over content. Placing primacy upon the essential aspects of the medium directly contradicted the postmodernist line, which called for the inevitable separation of process and product.

The accentuation of process and instrumentation followed a trend previously promoted by Frank Popper, who later emerged as a major historian and commentator on computer and electronic art.[102] In 1987, Popper felt it was necessary to adequately define the new artistic trends rising from a technologically advance society. He believed that in the 1980s the trend in technological art had been renewed and strengthened, and it had become increasingly visible. It was essential, Popper thought, to devise a strategy that would make these new art forms more "perceptible to the public."[103] This meant differentiating the new artworks from both their forerunners and their fellow artists working within traditional media. For Popper, the exhibition *Les Immatériaux*, with its "postmodernist bias," made no "categorical distinctions" between artistic and scientific images, and this, for him, created an uneasy ambiguity.[104] In contrast to the postmodern position, Popper felt that any future exhibitions should have its parameters "rigorously defined."[105]

Popper said that the artists who had taken part in the myriad of exhibitions through the early 1980s fit between two extremes: "those who use or pretend to use 'technoscience' as a tool only and those who wish to show through their works the aesthetic properties of scientific or technological phenomena or achievements."[106] Popper mistrusted those who employed technology as merely a means to an artistic end, with no investment in the wonder of science and technology. Likewise, scientists with a pretension for artistry who popularized their research with aesthetic decorations were dually unwelcome. While the "artistic imagination must dominate over scientific inspiration," the ideal artist for Popper "must have a strong interest in up-to-date scientific methods and/or discoveries and their technological applications."[107] He conceived of an artistic practice that had continual links to scientific and technological knowledge, yet had the necessary aesthetic dimension to keep it from pure scientific imperatives. Attempting to overcome the "overabundance of often arbitrary and absurd appellations" circulating at the time, Popper offered the term "technoscience art."[108] As the term suggests, the art that Popper was endeavoring to define was intrinsically linked to the institutions, parameters, and theories of science and technology.

As demonstrated, computer art and the wider field of electronic art had an innate connection to the ideologies of technoscience. Prevalent within computer art discourse and inherent in traditional technoscience paradigms was an underlying modernist ethos. Deep within the computer art consciousness was a desire for uniformity and a need to locate the internal logic of the art form. This was a part of the larger project of self-discovery and theoretical self-formation that computer art had embarked upon. Computer commentators and artists were continually concerned with notions of continuity, tradition, and evolutionary development. Like modernist orthodoxy, computer art had striven for a necessary self-reflexivity in its exploration into its own essential nature. Computer artists wanted, akin to Greenberg, to move toward greater autonomy in the definition of art. This usually took the form of differentiating the computational medium from others or creating a formal systematic criterion for computer art's evaluation and criticism. With a preference for internal properties, intricacies, and evaluation criteria, computer art's approach was essentially modernist in design.

Likewise, orthodox computer artists desired to achieve a distinctive style within their body of work, which followed the modernist imperative to invent personal and private styles.

Proponents of computer art also continually evoked the Hegelian modernist metaphor of growth and maturity. As explored in the previous chapter, computer art discourse is riddled with historical and teleological self-absorption. The computer artists and exponents continually looked forward to a new historical epoch, a kind of Hegelian imagining, where computer-based art would finally mature into an acknowledged and valued art form. Most often computer art narratives assumed an unbroken technological progress stretching indefinitely into a promising future.

Part of computer art's utopianism was the positioning of the computer artist at the vanguard of advanced technology. Up to the late 1980s, computer art never moved far from the concerns of modern science and technology and their underlying Enlightenment objectives. In many respects, computer art was another attempt to fulfill the Enlightenment dream, wrought by Descartes and Leibniz, of the mathematization of the world. Abstracting art, a core pursuit of the computer artists in the 1960s and 1970s, was applicable to the pursuits of the scientific revolution: formulate rules of method that aim at "disciplining the production of knowledge by managing or eliminating the effects of human passions and interests."[109] Computer art owed its heritage to one of the core features of modernity: the commitment to the ideals of technological progress—or, as Habermas wrote, the "infinite progress of knowledge and … infinite advance toward social and moral betterment."[110]

Through the art of programming, computer art had always been encumbered with a sober rationalistic mode of consciousness. Moreover, the computer as a machine was ultimately linked to instrumentalism. The postmodernists had been critical of universal pretensions of rationality, one of the most cherished assumptions of the orthodox Enlightenment. The overt abstracting and reductive process of programming appeared to run against the grain of postmodern pluralism. In addition, computer art had been throughout its history preoccupied by the ideology of the "new." For the postmodernist, the pursuit of formal or artistic innovation for its own sake was judged futile, because it resulted in novelty without authentic artistic or creative meaning. Kenneth Knowlton believed that computer art was not yet "beyond the gee-whiz state of cuteness, of stunts, and of novelty for its own sake."[111] The cult of originality, which underpinned the modernist avant-garde, was located in computer art's futurological claims of newness and innovation. Although it undermined the cult of originality through its reproductive techniques, as with Benjamin, the computer had its own capacity through its expanding protean character and rampant evolution to produce unique and original forms. As mentioned in the first chapter, many computer artists, technologists, and scientists saw themselves as the new techno-avant-garde. Like the modernist avant-garde, computer artists saw themselves as invading unknown territory, conquering, as Habermas wrote, "as yet unoccupied future[s]" and recognizing directions in "a landscape into which no one seems to have yet ventured."[112]

Part of computer art's modernist historicizing model was the direct attempt to prepare a history of art production by tracing it to earlier forms of abstraction, especially constructivist modernist movements. In Franke's early history, a bridge was constructed from early abstract movements such as constructivism to 1960s computer art, which was reinforced by later commentators. As a way to legitimize the form, Franke and others constructed a genealogy by showing that it had evolved from past forms, thus historically situating computer art within the history of art. Rosalind Krauss noted this modernist impulse in her analysis of contemporary sculpture:

> No sooner had minimal sculpture appeared on the horizon of the aesthetic experience of the 1960s than criticism began to

> construct a paternity for this work, a set of constructivist fathers who could legitimize and thereby authenticate the strangeness of these objects.[113]

Apart from its modernist historical framework, computer art continued to be dominated by formal aesthetics. Even though there was no agreement on specific aesthetic criteria, abstraction and formalism dominated computer art right through the 1980s, despite a shift away from the purity of formalism. Nevertheless, at the same time the, reductive and austere traits of modernism also gave way to the postmodernist idiom of pastiche and appropriation. The predominant attitude of postmodernist theorists was that formalism was a throwback to outmoded modernist aesthetics.

Predisposed by postmodernism, the new critics saw computer art as a nostalgic revival of modernism. This is why many mainstream critics described computer art as anachronistic. Jasia Reichardt positively described computer art as the "last stand" of abstract art, while Roy Ascott dismissed the conventional and crude use of the computer because it rehearsed and reiterated the "strategies of modernism and formalism."[114] Youngblood, in the early 1980s, pointed out that computer art was understood and put into the "service of those very same visual art traditions which the rhetoric of new technology holds to be obsolete."[115] Therefore, with computer art so entrenched within the modernist tradition, the new theorists saw it as their task to bring computer art under the rubric of postmodernism. For *Art Forum*, Kate Linker construed this ultimate disjuncture between the modern and the postmodern vision by comparing the exhibitions *Cybernetic Serendipity* and *Les Immatériaux*:

> "Cybernetic Serendipity" was launched in the name of Modernity, an ideal that, since the time of Descartes, has focused on the will and creative powers of the human subject…Underlying it was the premise of "technoscience" as a prosthetic, or aid, to universal mastery; the cybernetic revolution appeared to accomplish man's aim of material transformation, of shaping the world in the image of himself.[116]

The earlier exhibition was firmly framed within the modernist paradigm while *Les Immatériaux* captured, with its decentered, nonlinear construction and with its famous postmodern curator, a particular postmodern moment.

Popper was right to allude to the incompatibility of computer art with the postmodernist project because computer art was heavily invested in the modernist paradigm. Whereas computer artists celebrated technological progression, postmodernists turned away from what they saw as technocratic purism. Presenting computer art as an essential postmodernist strategy was problematic on many levels. Although there were undoubtedly some features that brought it under the rubric of the postmodern, the attempt to align computer art with postmodern preoccupations tended to be faddish. Those who had espoused postmodernism used critical theory in an uncritical and eclectic way. The new computer art theorists and commentators did not fully develop the critical approaches of contemporary art theorists and critics; rather they picked and chose the most suitable elements from postmodern criticism while ignoring the incompatible aspects.

The postmodernists essentially denied the link with modernism by placing computer art's genealogy within the historical context of disruptive technologies, primarily photography. However, the postmodernists' way of theorizing contemporary photography was not as adaptable as they assumed and offered a poor model and ill-fitting paradigm for the critique of computer art. For example, the postmodernist critics ignored the inherent differences in each technological form. Computer art, although mechanical, could not make the truth claims of photography. Although it shared origins in science and technology discourse, the computer did not originate from a visual heritage, rather it was from the beginning fully symbolic. At its beginnings, computer art was not naturally pictorial and did not have that almost immediate recourse to portraiture, as photography had. And computer imagery did not have the same causal link to natural phenomena or to the genre of landscape that photography shared with painting. Furthermore, through the semiology of Roland Barthes and the cultural analysis of Benjamin, the photograph had become not just an aesthetic object, but a medium in which to explore theoretical matters.

Yet there were historical similarities that were missed by the theorists. Like the birth of photography, computer art was invented by individuals with scientific or technical backgrounds, and the first photographers, like the first computer artists, began by mimicking well-established genres with simple forms of appropriation.

Computer art also differed from the overt polemics of postmodernism. In the early 1980s, art critics such as Donald Crimp, Hal Foster, Rosalind Krauss, and Craig Owens gave the debate on postmodernism a new, political direction. Their politics were based on poststructuralist theory and the Foucauldian belief in the interconnectedness of representation and power. As mentioned before, early computer art had been ostensibly apolitical. Historically, computer art theory was relatively unaffected by the social and political radicalism that permeated the society in which it emerged. In computer art and the writings that accompanied it, there was no intellectual critique of modern states and their institutional ideologies. Feminism had little effect, at least until the 1980s, even though women had played a significant part in the art form's development and dissemination. Computer art was conceptually and theoretically pedestrian in the light of the new social and political agendas emerging in contemporary visual arts. Furthermore, computer artists were still attempting to gain access to the institutions by arguing their case for legitimacy through modernist normative approaches. The content of computer art was far removed from the politically radical, anti-authoritarian, photograph-based art of Martha Rosler, Sherrie Levine, Barbara Kruger, and Cindy Sherman. Nevertheless, postmodernists such as Cox, Lovejoy, and Binkley all alluded to these artists when arguing for the computer to be inducted into the realm of the postmodern. Although the association was made, there were no examples of computer artists with any overt political message that would coincide with contemporary postmodern photography.

