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The Journal of Aesthetic Education, Volume 37, Number 1, Spring 2003, pp. 13-31 (Article)

Published by University of Illinois Press
DOI: *https://doi.org/10.1353/jae.2003.0004*

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> Before the computer is accepted unquestioningly as a legitimate artistic medium, some of the challenging aesthetic and philosophical issues raised by [computer art] must be solved. The most haunting questions concern the impact of the technology on the artist, the creative process, and the nature of art.[1]

How might we lead students in an exploration of the philosophical issues regarding art created with a computer? The most important step is first to guide them in exploring ontological concepts and questions asked about the nature of art and computer art, before investigating related issues of epistemology, value, and criticism. Students need to understand the nature of their art tool and medium of choice. Therefore, it becomes a matter of concern to discover that when discussing and writing about computer art, students sometimes use such terms interchangeably as "computer art" and "computer-generated art," when they are not synonymous, and talk about "virtual reality" as though engaging in any activity that involves a computer constitutes experiencing one. It is clear that this problem arises because many have not paused to examine the nature of computer art within the context of the process and product of art, and the subtle nuances regarding what might distinguish each from other human enterprise. To help clarify their thinking, we might use the foundation of art theory and the strategy of philosophical inquiry, implemented by adopting questioning strategies, to guide students through an exploration of the ontological nature of computer art. This can begin by launching the question: "What is the nature of art — or computer art?"

Philosophy of Art: "What is the Nature of Art?"

Many philosophers have attempted to describe or define the nature of art formulated in a theory of art. A theory of art attempts to specify where the essence of art is thought to reside, or what exactly art's essence *is*.

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Journal of Aesthetic Education, Vol. 37, No. 1, Spring 2003

The imitation theory, initiated in the 5th century B.C. by Plato, held that to be a work of art, an object must mirror reality.[2] As this theory placed the essence of art in the objective properties of the art work itself, we consider the imitation theory to be object-centered or objective in nature. Similarly, with his formalist theory of art, Clive Bell claimed that the essence of art lies in the object — within the structural design properties of a work of art. To qualify as a work of art, an object must exhibit significant form. Significant form consists of certain formal properties such as the art elements of lines and color combined in a particular way according to art principles, all used to create certain forms and relations of forms.[3]

The expression theories of art shifted attention to the artist and audience and thus are considered subject centered, or subjective, bound up in notions of the experience of creation by the artist and/or the response of the audience. Benedetto Croce asserted that a work of art resides in the mind of the artist. An artist must experience an intuition, and it is this mental process that constitutes art, not the object which the artist might create thereafter.[4] Robin Collingwood claimed that art is an exploration, clarification, and expression of an artist's emotion, made clear to an audience through a medium.[5] Leo Tolstoy believed that art should be a vehicle by which the emotion experienced by the artist at the time of creation is transmitted to an audience, so that the audience can experience that emotion as well.[6]

Morris Weitz asserted that none of these theories capture an essence of art because they are either too broad, too narrow, or else are circular. He claimed that the concept of art cannot be limited to one essence delimited in a definition. Weitz suggested that we must instead look at what theories of art have to say is important about art so that we know what to look for and how to look for it.[7] Maurice Mandelbaum challenged Weitz, and said that on the contrary, there is an essence to art, but its essence is an unexhibited quality, like the genetic ties of a family whose members may not resemble one another in physical appearance, but who share a relationship nonetheless.[8]

Arthur Danto and George Dickie contended that what makes anything art is not directly attributable to the object, artist, or audience. Instead, it is the cultural context within which art is regarded by society. Danto stated that what makes an object art is due to a culture, based upon a heritage of a body of knowledge about art theory and art history, which he called the *artworld*.[9] Dickie claimed that art could be defined, but not in the way that we would normally expect. He suggested that artists construct artifacts and present them for consideration by the artworld in order to gain, for consideration, an acceptance of the status of art objects for these artifacts in the art world. Art could be defined based not on its properties as an object, but based on its acceptance and role in a social institution.[10] In the final stage in the evolution of art theory — Dickie's institutional theory of art — we are left with the notion that "art can be defined, but the manner of definition

is of a very different sort" from traditional attempts.[11] This phase in the evolution of art theory is where we remain today.

Therefore, what criteria can we use to determine whether or not something may be a work of art, so we will know whether or not and how computer art can be classified as art — or as something else? It would seem that this brings us to an impasse. But, invoking Weitz's suggestion, perhaps we might adopt his advice to use art theories to lead our students in learning to attend to particular features which various art theories tell us are important aspects of art. In this way, we might arrive at a way to see whether or not the object under question — computer art — can be considered as art due to its similarities to or differences from other works that we paradigmatically call art.

What is the Nature of Computer Art?