From a postmodernist point of view, if computer art could be labeled irrelevant for its disconnectedness with social and political concerns and its lack of cultural polemics, it also came under attack from postmodernism's characteristic anti-technology stance. Cox recognized this contradiction:

> Many view electronic/computer media as evil, as a primary contribution to the negation of humanism. This technophobic attitude handicaps any emerging technological aesthetic. Unfortunately, computer art was born in the transition between modernism and postmodernism. While both paradigms broach computer art issues, for the most part these issues have been relegated to technological biases.[117]

For Cox, computer art was the "orphan child" of both "high modernist and contemporary art criticism."[118] While it was "shunned" by the modernists for its "lack of purity, authorship, or originality," it was also avoided by the postmodernists for its strong identification with technology.[119] Computer art's emphasis on technology presented a major impediment. Many "postmodern critics would be dismayed," Cox believed, at the way "computer art segregates itself via the medium rather than concentrates on the artist's 'aesthetic activities.'"[120] Cox went on to remind her reader that interdisciplinary activity, one of the "key descriptors" of postmodernism, "prohibits the classification of works merely by the medium."[121]

There were inherent contradictions in employing the intellectuals and theorists of postmodernism to emphasize the importance of new forms of technological art. From its very beginnings, postmodernism embodied a strong current of technological pessimism. Technology as a cynical power inhabits the work of Michel Foucault, Jacques Derrida, Roland Barthes, Jean Baudrillard, Jean-François Lyotard, Gilles Deleuze, Félix Guattari, and later Paul Virilio. In varying ways, the thinkers represented technology, in its contemporary form, as a potential threat to humanity's existence. Within the strong tradition of anti-humanism among French intellectuals, there had been a sustained critique of instrumental or technical reason. For the humanists and anti-humanists alike, the computer became symbolic of modern rationality and instrumental control. These sentiments formed the foundation of postmodernism's anti-humanist tendencies. Like the majority of French poststructualists, Lyotard took a cynical view of technoscience and was influenced by the anti-technology sentiment of Heidegger, who described technology as the affirmation of inhumanity.[122] Jacques Ellul also influenced Lyotard's skeptical attitude toward free technological development. Lyotard's reservations about the implication of technological change are expressed most forcefully in *The Inhuman* (1991), in which he accused technoscience of "marginalising the human at the expense of computer technology."[123] In *The Postmodern Condition* (1984), the seminal postmodern text widely used by the new theorists of computer art, the computer and its instrumental nature came under pointed criticism. For Lyotard, computer technology and information processing were part of the revolution that altered the status and form of knowledge. The consequence was that knowledge in the postmodern/post-industrial age must be "translatable into computer language."[124] For Lyotard, this led to the "hegemony of computers"[125] and the comprehensive "computerization of society."[126] The correlation of knowledge and computing had for Lyotard significant political consequence. Knowledge as an information commodity became an increasingly contested terrain, and the question of control and access became a matter of the politico-economic elite who controlled advancing technology and science. Thus, the post-industrial society was dominated by the spirit of "performativity," which attempted to reduce society to an efficient system, founded on the best possible input/output calculation.[127]

What the new postmodernists of computer art failed to acknowledge was that computer art developed out of those very institutions and systems that postmodern theorists such as Lyotard had persistently critiqued. Many artists worked with and for the large multinational corporations that the postmodern theorists criticized. Computer art, if we take Malina's and Franke's examples, could be seen in a Lyotardian sense as a narrative within the metanarrative of science that was seeking to legitimize both science and technology in the modern state. After all, computer science's initial impulse was to use computer art as the humanizer and popularizer of the new technodigital world.

The postmodernists also described how computer imagery and mediated environments constituted current understandings of cultural simulations, and how these processes fit the Baudrillardian concept of simulacra. Cox conflates scientific visualization, which simulated natural phenomena, with the postmodern cultural concept of simulacra, which removed the individual from the direct experience of reality. Instead of being part of the vocabulary of critical theory, terms like "simulacra" were transformed into emblems of a new, positive, and affirming digital order. Likewise, Lovejoy employed Baudrillard's new conception of the simulacrum to describe the critical challenges awakened by new electronic imaging capabilities, but was unable to describe what those challenges were. For these commentators, discourse on cultural simulation becomes a link to the larger critical discourse of postmodernism, of which Baudrillard had become a significant exponent. There is no intention to employ Baudrillard's model or deal with his more general criticism of mass media and technology.

Both Jameson and Baudrillard took a dim view of mass media culture in which the new postmodern theorists situated computer art. Baudrillard condemned advanced technologies for their part in the information-saturated, hyperreal, post-industrial world. For Baudrillard, electronic technologies were part of the collapse of meaning in the media world. The apocalyptic vision of Baudrillard's media-inundated world contrasted significantly with the celebrated electronic and digital world of the postmodernist commentators. While Baudrillard believed that the revolution in electronic technologies had made us victims of technological determinism, the commentators were more likely to take a more McLuhanesque utopian view of the electronic revolution. Skeptical of technology and the inherent structures of communication and mass media, Baudrillard viewed the present age as a "neo-capitalist cybernetic order that aims at total control."[128] Whereas Baudrillard lamented a world dominated by "cybernetic orders," cybernetics continued to hold a central position from which to understand computer art, even as late as the 1980s.

While postmodernism on the whole was incompatible with computer art, a number of characteristics within computer art were favorable to its induction into the postmodern cultural omnium. However, they went unremarked by computer critics and art theorists of the 1970s. First, postmodern theory signaled that individualism or personal identity, central to modernism, was as Jameson suggested, a "thing of the past" that the "old individual or individualist subject" was "dead."[129] Sherrie Levine posited a refusal of authorship through the rejection of all notions of self-expression and originality. Computer artists and commentators had, from the beginning, celebrated the fact that the computer questioned the artist's role in production and creativity. The humanist commentators of the 1960s and 1970s bemoaned the displacement of the artist. Because computer art questioned the privileged philosophical and political status of the subject, it incurred the criticism of many humanists. Artificial intelligence decentered the subject. Knowledge, for the artificial intelligence exponents, was not based on a finite or contingent subject, but on what could emerge from an intelligent machine. For the anti-humanists, however, the artificial intelligence project remained comfortably within the boundaries of the humanist tradition. The computer continued as an instrument for the empirical study of man and never strayed from the narratives and ideologies of the Enlightenment, which reinforced the centrality of the subject.

Second, computer art had a history of appropriation. While many computer art critics lamented the regurgitation of old styles, postmodernist theorists such as Jameson had stipulated that "stylistic innovation is no longer possible" and "all that is left is to imitate dead styles."[130] Over a decade before Sherrie Levine famously appropriated photographs from celebrated masters, Noll appropriated Mondrian's modern masterpiece, much to the distrust of the art establishment. Admittedly, Noll's work was framed within the scientific paradigm of experimental psychology. In addition, the act of appropriation or mimicry had no political intention and did not parody the stylistic mannerism. It was more an act of homage and an attempt to illustrate the computer's powers of simulation. Although Noll's work had none of the irony or indeterminacy of Levine's, it did manifest the deconstructive sensibility of postmodernism.

Third, computer art was a new form of mass art. The idea had always been firmly embedded in computer art discourse since the early writings of Waldemar Cordeiro and others. Its source can also be traced back to the aims of the constructivists and their democratic ideals for industrialized art production. Postmodernism was also interested in the idea of mass art, and the computer's reproductive and communication capabilities were the most significant factor the new postmodernist commentators used to claim computer art as a postmodern art form. Computer art, with its long-established dream of a mass audience, was posited as another measure in the democratization of art. In the Lucas study, the importance of the widespread dissemination of art was again raised when the computer's unique qualities were mentioned. For postmodernists like Binkley, the interconnectivity of individuals in self-styled information systems meant a future that was "outside the control of large institutions."[131] The situation where artists needed sponsorship and technical assistance from large computer companies was always looked upon with disdain by the art world. For Lovejoy, following Benjamin, computer art with its potential for widespread dissemination now had an increased social function and "currency in the public consciousness."[132] For Lovejoy, the new trends meant that the cultural sphere was "broadened, enriched, and democratized."[133] She also recognized the possibility that computer technology, through its dissemination, could reach a broader audience and expand beyond the confines of the gallery system. With more powerful home computers and graphics software, Csuri believed that a "computer folk art"—an "art of the people"—would emerge.[134] Paul Brown, in an important polemic essay first published in 1989, also called for computer art to break the "stranglehold of the gilded frame and bypass the parasitic high priests and culture vultures to establish an egalitarian art for and by the people … an art from the grassroots of democracy."[135]

While critical discourse initiated a significant trend toward plurality in expression and modes of production, its effect on the orthodox faction within computer art was less pervasive. For them, postmodern discourse was an unwelcome addition to computer art. While many postmodernists, for example Smith, looked upon the pioneering computer art with scorn, many pioneering computer artists felt that the early forms were truer to the uniqueness of computer art. Csuri believed that the "earlier works of art in this field exemplified much more potential" than current manifestations.[136] There were other counter responses, from Paul Brown for instance, with beliefs in 1989 that computer artists "shouldn't waste their time trying to convince the arts mainstream of the value of their work."[137] In direct opposition to Smith's position, Brown believed that computer art's involvement in SIGGRAPH, Ars Electronica, ISEA, and other events represented a vital *Salon des Refusés*, a grouping of those who had not been taken by the pretensions of the mainstream art world.[138] Roger Malina also noted the increasing influence of the then "fashionable French philosophers" at art-and-technology conferences.[139] Brown felt that the "postmodern dogma" of the early 1980s had less sympathy and gave less "support for the high-modernist formalism of system art."[140] The move toward the postmodern worldview meant that art education programs for computer art ultimately suffered, and as Brown points out with some bitterness, Slade's Computer Department closed in 1981.[141] Brown explains the alignment of postmodernism with new interface programs:

> … 1981 was also the year that IBM released the PC and, by the mid-80s affordable computers with lots of "user friendly" software were on the market. Ironically, the art mainstream, who had never endorsed the work of the systems artists, fell over

> itself to accommodate the neat little postmodern appropriations that were created using digital darkroom software (and with a singular lack of consideration for the unique and intrinsic capabilities of the computational metamedium). Baudrillard said it was OK and postmodernism, in its guise as romantic self-indulgence, concurred.[142]

Although critical theory had a certain fracturing and diversifying effect, bringing political consciousness and contextual understanding to computer art, it certainly did not take over as the dominant paradigm in which computer art was understood. While computer art did gain from the erosion of the older distinction between high art and mass culture—a by-product of postmodernism—many felt that the computer and its essential algorithmic form was increasingly lost to pluralist trends. Diane Fenster, who became an important exponent of the digital collage style, said that she had been "fighting the bad press engendered by the original computer art, [which had been] done by programmers rather than artists."[143] Fenster wanted viewers to "view computer art based on content and artistic merit rather than just on the algorithms used."[144] She went on to accuse SIGGRAPH and Ars Electronica of bias toward technique over content. For Fenster, "computer art" was a problematic label that suggested that the judging and criticism should be based on technique. Under these circumstances "it is not an art competition," but a "programming or engineering competition."[145] The bias toward artist-programmers prompted Fenster to spend less time trying to enter computer-based competitions and more time focusing on the "fine art world," where she finally found acceptance in the photographic periodical *Aperture*.[146]

As the computer medium expanded, the term "computer art" became less meaningful. Faced with an ever-growing field, many artist-programmers felt the need to rearticulate the essential features of the computer. Like the postmodernists, they effectively abandoned the term. For artist-programmers, the term did not distinguish effectively those who formulated their own programs (or art systems) from those who used predefined software packages. In the 1989 issue of *Leonardo*, Judson Rosebush wrote the "The Proceduralist Manifesto" to remedy the lack of understanding within the "art industry" and point to the "germane aesthetic issues" at the core of computer-made art.[147] Mirroring previous modernist movements, Rosebush wrote the manifesto as both an announcement of his intentions and an explanation to the art community and to the public. For Rosebush, the term "computer art" with its varying applications had become a "meaningless term" because it lacked the precision and did not accommodate or describe those aspects of the computer medium that made it a "unique movement in the world of art."[148] Rosebush felt that the aesthetic in computer art was intrinsically related to the computer itself—a sentiment common amongst artist-programmers. This differs from the postmodernist position, which valued the computer as a communication tool and an aid to image production and manipulation. Valuing technological transparency, the postmodernist rejected any medium-based purism.

For purist artist-programmers, such as Rosebush, the computer had an exclusive algorithmic quality that made it unique as a movement. His new art-based term "proceduralism," invented to capture the underlying nature of computer production, defined itself against the "interactive paintbox," which for him simply simulated "classical painting methods."[149] Importantly, the self-styled algorithm, compared to commercial software, introduced a whole new class of images. Rosebush used fractals as a prime example of this revolutionary image. Likewise, the fractal artist F. Kenton Musgrave was an adherent to the proceduralist's cause.[150] By "disallowing post-process meddling or local intrusions and modifications," Musgrave believed he reached a certain "purity" through the algorithmic process.[151]

By the close of the 1980s, artist-programmers were increasingly mythologizing the algorithmic process. Roman Verostko and Jean-Pierre Hébert played a significant role in theorizing the importance of the algorithmic process in the following decade.[152] For Verostko, there was no computer-generated art that is not algorithmic.[153] To achieve "individual algorithmic style," the artists needed to "customize" their own algorithmic procedures.[154] It was the "individualized stylistic features" and the interaction "with the algorithm itself" that gave the artist freedom to "proceed further into the new frontiers."[155] The algorithm, for Verostko, invited us to "savor the mystery" of the coded procedure and its "stark logic" that for him yielded beauty.[156]

The purity of algorithmic process was increasingly associated with generative art systems in the last years of the decade. In large part this was a result of the newest technoscience paradigm "artificial life," which was officially founded in 1987 at the Los Alamos National Laboratory in New Mexico. Through the popularity of genetic algorithms and other forms of genetic programming, scientists and technologists in the late 1970s began to recognize the potential for a deeper understanding of biology through artificial systems. Through paradigms like cybernetics and chaos theory, the workings of biology were closely correlated to the mechanics of information. Increasingly, the basis of life was seen as a digital process. Within the new interdisciplinary field of artificial life, exponents believed that they could create, through a materialistic and reductive method, a new class of organism in a nonorganic structure. By extracting the logical principles of nature and correctly digitizing them, the artificial life pioneers hoped to produce with some fidelity the properties of living systems.

The basic analogy made between computational and biological processes had been implicit in computer science ever since its emergence. In fact, the dream of conflating artificial systems and life can be traced back to Enlightenment automata. Nevertheless, Von Neumann, viewed as the father of artificial life, worked on a project of self-reproducing cellular automata in the 1950s, which was later built upon by mathematician John Conway in a game called "Life." Paul Brown recorded the effect that John Conway's systems of cellular automata "Life" had on computer artists at Slade's Experimental and Computing Department in the 1970s.[157]

In computer art, there was a natural alignment between the idea of the "generative" program and biological growth and transformation. As early as 1968, the scientist Petar Milojević had produced an organic flora series. Milojević made the first attempt to represent the mechanisms of organic growth by setting various random parameters that mimic branching patterns and stochastic behavior in natural form. For the art critic Jonathan Benthall, this early work "implied discreetly, rather than asserted" the analogy between the computer's programming instructions and the genetic code responsible for evolutionary specificity and variety.[158] By the late 1970s, one of Japan's most celebrated computer artists and animators, Yoichiro Kawaguchi, had developed models based on mathematical growth principles that mimic simple patterns found in life forms. In 1978 Kawaguchi presented growth algorithms that produced biomorphic forms such as spirals. By employing the laws underpinning formative patterns, the artist found basic principles for design and art generation.[159] The resulting art is a plethora of forms such as ammonites, nautili, tentacles, plant vines, and coral structures. In *Tendril* (Figure 5.2) Kawaguchi used a series of growth patterns including fractal dimensions to produce a vivid organic form. As noted in the previous chapter, the early 1980s marked a period of intense interest in fractal and biomorphic form. Growth algorithms, of which fractals are just one example, seemed to offer an interesting future for art. Moreover, fractals had always been linked to natural phenomena. Through iterative and recursive processes, fractal procedures generated objects which show a high resemblance to biological objects. The mathematician John Hubbard wanted the viewer to perceive fractal imagery as a "metaphor for living things."[160]

FIGURE 5.2 *Yoichiro Kawaguchi,* Tendril, *1981. © Yoichiro Kawaguchi.*

With artificial life entering cultural consciousness in the late 1980s, the biology metaphor became increasingly evident in computer art. Verostko in particular popularized the biological metaphor or "form-generating procedures" in his use of the term "epigenetic" and his references to Paul Klee's organic idealism.[161] His ideas were present in 1988 at the first International Symposium of Electronic Art (ISEA) in Utrecht. Verostko linked his art-generating system to the biological process of epigenesis by analogy. In genetics, the term "epigenesis" is used to describe the process whereby an organism (the phenotype) grows (unfolds) from its coded DNA (genotype). In Verostko's model, the software is viewed as the genotype (seed) that contains all the information necessary for the mature form (art). Verostko's increased use of concepts from biology was part of a wider trend in computer art that started in the late 1960s and saw the widespread influence of generative systems emanating from the life sciences.

In many ways, computer art developed within the same metacreative paradigm as artificial life and shared its basic premise: to create a simple abstraction in order to build complex entities. Like artificial life practitioners, computer artists yearned to generate creation, variation, and otherness. As Mitchell Whitelaw suggested, art employing artificial life models was often "founded on a desire for emergence, a desire to have novel, unexpected, or unpredictable results spring from controlled, designed systems."[162] Even Cohen's AARON, which is situated within artificial intelligence, was programmed to be indeterminate and to behave according to the processes of life.

While the biological metaphor was more implicit in the work of the 1970s, by the 1980s—with growth, fractal, and genetic algorithms—the metaphor was fully active.[163] However, the most pervasive concept to emerge within the late 1980s was that of evolution. The evolutionary mechanism, embodied in the computer through a simple algorithmic procedure, could create endless diversity and highly complex forms. In the late 1980s and early 1990s, theorists and philosophers investigated the computer algorithm in terms of the evolutionary process which, like the computer program, was a blind step-by-step mechanical process that could yield complex results.

One of the most important shifts for computer art was the work of the evolutionary biologist Richard Dawkins. In preparing his influential text *The Blind Watchmaker* (1986), Dawkins created aesthetic figures by simulating artificial genetics and evolution procedures on his computer. Dawkins was seeking to illustrate how complexity could be generated by simple rules. By controlling a number of parameters on a tree-like structure, such as branching, segmentation, and symmetry, Dawkins created graphic organisms he called “biomorphs.” These parameters or “genes” were subject to artificial selection from a subjective outsider—Dawkins himself. Dawkins was astonished at how lifelike and complex the graphics became in a matter of a few generations. Significantly, the process of evolving these creatures felt, for Dawkins, like “one was not creating them but discovering them.”[164] As Dawkins wrote, “when you first evolve a new creature by artificial selection in the computer model, it feels like a creative process.”[165]

In this system, the creatures already existed, in a mathematical sense, as possible permutations on a given set of genes through a finite number of mutations. This corresponded to what biologists referred to as genetic space, a mathematical atlas that geographically located all possible life forms.

This field of logical potential—the theoretical genetic space generated by an evolutionary mechanism—had a powerful effect on computer artists. After all, the unthought and unseen had always been a central mythology within computer art. Daniel Dennett, in *Darwin's Dangerous Idea* (1996), extensively theorized this as “Design Space” by eliciting Jorge Luis Borges' literary metaphor of the library of all possible books to theorize the “scope of biological possibility.”[166] Borges, in his written collection *Labyrinths* (1964), imagined a library of seemingly infinite books (laid out in a maze of corridors and shafts) to explore the notion of logical potentiality. Like the Borgian space, the potential for aesthetic form in an evolutionary art system was vast. The artist, like the librarians in the Borgian library of all possible books, explored and searched the labyrinthine maze of computer-generated forms. This space of seemingly infinite logical possibilities caught the imagination of William Latham.

Following Dawkins' lead, Latham, with mathematician and programmer Stephen Todd, further elaborated the potential generating power of evolutionary algorithms.[167] Together they created a new art system for breeding “synthetic organic forms,” or “virtual sculptures” as they became known. Latham and Todd gave the name of "Evolutionism" to this "new artistic style," after the distinctive movements of twentieth-century art and the particular brand of neo-Darwinism that underpinned much of the art-making system. The art, when first exhibited, met with wide acclaim, prompting a series of international exhibitions. Beyond its interdisciplinary range, the audiences were captivated by the evocative and strangely organic forms (Figure 5.3). The latest advance of 3-D modeling programs, animation capabilities, color definition, texturing, and rendering techniques bolstered the visual impact.

Like many of the other computer artists, Latham came to his technique via traditional drawing techniques. Through his first

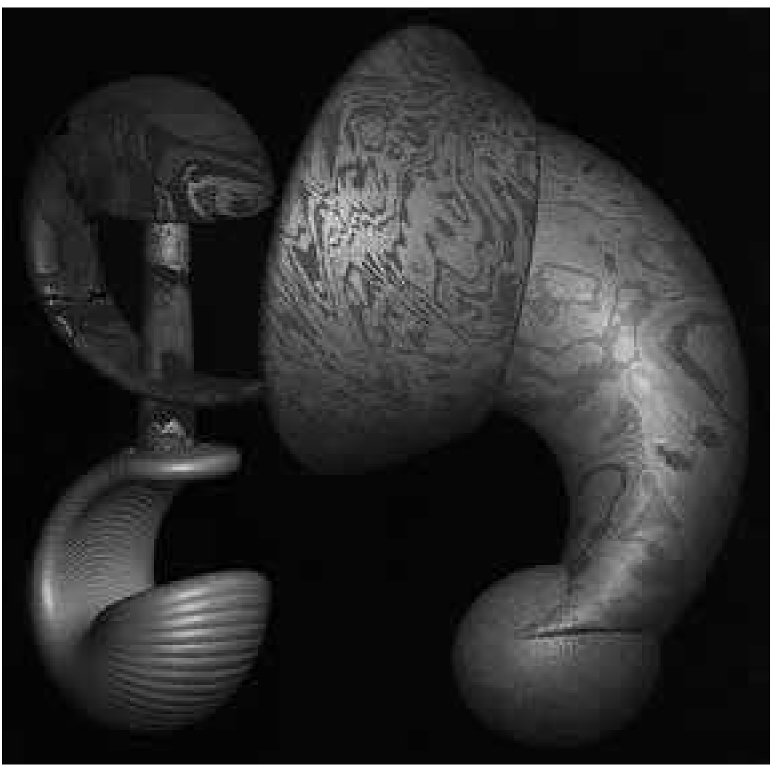

FIGURE 5.3 *William Latham*, Standing Horn, *1989. Computer 'C' Type, 59.8 × 58.8 in. © William Latham.*

experimental system for art generation, FormSynth, Latham discovered the power of simple generative grammar that allowed for an inexhaustible reservoir of possibilities. By applying simple rules to a series of drawn shapes, the artist could create an evolutionary tree of increasingly complex forms. Latham was struck by how the simple algorithmic method had a "creative power of their own."[168] In 1987, as research fellow at IBM, Latham began to realize the potential of automating his generative systems via the computer. Collaborating with Todd, Latham built three complementary artistic systems which were based on the techniques developed in artificial life and the latest computer graphics.

Through iterative and recursive computational functions, the FormGrow system generated complex forms from a number of geometric primitives. The multiple structures, such as horns, twists, ribs, and so on, coupled with different number and gene values meant a limitless amount of expression. Like Dawkins, Latham employed the biological analogy of genotype and phenotype: the genes are a particular set of changeable numbers that are linked to a (geometric expression) structure, and their interaction produces the computer form (the phenotype). Increasing the number of genes and changing the structures opened up a vast form space to explore. The form generator gave access to a library of possible forms that could be searched through artificial breeding. The organic forms, like the books in Borges' imaginary library, are out there logically in a vast mathematical space. The artistic interface, named Mutator, was a parody of mutation and natural selection, allowing the artist to navigate through the multidimensional form space. Mutator operated by generating gene values and by a process analogous to biological breeding and random mutation, which married and mutated forms and then displayed them for the artist to make a subjective decision (based on aesthetics). As in Dawkins' model, Latham replaced "survival of the fittest" with "survival of the most aesthetic." Mutator allowed the artist to steer, via feedback, through the form-generating system, using it as an exploration tool. Through gene interpolation, the program LifeCycle animated these forms and showed the forms' metamorphosis from birth to death (Figure 5.4).

Importantly, as a contrast to other computer art systems, Latham's Mutator interface allowed the artist to avoid the analytic knowledge and the structure definitions required within the program. The interface permitted a far more intuitive and

FIGURE 5.4 *William Latham,* Breeding Forms on the Infinite Plane, *1992. Computer image. © William Latham.*

subjective approach. The visual feedback and interaction with the computerized art system hearkens back to the artwork from the 1970s (such as Mohr's and Molnar's) that was the result of changed parameters and definitions within the contexts of heuristic search modes. Like the systems devised by the artists in the 1970s, the art process occurred in two stages: composing a structure and then exploring the consequence of that structure. The power of this exploratory process, and the new digital aesthetic that it allowed, was lost on most mainstream critics.

With the advent of evolutionary algorithm and other metaphors stemming from artificial life, the interest in generative systems and the possibility for an aesthetic founded on these analogies grew. Biological analogs were relatively recent, compared with the use of mathematical operations as a mechanism for computer art generation. In the 1989 *Leonardo* issue, Franke restated the importance of studying "generative mathematics."[169] He stressed the point that computer-generated imagery was founded on mathematical relations and methods. The same *Leonardo* issue also had an article by Benoît Mandelbrot, who felt that generative art redefined the boundary between "invention" and "discovery."[170] The prime example was fractal art. The new artists, as he saw it, recognized that "very simple mathematical formulas," which may seem "completely barren," are in fact "pregnant, so to speak, with an enormous amount of graphic structure."[171] Roger Malina also signaled the move toward "dynamic art subjects," where generative systems produced "families of aesthetically interesting outputs."[172] Malina recognized that there were a "number of attributes that could allow the computer to become a *creative art-making machine* rather than merely a significant art-making tool."[173] Software, for Malina, made possible a "different kind of reproduction"—what he called post-mechanical reproduction or "generative reproduction."[174]

For the postmodernists, the generative nature of computing and an aesthetic founded on the computer algorithm were insignificant compared with the computer's photo-image-manipulating and communicating abilities. Gips, writing in *Art Journal*, recognized the impressive manner in which the computer could be used to generate images, but argued that when employed in this manner it failed to create "meaningful art."[175] The subtle nuances of difference between generate and create was at the heart of the "impasse that characterized computer art for so long":

> To "generate" means to bring into existence by natural processes, while to "create" means to bring something from the imagination … [to] … go beyond the aimless adoption of the computer as an efficient spawner of images to dazzle the audience with visual acrobatics but little else.[176]

Although there was postmodern opposition to the idea of generative art, its position was secured by the growing influence of artificial life and the more general cultural fascination with the possibilities promised by biotechnologies. Using Verostko's epigenetic as an example, Malina believed that there was a compelling argument to suggest that computer art was on the brink of a “new aesthetic.”[177] The importance of an aesthetic based on the algorithmic and generative capabilities became increasingly theorized in the 1990s, further providing the technoscience underpinning that computer art had always existed.

Paradoxically, the postmodernists, following Lyotard’s concept of postmodern science, were also embracing certain aspects of technoscience. The science of complexity, as mentioned in the previous chapter, garnered special positive attention. The openness and unpredictability of chaos, and the way it appeared to limit human control and undermine totalizing projects, eventually became part of the postmodern vernacular. Ultimately the computer, which was able to manufacture contingencies and instabilities, was at the heart of this trend. However, the conversion of many artists and commentators to postmodern criticality had little effect in gaining acceptance for computer art in the contemporary art scene. While the modernist art historians developed fundamental critiques of conventional art history, they still drew from the traditional canon of the discipline. For the radical art historians, computer art was deemed an artifact not worthy of study. In fact, much radical art history in the 1970s and early 1980s had only marginally increased the diversity of objects subjected to substantive analysis. Indeed, some scholars—T. J. Clark and John Barrell included—had quite unapologetically “confirmed the value of the narrow canon of conventional art history.”[178] Thus, the postmodernist critics were often as elitist as their modernist counterparts, giving their narrow attention to avant-garde photographers and video artists. Postmodern politics, with its internal debates, took on an increasingly parochial character, with purists such as Crimp and Foster emphasizing and celebrating the art of resistance. Computer art, for all its postmodern qualities, never gained full critical attention. Cultural and media studies, which grew out of the same social, political, and intellectual developments as the “new art history,” widened the scope of subjects to take into account the recent cultural forms and practices in popular culture. However, the range of visual culture’s analysis did not extend to computer-based art.

Although computer art never became part of the postmodern canon, postmodernism did change the cultural understanding of the computer. Technology was increasingly understood through cultural paradigms and discourses. For example, Turkle understood computer technology through the paradigms of both modernist and postmodernist aesthetics. By the late 1980s, the culture of personal computing found itself, according to Turkle, dividing into "two cultures": the IBM reductionist paradigm, characterized by deep comprehension; and the Macintosh paradigm, exemplified by "simulation and surface."[179] Postmodern theorists suggested that the search for depth and mechanism was futile, and that it was more important to explore the world of shifting surfaces than to seek deep structures. As Turkle stated, the computer began to serve as a "carrier object" for cultural ideas.[180] This was increasingly reflected in computer art, where the way one employed the computer, either as artist-programmer or artist user, spoke of a central worldview, be it modernist or postmodernist.

One of the major impacts of critical discourse was in the new conceptualization of technology toward a multifaceted, transformative, individualistic, and politicized instrument. Technology, and the computer in particular, was increasingly represented as liberating, democratic, and open rather than rational, reductive, and centralized, as it had been in the 1960s. Within the modernist paradigm, the computer was an instrument for gathering knowledge and dominating nature. The humanists deprecated the computer for its dehumanizing influence, while the anti-humanists came to perceive the computer as a symbol of centralized power and authority. Influenced by the anti-humanists, postmodernists were also skeptical of the belief in technology as morally neutral. However, those who theorized computer and electronic art in relation to postmodernism effectively dampened the anti-humanist pessimism by seeing technology as personally empowering. By the close of the 1980s, computer technology, illustrated in the rise of the artist-programmer, moved from the hands of the technocrat and from its instrumental paradigm to the hands of the individual in the public and cultural sphere. Later, through the Internet, this change would become global. The postmodernist realized that information technology, in its new personalized form, had a democratizing and polemical facet that could disrupt the unique, symbolic, and visionary within the modernist paradigm and replace it with plurality, connectivity, and contextual understanding. This pluralist understanding provided the theoretical framework for digital art and new media art in the 1990s.

Through postmodernism there was a shift away from the self-absorbed and technocratic purism of the artist-programmer toward an interest in the vernacular and history. This introduced the humanizing narrative element in computer art. Part of this trend was the increasing hegemony of photography in critical discourse. With the appearance of computer software that digitalized photographic imagery for manipulation, computer art became linked to the critical discourse and histories of photography. Increasingly, as artists used photographic manipulation software, the pluralism of styles increased, along with the irony, ambiguity, and contradiction found in many postmodern practices. The trend in painting software and digital photography precipitated an art based around what Fredric Jameson had once described as "pastiche."[181] With the computer, it became increasingly easy to mimic styles and mannerisms. Disregarding the need for purity and a sense of authorship and uniqueness, which the artist-programmers still valued, computer artists began sourcing imagery from diverse quarters. Methods of critique and appropriation, paramount to the postmodern strategies of contemporary photography, became central. Joan Truckenbrod was a pioneer of computer-digitalized techniques.[182] Truckenbrod and other artists such as Nancy Burson and Carol Flax found the ability to bring photographic imagery into their work allowed them to "deal directly with content and issues current in the art world, such as gender, identity, and family structure."[183] Susan Ressler, commenting on socio-environmental issues, used a variety of media including a video to produce the digital collage *Earth 1* (Figure 5.5). Digital photography and the pixel-by-pixel mode of manipulation and control became increasingly popular. Within five years, digital photography and its various modes and practices resulted in a number of exhibitions. By the mid-1990s, the digital collage began to dominate over art produced by the artist-programmers, as the catalog for the 1991 SIGGRAPH exhibition showed.

By the early 1990s, artists working with computers were more inclined to talk about social and political realities than about the computer and its technical proclivities. This was a result of the postmodernist emphasis on content rather than its mode of production. While traditionally computer art had taken on the modernists' demand for purity and separateness of medium, postmodernist practice was, as Krauss suggested, "not defined in relation to a given medium ... but rather in relation to the logical

FIGURE 5.5 *Susan Ressler,* Earth 1, *1989. © Susan Ressler.*

operations in a set of cultural terms."[184] "Postmodernist practice is no longer organised," Krauss continued, "around the definition of a given medium on the grounds of material, or, for that matter, the perception of material."[185] Jenny Holzer's work was a prime example of the more enduring legacy of critical discourse and how it changed the perception of technology. Lovejoy signaled Holzer as the "first woman artist" chosen to represent the United States at the 1990 Venice Biennale and as the "first artist using the computer to receive such a distinction."[186] Yet Holzer never called herself an electronic artist, let alone a computer artist. Her medium, the electronic billboard, was only important in its ability to communicate the message. Although the medium, according to McLuhan, became the message, there was no desire to adhere to the purity of medium for its own sake.

By the 1990s, there was a widespread transdisciplinary approach to technology, which coincided with the incorporation of political, social, and cultural theory into artistic practice. The most recognizable effect of this combined trend was the gradual decline of the once autonomous category of computer art and the eventual collapse of the term. While the term "computer art" had been contested from the beginning, its use had been widespread. Computer art was first a loose and ad hoc designation, then solidified into a more universal category to authenticate a group of scientists and technologists. However, in the 1980s, the term was being increasingly replaced with others such as "computer-assisted art" and "computer-aided art," effectively asserting the artist's position over the machine. Authors also avoided conflating computers and art by drawing a semantic boundary between them, titling their publications computers "in" or computers "and" art. In 1989, Richard Wright began to recognize that the term "computer art" was beginning to "drop out of usage."[187] With all the new technologies of "image digitalising and processing, animation, 3-D modelling, paint systems" and many artists operating under the banner of "conceptual art, video art, installation" and "Post-Modernist," Wright wondered whether it still made sense to "talk of 'computer art.'"[188]

With the increasing redundancy of the term, the broader field of art and technology took in more inclusive terms such as "digital art," "new media," and "electronic art." In line with the widening effect of postmodernism, there was a move away from modernism's rigid distinctions and categorical and definitive terms. Computer art's modernist compression, focus, and specialization were replaced by postmodernist expansion and inclusion. The artist-programmers, although sharing the postmodernists' impulse to abandon the term "computer art," took the opposite approach by defining the central aspect of their practice. From 1989, consumed by the anxiety over trends in commercial software, orthodox computer artists neologized a myriad of art terms and movements, such as the proceduralists, dataists, and later the algorists. Many presented veiled or forthright criticism of the mounting use of commercial software and the commodification of the computer art process. All stressing the importance of programming and the metaphor of the algorithm, the groups called their art generative art, algorithmic art, program art, and many other names.

The increased influence of photographic manipulation software such as Photoshop and critical discourse meant that by 1989 there were more works with cultural content. Elements such as figuration and collage outnumbered the abstract and linear works. In addition, there were nearly as many women exhibiting in SIGGRAPH as men.

By the time of the Digital Salon in 1995, artists using modeling and photo-manipulation software far outnumbered artists who constructed their own art-making programs. Digital photographic imagery became a primary source for computer imagery, and the photo-mosaic works alone rivaled the abstract linear and the 3-D modeling imagery in these exhibitions, such was their popularity.

In the 1990s the visual arts sphere that now engaged computer technology had expanded beyond all recognition. The computer as a technology had diversified and converged in so many areas that it was impossible to speak of a unified, homogenous movement of computer artists. While the orthodox artist-programmer had rallied around a relatively cohesive technocratic and modernist vision, the influx of critical discourse and its effect on the perception of technology eventually laid the ground for today's pluralistic understanding of digital technology. However, this is not to say that postmodern pluralism usurped the prime position of technoscience within computer-based arts. As with the paradigm of artificial life, technoscience remained the main source for their mythology, vision, and technical knowledge.

In the Epilogue, fittingly titled "Aftermath," I examine the eventual fate of computer art and its criticism. The movement continued, in spite of decline, to resonate enduring ideas. These ideas and the history of their development in computer art became central. In the late 1990s, for example, the generativists invested heavily in both the idea of the algorithm and the evolving notion of the generative, while the digital artists underwrote their practice with an understanding of the historical dimension of the computer and its development as a creative medium. Computer art owes its enduring influence and importance to the pioneering artists who established the courses, art festivals, institutions, and conferences that form a major part of our contemporary digital art landscape. Although much of the early computer art is lost, the practice forged by those indomitable artists from the often intractable area of early computing is a legacy worth elucidating.

Epilogue: Aftermath

The general ambivalence that permeated computer art continued undiminished into the 1990s. In every decade since its inception, commentators anticipated an era in which computer art would finally gain acceptance and validation from the artistic and wider cultural community. Habitually, commentators identified computer art within an embryonic stage of development. They pointed to technological advancements that would someday present a salient juncture in its history. The sentiment was no different in the 1990s. For example, Clifford Pickover felt that computer-generated art would eventually "come of age," though not until the new millennium. As this demonstrates, the eternal deferral of success remained a central tenet even as computer art began to fade. As Nicholas Lambert observed in 2003, over 30 years ago Franke recognized computer art as "the art of tomorrow," and that is where it perpetually remained.[1] There was an element of technological determinism or naïve teleology in the belief that computer art's viability and success were assured because the computer was an agent of social change and progress. They felt that computer art was the culmination or end point of art's technological evolution and that art, like society, would be inexorably shaped by the dominant technology.

However, computer art's latent potential, persistently foreseen, was never fulfilled. In response to Reichardt's pronouncement in 1971 that art movements are remembered through "great works" and "exceptional individuals," there had been a substantial body of work, but no defining art.[2] In Reichardt's view, those movements that fail to produce great works are fated to "leave an incomparably lesser trail."[3] Nonetheless, although computer art had produced no masterpieces, Reichardt believed that computer art was significant "both socially and artistically."[4] In 1989, Margot Lovejoy considered anew the question of a canon of computer art with a commonly agreed set of masterpieces. She believed it was too early to "form judgements" because computer in the arts was "still at the stage of experimentation."[5] She admits that the premature exhibitions of "poor art" based on what she saw as "obsolete art issues" has "stigmatized the computer" and the field generally.[6] She believed that historical perspective was necessary. Writing in the new millennium, Mike King again approached the issue first raised by Reichardt and later by Lovejoy of identifying computer art masterworks. He believed that while there was a "substantial body of fine work" at the dawn of the new millennium, there was, he stated with despondency, "no great masterpieces of computer art."[7] Pioneering artists such as Mark Wilson have stated even more recently that "computer artists probably had overly optimistic expectations for the medium."[8] He felt that the utopian quest "to create a distinctive 'computer' style" was at that point a fading dream, and in retrospect some of the work "has been a failure."[9]

Following the 1989 crisis there was further fragmentation. By the close of the 1980s, computer art had made little impact on the fine art arena. Ominously, the Computer Arts Society bulletin, *PAGE*, which had been so important in the UK, ceased production. While video art had found commercial and critical success and matured as an art form, computer art remained alienated. Even in the late 1980s, with the enthusiasm for the new personal computer, there were skeptics in the arts who saw the computer, according to Timothy Binkley, as an "inhuman technological monster."[10] The ceaseless technophobia surrounding computer art drove many artists, such as William Latham, to abandon the art world for commercial fields. Following the 1989 crisis, although there was an introduction of new modes of criticism and a renewed desire for consensus, there was also, as Delle Maxwell wrote, "something in computer art that still remains rather elusive."[11] Maxwell, writing in the early 1990s, felt that the dissatisfaction with computer art was a wider phenomenon: "These aren't just the grumbling of the general public; artists, enthusiasts, and engineers alike join in mutual complaint."[12] Whether it was conflict between the "technical-minded factions" who coded their art and the artists who used the "canned paint" systems, the lack of self-conscious critical reflection in this "isolated small community," the "bad critical reception" of what was called "spin art" by some "uniformed, myopic" critics, or the problems between the art world and the graphic industry, Maxwell believed it was the lack of aesthetic standards and self-reflection within computer arts that ultimately impeded the movement.[13] With no market share and no constituency collecting computer artworks, some exponents wondered if computer art would remain a category.[14]

In 1996, in an Internet blog, Lev Manovich provocatively proclaimed the death of computer art. He argued that the potential convergence of the art world and computer art would never eventuate.[15] Manovich believed two irreconcilable spheres were in "battle": the Duchampian world, which characterized the contemporary art community, and the Turing world, which encompassed computer art and its supporting institutions such as ISEA, Ars Electronica, and SIGGRAPH. For Manovich, the content-driven and self-referential aspect of contemporary art with its postmodern irony is diametrically opposed to the state-of-the-art, technology-inspired art, which, lacking the complexities of irony, was ostensibly research-driven. Manovich felt that contemporary computer art was too serious, as opposed to the Art and Technology movement of the 1960s, which had a sense of playfulness and whimsicality. Another criticism that Manovich voiced was the belief that computer artists failed to problematize the issues surrounding their technology, such as the reality that computer technology was "highly unreliable, transient, and incomplete."[16]

While Manovich's generalization mirrored the interminable *Two Cultures* debate and missed some of the diversity of computer art practice, his recognition of the division and the underlying tensions was largely valid. By 1995, Prince felt that the fundamental questions regarding the status of computer art's originality and whether one should program or use commercially available software remained unresolved.[17] Through the 1990s, the two factions that constituted the orthodox artist-programmers and the artists using commercial software remained strong. Orthodox computer artists continued to emphasize originality and integrity through the development of personalized programs, while deriding those who produced what was disdained as "canned" art.[18] Artist-programmers such as Hébert were disenchanted with the commodification of computer art through the influx of personal computers and commercial software, which resulted in low-quality art being produced under the rubric of computer art.

Hébert was not alone in asserting the individual independent algorithmic style of art generation. There was a raft of outspoken artist-programmers who would, as Gary Greenfield asserted, "militantly" define computer art in programming terms, and celebrate only those art forms that could be accomplished through an intimate knowledge of the computer.[19]

The orthodox artist-programmers went about conceptualizing their work under the term "algorithmic art." While the concept of the algorithm had been theorized by Verostko at conferences in Europe and Australasia since the mid-1980s, it was in Los Angeles that the group finally coalesced and the artist group the Algorists formed. Like many new art movements, the Algorists formed at the outermost peripheries of the art world.[20] Under the leadership of artists Versotko and Hébert, the Algorists would formalize at the 1995 Los Angeles SIGGRAPH art exhibition. At the conference panel entitled "Algorithms and the Artist," the creative potential of the algorithm as a generator of artistic form was theorized and debated by Stephen Bell, Peter Beyls, Brian Evans, Ken Musgrave, Hébert, and Verostko. Hébert recalled a heightened sense of congeniality among this gathering of artists, while Veroskto felt a passionate desire to give proper identity to a unique practice, a working methodology he had intellectually engaged with for more than a decade. Following the conference, Verostko, who had experience as an encyclopedist and art historian, would carefully trace the complex etymology of the word "algorithm" back to the ninth-century Persian mathematician Muhammad al-Khwarizmi, who is credited with providing the step-by-step rules for adding, subtracting, multiplying, and dividing ordinary decimal numbers. For the movement's founders, Muhammad al-Khwarizmi was the first Algorist and proof that the concept had ancient lineage. By concentrating on the algorithm, the artist-programmers identified the core concepts fundamental to mathematics and computational science. A major part of computer science research was devoted to the study of the algorithm and its structures, efficiency, and inherent limitations. The algorithm became the spirit of computer science. Verostko and Hébert linked the algorithm to previous methodologies in art, both ancient and modern. Importantly, the Algorists were formed to differentiate themselves from the majority of other computer artists and clarify the position of each other's work within the group. More of a group than a movement, the Algorists included other significant artist-programmers such as Csuri, Mohr, Wilson, and Musgrave.

The lack of consensus, the competing ideology, and the rhetorical debates seemed to confirm the decline of computer art. One of the most substantial shifts for computer art in the 1990s was that from being a relatively autonomous subject in the 1970s and 1980s, it was now relegated to a position where it merely complemented other discourses. No longer did book-length publications appear on computer art, like those that had been written at the nadir of its fortunes. Now computer art was subsumed under electronic, and then digital, art. In Frank Popper's influential *Art of the Electronic Age* (1993), computer art was one form within a spectrum of other electronic art forms. By the late 1990s, the term "computer art" was used mostly as a historical term to denote the pioneering efforts of artists using computers.[21] In Michael Rush's *New Media in Late 20th Century Art* (1999), the term was employed in a similar historical way; significantly, though, computer art was placed in the larger history of digital art.[22] Likewise, the new exhibiting initiatives and institutional courses that began in the 1990s acquired the title "digital art" or "new media art."

The transition from "computer" to "digital" is best illustrated in the formation of the New York Digital Salon in 1993. In the early 1980s, the term "computer art" was the central descriptive term in degrees offered by the newly formed Institute for Computer in the Arts, at the School of Visual Arts, New York. In the early 1990s, the New York Digital Salon, which grew out of the School of Visual Arts in New York, began using the term "digital art," reflecting current shifts in terminology. The Salon posited the late 1980s as the beginning of digital art, when the first significant wave of digital art emerged through affordable personalized hardware and the development of sophisticated drawing, painting, and 3-D software. Even though the Computer Art Department still used the term "computer art" in the 1990s, the term specified what was becoming commonly associated with digital art, including animation production, Web-based art, CD-ROMs, gallery installations, digital video, and performances.

This shift in terminology from "computer" to "digital" was part of a larger cultural trend. When one spoke of digital, it conjured, as Charlie Gere suggested, a "whole panoply of virtual simulacra, instantaneous communication, ubiquitous media and global connectivity that constitutes much of our contemporary experience."[23] The shift to digital art arose not only from the perceived lack of meaning and mechanistic association, but also from the need to dispense with the gender connotations that the term "computer" had accumulated in its early history.

The 1990s saw a diminishing use of the term. *Ars Electronica*, for example, preferred the term "digital art."[24] Computer art commentators such as Patric Prince followed suit.[25] Consequently, as has been confirmed by recent publications, "computer art" is now consigned to the role of a periodizing term. It distinguishes a pioneering movement and has become a symbol of the technological past.

By the mid-1990s, the artist-programmers and the closely aligned plotter artists and Algorists were viewed as increasingly outmoded. Even as early as 1988, as indicated by the SIGGRAPH exhibition of that year, interactivity had become the international paradigm of interest. Rather than contemplating the two-dimensional computer-generated images, which were once the traditional and most widespread computer art form, the viewer was now transformed into an interactive actor in the creation of the artwork itself. Interactive interfaces and newly engineered input devices made two-dimensional static imagery appear antiquated and hopelessly redundant. In the 1990s, festivals such as Ars Electronica favored new media work over the traditional computer genres of drawing, painting, and sculpture.

Although there were important forums such as the "Computerkunst" for traditional computing techniques, overall static computer-generated art forms were now struggling to find welcoming venues. Verostko revealed:

> These juried showings provided a forum for exhibiting fine art objects at a time when other "computer art" venues abandoned "hang it on the wall art objects" in favor of virtual art and/or strictly "plugged in" art. Aside from SIGGRAPH, the Digital Salon in New York, and occasional specialized shows, the venues for showing "hang it on the wall" algorithmic art became more and more restrictive.[26]

By the 1990s, the plotter, which was seen by orthodox exponents as closer to traditional practice, was increasingly romanticized and idealized as the first classical computer imaging device. The Golden Plotter Award, which had been an annual event at the computer art show in Gladbeck, Germany, since the 1980s, provided encouragement for many artists whose work may not otherwise have been seen. However, the plotter was already giving way to new technology, such as ink jet technology and laser printers. The HP plotters, which were widely used by the artists, were being phased out in the mid-1990s. The drawing plotter was becoming obsolete, and in doing so would bring to a close a unique mode of production. Ironically, because the plotter has become a technological relic, plotted art currently has the strongest market among early computer artworks. If one visits the studios of Hébert, Wilson, or Verostko today, you have the sensation that you are in a museum dedicated to the now defunct plotter industry. Moving through their studio—as you pass the archaic technology carefully stored and other peripheries that remain dutifully functional—it becomes a curious exercise in computer archaeology.

Sadly, the fate of many computer artists seemed tied to the obsolescence of computer technology. In the 1990s, Musgrave found it regrettable that the "vast majority of practicing 'computer artists' will always use such 'canned,' pre-existing software."[27] He went on to say that artist-programming "will always exist and be practiced on the fringes."[28] However, he laments that "a full appreciation" of the art form requires background in "mathematical logic, natural sciences, and computer science, as well as aesthetic training and sensitivity."[29] Regarding the reception he received from the mainstream art world, Musgrave remained bitter, feeling that critics did not possess the will or desire to understand his work. To be a pioneer was to be, as he described, "the ones with the arrows in our backs."[30]

The rapidly expanding digital realm, the negligible influence of the now increasingly marginal artist-programmer, the increasingly obsolete, static fine-art works, and the constant criticism levelled at computer art should all doubtless lead to the conclusion that computer art—in Manovich's terms—had in fact expired. However, this conclusion is too simplistic and does not take into account the level of investment that artists and theorists brought to their work. Although the term "digital art" eventually became the common term, there were institutions and exhibitions that still used the term "computer art" throughout the 1990s. Most often, these organizations were established in the 1970s and early 1980s when the term was still prominent; they merely continued the tradition. Although many computer art journal publications ceased in the 1980s and 1990s, there were some that resisted the trend, such as the *Computer Art Journal* (*CAJ*) in France, edited by Bernard Caillaud. Although the organizers of the 2008 Computer Art Congress, a large-scale international conference, debated changing the name, they resisted trends and chose not to.

While computer art still existed in the 1990s, it was a fragment of its former self. Apart from the discourse of digital art using computer art's history, the 1990s saw technoscience paradigms also incorporate its central tenets. Whereas photo-mosaic, 3-D modeling and the painting software came under the rubric of digital art, the algorithmic-based art was increasingly considered within the discourse of generative art. The generative art discourse arose out of the increasing interest in artificial life, which was the dominant technoscience paradigm of the decade. Throughout the 1990s, the interest in generative systems would permeate other artistic domains, leading to a number of conferences on the subject. A new generation of computer-based artists celebrated the ability to invoke what the generative discourse termed emergence and endless excess in a dynamic and evolving digital world.

Significantly, those who began to formalize generative art discourse in the 1990s historicized the concept rather than the technology. This trend was previously formalized by the Algorists with their conceptualization of the algorithm. Importantly, the term "generative" linked the procedural approaches across a variety of old and new media. Thus, the idea of the generative became a conceptual umbrella for an assortment of different technoscience-inspired practices, which included artificial life, catastrophe theory, chaos and complexity, fractals, and generative mathematics. Importantly for the orthodox computer artist-programmers, who were not content with computer art discourse, generative art offered new conceptual paths. Also attractive was the fact that the algorithmic imperative was central to the concept of generative systems. The term "generative," like "algorithmic," described a broad process that incorporated the multiplicity of techniques and applications, rather than a term like "computer," which implied mechanical contrivance.

Like digital art discourse, generative art subsumed the history of computer art. First, generative art, like computer art, sought to encapsulate the constructivist and system-building nuances of early modernism. It understood generative in terms of generative grammar and Chomsky's linguistic heritage. Second, generative art located its lineage in Max Bense's "generative aesthetics," Sonia Sheridan's program of "generative systems," and the research done by J. Gips and G. Stiny into algorithmic and generative aesthetics.[31]

While computer art fragmented into an aggregation of terms, and its history was absorbed into new technoscience and technoart discourses, there was little reflection on its systematic dismantling. Historically, many of the reasons given for computer art's failure have been one-dimensional. Culpability had been assigned to opposing factions or groups. The scientists laid blame on the reticent artists, and then the artists conferred blame on the early technologists, and finally the exponents held responsible the prejudicial art critics and wider art community. In the 1990s, Maxwell felt the cause of computer art's nonfulfilment was located in the marketing of computer graphics. For Maxwell, the marketeer's lack of "high evaluation standards" resulted in their promotion of "everything indiscriminately as art."[32] Using what had been a powerful marketing strategy, the graphics industry used artists, Maxwell believed, to soften and humanize computers. Furthermore, Maxwell felt that is was difficult to filter out trivial work because some of these practitioners have long been "entrenched in the computer graphic establishment."[33] The result was that while the artists had taken control of computer art by "ousting the engineers from the limelight," they, as successors, did not "offer much additional vision, innovation, or integrity."[34]

While these criticisms are valid, they only deal with the rhetoric of computer art at a particular point in its history. The criticism does not explain the underlying contradictions at the center of computer art's fluctuating fortunes. Underneath the rhetoric are a number of paradoxes that have meant that computer art remained a contested cultural practice.

The computer's spurious beginnings in the military meant that it was immediately an anathema to artistic values. But what antagonized the arts community the most was the fact that technologists and scientists were the first practitioners. Because the scientists called their aimless aesthetic testing of computational experimentation "art," the creative community found the scientists presumptuous. Bolstering the art critic's untrusting attitude was the divided cultural field, as manifested in the *Two Cultures* debate. The art and science dichotomy has in fact tainted all discourse on computer art. In general, the traditional artists felt that computer art relied too much on the technoscience concepts and techniques. Rather than having recourse to the humanistic thematic and traditional craft, computer art received its techniques, terminology, and cultural stimulus from abstract science and the latest technoscience paradigms such as cybernetics, information theory, artificial intelligence, science of complexity, artificial life, and others. Deeply indebted to the ideologies and working rationale of the abstract sciences, computer art always manifested the cult of science and technology. Coupled with this, the art community typically believed that the often hysterical enthusiasm within computer art's futurological idiom was facile and did not suit the rigors of high art and criticism.

Beyond the recourse to technoscience, computer art consistently situated itself in opposition to art. From the celebratory bravado of Noll's Mondrian Experiment to Franke's belief in art's demystification, the computer was championed as either a usurper of the artist or the ultimate abstractor and codifier of art and its mythical tradition. While rationalization and dematerialization occurred in contemporary art, the mechanistic tenor and extreme reduction of art to mathematical principles was objectionable to the mainstream art community. Art could be simple, but not reducible. Even for the most devoted abstractionists, computer art was one step too far in the depersonalization of art. Part of this reaction was from the humanists who felt that the human-as-machine metaphor, implicit in computer art, was disquieting. Humanism, especially the romantic strain, drove the criticism of computer art from the beginning. Judgments of blandness, exhaustive order, and impenetrable coolness, touted as aesthetic evaluations, were more about the art-making machine than the art itself. Computer art never freed itself of this criticism.

In addition, criticisms from the mainstream art world can be traced to the perceptions of the computer within the intellectual community. While in the 1960s computer art had endured the anti-computer sentiment of humanists, the ensuing age of radicalism targeted the computer as a symbol of instrumental control. The anti-humanists attacked the computer, with its abstract detachment and rationalist foundations, as the Enlightenment instrument *par* *excellence*. As a child of the military-industrial complex and Cold War imperatives, the computer became a symbol of systemized control. As a result, anti-humanism joined forces with humanism to impact negatively upon computer art.

Much of the 1970s pessimism and technophobia inherent in anti-humanism became part of postmodernist dogma in the late 1970s and early 1980s. In the late 1980s, postmodernism finally infiltrated computer art discourse in an attempt to introduce a measure of critical rigor. While many critics began championing the postmodern ethos in new, especially technology-oriented areas of the visual arts, postmodernism's relationship to computer art was exceedingly problematic. From its conception, computer art exalted modernism's main principles, including the inclination to historicize, the affirmation of abstraction and formalism, the language of futurology, and the will for aesthetic criterions. A major contradiction the postmodernists needed to overcome was that computer art had from the beginning supported rather than undermined modernist assumptions. Immediately, postmodern critics identified the old history of computer art as a throwback to formalism and purism and attacked computer art for being ostensibly apolitical. At first championed as a humanizer of technology in the modernist mode, computer art, once it came under the influence of postmodern critical discourse, was imagined as a dynamic, open-ended, and transparent process. Whereas the modernist art object was finite, the postmodern art object was characterized by flux, process, interactivity, multiplicity, improvization, and spontaneity. Computer art was immediately associated with avant-garde photography and video, which had been viewed as the postmodern media *par excellence*. This way the postmodernists reconciled postmodern anti-technology doctrine by emphasizing the computer as a democratizing agent and disrupter of modernist convention.

While postmodernism was a destabilizing factor within the computer art discourse, advances and convergence in digital technology compounded the problem. Since the 1970s, the normative paradigm of artist-programmer had emerged to displace the scientists and technologists from the position of chief practitioners. Signaling the early modernist abstract movements as their antecedents, these artists had strong modernist convictions. They also expressed a profound devotion to the computer and its potential. With the advent, in the 1980s, of commercial software and user-friendly interface, a new generation of artists emerged that had little need or will to understand the underlying structure and disconcerting complexities of the computer. Rapidly, artists could engage the computer on a haptic and tactile level rather than on a cerebral and abstract level.

In 1989, as a result of the relentless pressure from humanist art critics, the anti-technology sentiment from the anti-humanists, the general anti-computer sentiment from some sections of society, the internal division resulting from the introduction of user-friendly interface, and the politicization of technology by the postmodernists, computer art plunged into a crisis. Besieged by a number of opposing ideologies, computer art eventually fractured into an array of different appellations and, as time passed, the computer art project became outmoded.

While the external forces and the internal divisions have been well documented, there were a number of other problems that impeded computer art's success. The difficulty for those devoted to computer art was that they sought acceptance or recognition through a modernist framework. As Lambert suggested, "The need to satisfy the various criteria of art, and the need to continually check to see if the art world's dictates are being fulfilled, has somewhat imprisoned 'computer art'."[35] The criterion for success was computer art's acceptance into the canon. Its claims for acceptance into the prestigious pantheons of the art world were, however, misguided and impracticable at best. Computer art's apologists accused art critics of being myopic and wholly uninterested in digital culture. For Franke, the critics lacked the ability or foresight to judge the new art form critically because they were simply unable to incorporate the new technoscience theories that nourished the art form.[36] This is true, as mainstream critics on the whole did not have a sufficient desire to investigate the new theories that would reveal the worth of this new medium. It is difficult, however, to burden the overtaxed critic with the responsibility for the fate of computer art, as the complexities of the computer were often bewildering. It is hard to imagine how foreign the computer must have seemed to a critic with traditional classical training. It was far easier to surrender to the anti-computer sentiment, which was shared by most in the art world, quickly and cleanly dismissing computer art. Consequently, much of the criticism from the likes of Canaday was superficial, condescending, and at times mocking.

In the call for art world endorsement, there was an innate disavowal of computer art's real strengths. While computer art had always remained on the margins of Art and Technology and the outermost fringes of contemporary art, it was central to many technoscience discourses. Computer art gained substantial support and held an important position in computer science, especially in computer graphics, which shares much of computer art's heritage. While computer art's exponents complained of being elided or occluded from art-based institutional support, they received support for exhibitions from IBM, Calcomp, Microsoft, Boeing, Bell Labs, U.S. Air Force Laboratories, and many other government and corporate bodies. Commentators often forget that computer art's genesis was in the major research facilities, and as a discourse it was embedded in the burgeoning computer graphics industry. Through this support, computer art had its own infrastructure, conferences, awards, and publications. A remarkable amount of written material from outside the art world was devoted to computer art, rivaling and often exceeding mainstream movements.

Paradoxically, the computer, the very object that resulted in computer art's exclusion from the art world, is the reason for computer art's relative success and longevity. Although computer artists bemoaned their lack of acceptance, they did attract theorists to their work because of the computer's importance as a symbolic and experimental technology. Another example of the computer's allure is in the curating of *Cybernetic Serendipity*. While it was intended to explore the relationship between technology and creativity without any necessary recourse to computers, computer-based art was included for both publicity and fund-raising purposes. The popularity of the computer was also computer art's popularity.

Ironically, the computer as an evolving technology also added to computer art's struggle with its own discontinuities. In modernist terms, it was impossible for computer artists to form a unified movement with the rapidly evolving nature of computer technology. Some believed that rapid technological development had prevented the computer medium from maturing. It is apparent that computer artists often struggled against the ceaseless momentum of digital technology, and its protean and many faceted nature meant that it would not submit easily to modernist or postmodernist understandings. Theoretical and practical engagement required a malleable and dynamic approach. With the way computer technology expanded the sensorial experience, the traditional modality of the static picture became increasingly *démodé*. Moreover, because computing always worked toward imaging processing and software development, it was difficult for the purists to argue for computer art's essential characteristics. The insistence on the artist to write his or her program was incompatible with the direction of computing.

The technological landscape through the 1990s changed dramatically. The computer, through its falling price, had become a major household appliance and source of entertainment, information, and communication. The Internet and other telecommunication networks became increasingly embedded in the fabric of modern society. The computer had departed considerably from its scientific and militaristic beginnings. Effectively, the computer, with its interactivity and multimedia, diverged from its Cold War context and became reoriented as a democratic, open, and potentially revolutionary technology. The democratization of the Internet and the birth of the World Wide Web confirmed this shift. While the traditional artist-programmers complained about their exclusion from traditional exhibition space, the advent of the Web provided a new habitat for computer art. In fact, computer artists, who had the necessary programming skills, were the first artists to build Web sites to showcase their work, something that is almost universal today. In the mid-1990s, the Web became crucial to the diffusion and popularization of digital arts. While many art critics saw fractal art as a passing fad, it actually grew in popularity among the new technoculture emerging on the Web. Moreover, Web-based art became a genre in itself. In addition, the Web provided an online resource for artists, educators, and the public. SIGGRAPH, New York Digital Salon, and other major digital art festivals began placing their exhibitions online. In 1994, the Fine Arts Forum became a major online forum that had information concerning events, competitions, conferences, and new sites about the field of art and technology. Other online organizations like Rhizome, started by Mark Tribe in 1996, became popular as a way of joining geographically dispersed artists, critics, and curators in a communications network that fostered experimentation with new media.

Since the mid-1980s, interest in the computer had spawned a growing technoculture, which proliferated a raft of unique magazines that combined technological utopianism, fetishism, and digital transcendentalism. A new cyberculture emerged that would bring about "cyberpunk" movements, influenced by William Gibson's now canonical science fiction novel *Neuromancer* (1984) and the "Extropians" who imagined future technological scenarios where the human body was redundant. Combined with postmodern critical discourse, the new technocultural manifestations moved technoscience paradigms such as cybernetics in new directions. With the advent of the Internet, the frontier mythology, already embedded in computer discourse, was further articulated through cyberspace, networking, and virtuality. From the early 1990s, cyberspace narratives dominated art and technology discourse, while virtual reality dominates the artistic and cultural imagination, culminating in *Virtual Reality: An Emerging Medium*, held at the Guggenheim Museum in 1993.

Cyberspace was understood through a number of historical and critical paradigms. Retaining many deconstructionist elements of postmodernism, commentators of virtuality implemented a variety of interdisciplinary modes into the composition of their theories. Postmodernism reenergized, transformed, and repoliticized the cultural understanding of technology. Donna Haraway, Sadie Plant, and others who theorized the new modalities of cyberspace evoked technology as a positive presence by formulating gender constructs and further disrupting the modernist subject. With its overwhelming self-confidence, postmodernism in the early-1990s transformed art and technology discourse. Under the influence of Lyotard and others, postmodernism meant a pluralistic attitude toward technology. Technology, and the computer in particular, shifted from a centralized power to individual personal computers that effectively bypassed central authority. Now technology was conceived as a radical challenge to the cultural and political status quo. The metaphor of distribution and empowerment through individual technological sites was strengthened with the Web. The Internet, frequently registered as a quintessentially postmodern phenomenon, was seen by many to have bypassed older power structures and created a proliferation of new social interactions, even though it was originally constructed as a communication system for the U.S. military. Increasingly, Gilles Deleuze's biological metaphors of rhizomatic, nomadic structures and machine assemblages were applied to theorize these new technological trends. Consequently, the works of Gilles Deleuze and Félix Guattari precipitated a more positive view of digital technology. Their concepts and vocabulary in particular have become, as Gere suggests, part of the discourse of digital culture and technoculture.[37]

In light of today's ascendancy of social media, concepts such as virtuality and cyberspace even appear antiquated. Much has changed. The digital is everywhere and nowhere, internalized in every object we use, yet externalized in our social networks, connecting us with a seamlessness that defies its own technological history, so much so the criticism of computer art appears almost peculiar to new generations. Hébert, during a recent interview, reflected on the hostility that the general public, even the youth, showed toward computers in the 1970s. "Everybody was fearsome of those machines," he said, "they did not want to be involved at any level with computers; they simply refused." "But now," he stated, "go into an Apple Store any given afternoon, and you'll find hundreds of people, young and old, struggling to buy the latest digital technology."[38]

If we evaluate computer art criticism in retrospect, we find that critics were quick to deliver judgment. There was no sophistication that marked good criticism, no dispassionate, independent point of view or will to bring new insight. Instead there existed a type of anti-computer dogmatism: the proverbial "all computer art is bad" response. Admittedly, some of the art was often rudimentary, but there was little recognition, even by exponents of the movement, of the incredible difficulty in making the computer into a visual medium. The blanket criticism of aesthetic ineptitude also blinded many critics to the complexity and subtlety of many of the designs. For example, Lloyd Sumner, who exhibited in *Cybernetic Serendipity*, is absent from all history of digital art because of his seemingly unsophisticated designs. Yet, if one examines his entire body of work from the late-1960s, one finds a complexity and subtlety that rivals the successful op artists and abstractionists of the day (for example, see Figures 3.2 and 3.3). Rather than singling out the most successful work for evaluation, as was common in the profession, critics went for the most unsuccessful and made it emblematic of the entire movement.

One of the reasons why supporters of computer art were continually frustrated was expectations were exceedingly high. Whether it was the futurology that continually forecasted an upward trajectory or the belief that validation was assured in a shifting art world, there was a false sense of inevitability. While computer art emerged in the age of "cool modes of painting and construction" where "process prevails," to use Harold Rosenberg phrasing, it was wholly remote, acting on the absolute peripheries of art.[39] Computer art emerged in a period, as Rosenberg suggested, where the art object "exists under constant threat of deformation and loss of identity."[40] For this modernist critic, there was constant expanding of art history to incorporate these "new species" of cultural production.[41] Computer art could be described as one of those "anxious objects," as Rosenberg called them—an art form that had pushed art in ways that undermined its once secure identity.[42] Art's nature, as the influential critic wrote, is "contingent upon recognition by the current communion of the knowing. Art does not exist. It *declares itself*."[43]

Computer art was perhaps the most "anxious" of all objects of late twentieth-century art. The transition from scientific non-art to art, allowed in part because of art's changing epistemology, was a slow and often tortuous process. As Rosenberg wrote in 1966, there was no "agreed-upon way of identifying works as art except by including them in art history."[44] For computer art, inclusion in the narrative of art history has only happened in the last decade, following recent scholarship and historical-themed exhibitions. Though computer art is rarely found in orthodox art survey books (instead it is commonly part of digital art histories), it is no longer questioned as an art object. Incredible as it seems, it has been over 50 years since the first computer artworks were produced.

But even with the broad enculturation of digital technology and the final acceptance of computer art as a legitimate art object, early computer artists still experience resistance. Incongruously, American pioneers in the field of computing have gained much notoriety and success, even if we discount revolutionary figures like Bill Gates and Steve Jobs, yet the pioneers of computer art remain largely unknown, having no place in the history of American art. Ironically, the lonely artist charting the outer edge of the frontier, struggling to capture the mysteries of a vast and untamed landscape, is one of the most evocative parts of the American art narrative. Though this mythology is attached most readily to the nineteenth-century artists of the Hudson River School, it could also easily be applied to early computer artists. Like the early American landscape painters, computer artists were the first to explore a new frontier—not the expanding Westward territories, but the emergent digital terrain made possible by the modern computer.

What is so important about computer art is that its history gives us a glimpse of the outer extremities of art as it expanded, diversified, and reconfigured in the late twentieth century. Computer art, it can be argued, was more peripheral than traditional forms of outsider art. Outsider art, or "art brut" as it is also referred, was first employed to describe art done by a few gifted nineteenth-century asylum inmates, and then widened in the twentieth century to include naïve artists, so-called "primitives." Lacking formal training and without proper links to artistic establishments, these artists were largely excluded from art history and its canon. But what was central to the interest in outsider art was the human impulse or the hidden genius that seemed to personify this type of artist. The audience was attracted to the unworldly artist because they embodied a sense of humanity that was often lacking in the spiritless modern world. Computer art, conversely, was seen as the epitome of soullessness, a cold cultural product produced by machines under the control of technologists rather than artists. Computer art appeared to mock all that was human.

The acrimony between artist and scientist that seemed to define the history of computer art conceals the achievements of collaboration. At no other time in the twentieth century have artists, scientists, and technologists come so close and achieved so much. The history of computer art is a history of interdisciplinary exploration, and this interdisciplinarity has emerged as a central tenet of contemporary new media art. Although it was hard for many artists to admit, many of the scientists and technologists were highly creative, taking digital image-making in a variety of imaginative directions. These individuals disrupted the prototypical model of the twentieth-century scientist, becoming in the process a type of transgressive technologist. In addition, the artist-programmer that was to emerge following the era of technologists was just as important. The artist-programmer was a totally unique conception of the artist and changed the archetype forever. Never before had the artist moved so far outside traditional forms of knowledge and skill to seek entire new systems of thinking and practice.

One of the greatest myths of the computer art—the belief that you merely "push a button" to produce art—still remains a sore point with artists. Reading the early accounts and interviewing pioneering computer artists gives some indication on how tremendously difficult it was. Showing incredible fortitude in the face of continual rejection, these self-taught and self-funded artists displayed dogged persistence with an intractable technology. Today the myth has largely disappeared. We tend to acknowledge that early digital technology was an exceedingly difficult frontier, especially when we look through the lens of today's highly evolved digital technologies. In retrospect, it is also easy to see the legacy of the pioneers in higher education. Beyond the myriad of new media festivals that attract participants from around the world, the pioneers built the innovative interdisciplinary programs and research centers that dot the globe. The digital art landscape is largely shaped by these individuals.

The importance of computer art to the history of twentieth-century art is also vital. Computer art was more than an aberrant art form that struggled with its own self-formulation. It reflects the paradoxes and irreconcilable differences of all art forms that operate in that uneasy ground between art and science. Its history also reveals the anxieties and preconceptions of art as it struggles against its own evolving nature, having to constantly redefine itself as digital technology metamorphosed. However, computer art should not rely on its historical impact alone, becoming a simple lens to examine shifting cultural dynamics. We need to look thoughtfully at the art itself, to reevaluate it with sophisticated and informed responses. Because the dogmatic criticism which judged computer art as unimportant has faded with history, we are now able to adequately evaluate the computer-generated artwork of those artists who have given a lifetime of practice and are now in the twilight of their careers. Within their back-catalogs, which are safely housed in their busy studios, remain some of their most important works, all ready to be collected by museums of private collections. Deep inside this rich oeuvre are the long-desired and elusive masterpieces of this unique yet misunderstood art form.

NOTES

Introduction

1 See, Holland Cotter, “Art in Review; Wade Guyton,” *New York Times*, December 14, 2007, E. 38; and Ken Johnson, “Art in Review; Wade Guyton and Kelley Walker” *New York Times*, March 18, 2005, E. 42.

2 For example, Bruce Wands, the Chair of the MFA Computer Art Department at the School of Visual Arts, believes those past graduates from the MFA program, a program started in the late-1980s when the term “computer art” was still in vogue, would be angered by a name change. Although Wands and others entertained the idea of changing the name, the term’s historic value proved too strong and because computer art was rarely employed after 1990, it was effective in differentiating the SVA’s educational offerings from the others.

3 Dominic McIver Lopes, *A Philosophy of Computer Art* (London: Routledge, 2010), 2.

4 Peter Weibel, “Digital Art: Intrusion or Inclusion?,” in *A Little-known Story about a Movement, a Magazine, and the Computer’s Arrival in Art: New Tendencies and Bit International, 1961–1973*, ed. Margit Rosen (Cambridge MA: The MIT Press, 2011), 43.

5 Douglas Kahn, “Between a Bach and a Bard Place: Productive Constraint in Early Computer Arts,” in *Media Art Histories*, ed. Oliver Grau (Cambridge, MA: The MIT Press, 2007), 423.

6 Lejaren A. Hiller Jr., “Computer Music,” in *Cybernetic Serendipity: The Computer and the Arts*, ed. Jasia Reichardt (New York: Praeger, 1969), 21.

7 Joel Chadade, e-mail message to author, May 12, 2008.

8 Elliott Schwartz, *Electronic Music: A Listener’s Guide* (New York: Praeger, 1973), 87.

9 See, C. T. Funkhouser, *Prehistoric Digital Poetry: An Archaeology of Forms, 1959–1995* (Tuscaloosa: University of Alabama Press, 2007), 28.

10 C. T. Funkhouser, *Prehistoric Digital.*, 81. For an example of this sentiment in computer-generated music, see Hiller, "Computer Music," in *Cybernetic Serendipity: The Computer and the Arts*, 21–25.

11 John Morris, "How to Write Poems with a Computer," *Michigan Quarterly Review* 6, no.1 (Winter 1967): 20.

12 Jeanne Beaman, telephone correspondence with the author, May 6, 2008.

13 Jeanne Beaman and P. LeVasseur, "Computer Dances," an essay/presentation accompanying performance exhibitions in the early 1960s. The original typed and annotated text is held in the author's archive.

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15 Delle Maxwell, "The Emperor's New Art?," in *Computers in Art and Design*, ed. Isaac V. Kerlow (Las Vegas: SIGGRAPH, ACM, 1991), 94.

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17 Mueller, "Idols of Computer Art," 72.

18 Phillip J. Davis and Reuben Hersh, *Descartes' Dream: The World According to Mathematics* (Sussex: The Harvester Press, 1986), 48.

19 Paul Brown, "New Media: An Emergent Paradigm," *Periphery* 29 (November 1996): 13.

20 Grace Hertlein, telephone correspondence with author, December 12, 2011.

21 Mihai Nadin, "The Aesthetic Challenge of the Impossible," in *Images Digital: Computer Artists in Germany 1986*, ed. Alex and Barbara Kempkens (Munich: Barke Verlag, 1986), 19.

22 Michael Rush, *New Media in the Late 20th Century Art* (London: Thames & Hudson, 1999), 172.

23 Kahn, "Between a Bach and a Bard Place," 424.

24 Margit Rosen, "Editorial," *A Little-known Story about a Movement, a Magazine, and the Computer's Arrival in Art: New Tendencies and Bit International, 1961–1973*, ed. Margit Rosen (Cambridge MA: The MIT Press, 2011), 10.

25 See, *White Heat Cold Logic: British Computer Art 1960–1980*, ed. Paul Brown, Charlie Gere, Nicholas Lambert, and Catherine

Mason (Cambridge MA: The MIT Press, 2009), *A Little-known Story about a Movement, a Magazine, and the Computer's Arrival in Art: New Tendencies and Bit International, 1961–1973*, ed. Margit Rosen (Cambridge MA: The MIT Press, 2011) and *Mainframe Experimentalism: Early Computing and the Foundations of the Digital Arts*, ed. Hannah Higgins and Douglas Kahn (Berkeley: University of California Press, 2012).

26 Edward Shanken, "Historicizing Art and Technology: Forging a Method and Firing a Canon," in *Media Art Histories*, ed. Oliver Grau (Cambridge MA: The MIT Press, 2007), 44.

27 Charlie Gere, Introduction to *White Heat Cold Logic*, 1.

28 Bruce Wands, *Art of the Digital Age* (New York: Thames & Hudson, 2006), 8.

29 Herbert W. Franke, *Computer Graphics—Computer Art*, trans. G. Metzger (New York: Phaidon, 1971), 7.

30 Dieter Daniels, "Art and Media," in *The Age of Modernism: Art in the 20th Century*, ed. C. M. Joachimides and N. Rosenthal (New York: DAP Publishers, 1997), 564.

31 Mark Wilson, *Drawing with Computers: The Artist's Guide to Computer Graphics* (New York: Perigee Books, 1985), 13.

32 See endnote 24 for a list of examples.

33 Richard Wright, "The Image in Art and 'Computer Art,'" *Leonardo,* Supplemental Issue, vol. 2 (1989): 49.

34 For example, the animation work of Lillian Schwartz and Charles Csuri was shown and collected by the Museum of Modern Art.

35 Gustav Metzger, "Untitled," in *A Little-known Story about a Movement, a Magazine, and the Computer's Arrival in Art: New Tendencies and Bit International, 1961–1973*, ed. Margit Rosen (Cambridge, MA: MIT Press, 2011), 422. Originally published in *Bit International 7*, ed. Boris Kelemen and Radoslav Putar, Galerije Grada Zagreba, Zagreb, 1971, 26–33.

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37 Franke, *Computer Graphics—Computer Art*, 57. Quote appears in table, 28.

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Chapter one

1 Arnold Rockman and Leslie Mezei, “The Electronic Computer as an Artist,” *Canadian Art* 11 (1964): 365.

2 Although the pioneers of computer art refer to themselves as scientists or mathematicians, it is more apt to categorize them as technologists, because most of their research revolved around the development and advancement of digital systems and technologies. These ranged from developing weapons and industrial computer systems to business information and graphic processing systems. For those who called themselves mathematicians, it is fair to say that they were applied mathematicians such as mathematical engineers.

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33 Mumford, *Art & Technics*, 6.

34 Mumford, *Art & Technics*, 6.

35 Philip Marchand, *Marshall McLuhan: The Medium and the Messenger* (Cambridge, MA: The MIT Press, 1998), 77.

36 Marchand, *Marshall McLuhan*, 116.

37 Herbert Marcuse, *One-Dimensional Man* (Boston: Beacon Press, 1964).

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39 Marshall McLuhan, *Understanding Media* (New York: McGraw Hill, 1964), 46.

40 Jack Burnham, "Art and Technology: The Panacea that Failed," in *The Myths of Information: Technology and Postindustrial Culture*, ed. K. Woodward (London: Routledge & Kegan Paul, 1980), 207.

41 Frieder Nake, "There Should Be No Computer Art," *PAGE: Computer Art Society Bulletin* 18 (October 1971): 18–19.

42 C. P. Snow, *The Two Cultures and the Scientific Revolution* (Cambridge: Cambridge University Press, 1959).

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> The series of drawings were dissected into points and, using punch cards and a state-of-the-art computer at Brown University, I created animation of a woman provocatively but innocently lifting up her dress revealing garter belts and underwear … I liked the contrast to the extremely mechanical, tedious, number process of creating animation on the computer then. When the animation first appeared on the screen, the computer scientists I worked with were not amused.

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Chapter five

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