In beginning an aesthetic inquiry into the nature of computer art with students, we might address questions similar to those that have been considered by computer artists:

1. To what extent do hardware and software determine the results?
2. Is an artist creatively restrained by the options available, either by available data or by the way in which it may be retrieved?
3. Are new aesthetic criteria required to evaluate computer art?
4. Is the value of some computer art decreased by its non-unique nature and the fact that it may have been executed by a machine instead of by hand?[12]

To launch the investigation from familiar ground, we might start by first examining aspects of the computer and computer art that share similarities with more traditional forms of art tools, media, processes, and products.

Features of the Computer That Artists Use in Art Production

What are the distinguishing features of the computer which allow artists to use it as a tool and medium in art production? Most would agree that these are determined by (1) hardware, and (2) software.

The physical electronic components that make up a computer system are referred to as the computer hardware; "if you can stub your toe on it, it must be hardware."[13] The standard features of computer hardware to include the central processing unit (CPU), internal memory, and auxiliary memory devices, such as magnetic floppy or optical compact disks (CD ROM). Artists can issue commands to the computer by way of a keyboard, mouse, graphics tablet, and electronic pen or stylus. The results of the computer's calculations are displayed visually as output on the computer monitor. A monitor displays text and images either as a collection of picture elements or pixels, or points of light connected by lines called vectors. Other types of computer

hardware can be connected to the computer through means of an interface, which functions as a connection between two hardware devices and allows them to share information. One such device, called a modem, permits artists to receive as input and send as output computer data over telephone lines and telecommunication networks linked to other computers that comprise the Internet. Other devices that permit artists to input data into a computer system include electronic pens, scanners, digitizers, and digital or video cameras. Peripheral devices such as printers, plotters, and film and video recorders allow artists to output text and images onto some other form of media such as paper, videotape, or photographic and cinematic film.

All instructions from artists and information placed into a computer are collectively called software. Software in the form of a computer program, or set of instructions written in computer code, directs the computer in its function under the auspices of an artist's commands. Each pixel of an image, letter of the alphabet, and numeral of the number system, is assigned a coded sequence of binary digits or "bits," consisting of strings of 0's and 1's, read by the computer as electronic impulses. Without a computer program placed in it, a computer cannot function. Programs written for guiding the computer in performing specific tasks, such as manipulating images, are called "application programs." The program instructions can be entered into the computer's memory either by keyboard, accessing instructions from an external memory device such as a magnetic floppy or CD ROM disk, or from a telecommunications resource. Artists who write their own computer programs type their computer programs into the computer as lines of text. Most artists, however, use commercially developed application programs. When entered into the computer, the program's options are presented to the artist on the monitor in the format of a graphical user interface (GUI), which allows artists to make selections from a menu that displays a list of text commands or icons.

There are broad categories of software that artists can use to achieve different results. Software may differ according to authorship, degree of artist intervention, and point of origin of the image, as well as attributes of spatial orientation to two-dimensions and/or three dimensions, and temporal characteristics for real-time and real-motion.

Computer artists can create and write their own software programs, or, they can use commercially developed and pre-packaged application software. Software permits artists to use the computer to produce either computer-*generated* images or computer-*assisted* images. Computer-generated images are created when the artist uses scripted software. This means that the artist writes a script or computer program that describes to the computer how to create an image, then loads it into the computer and the computer executes its instructions without the artist's intervention. In contrast, computer-assisted images are made with software that permits the artist to

work interactively with the computer. When the program is loaded, the artist continuously intervenes in computer function to make choices from the options offered by the program. The computer "assists" the artist by executing these choices throughout each step of image creation. Artists may create their own images through the use of a program. Or, they can appropriate images from other sources. Images from other sources can be input into the computer through the use of scanners, digitizers, optical storage devices, or modems that are linked to the Internet. When the image is displayed on the monitor, artists can use image processing and editing application software to alter and manipulate it in some way.

Software permits artists to create and manipulate images or objects in either two dimensions (2D) or three dimensions (3D). Two-dimensional programs permit artists to create bit-mapped *images* or mathematically described vector *objects*. Bit-mapped "paint" programs allow artists to create or alter appropriated images that appear displayed as an array of colored pixels on a monitor like the surface of a mosaic or painting. Each pixel of the image is positioned in the computer's memory as a location on the height and width of a bit-plane determined by Cartesian coordinate points (x,y). Two-dimensional image processing/editing software enables artists to modify a bit-mapped image that has been digitally scanned or appropriated from another source. However, once an image is created, unless it is saved, the (x,y) coordinate points of the image subsequently are replaced in the process of ongoing modifications. In contrast, object-oriented "draw" programs permit artists to create objects by connecting points-to-lines, or vectors, to create shapes in two-dimensional space. These points are stored in the computer's memory as virtual objects defined by mathematical formulas. Therefore they can be modified or repositioned by the artist at any stage of the creation process.[14] We call these *virtual* images and objects, because until output or produced onto a tangible medium such as paper, film, or videotape, the images or objects exist only in the computer's memory *by virtue of* the program instructions, conceptual digital data (0's and 1's), and the artist's decisions.

Three-dimensional programs enable artists to create and manipulate an object as though it were a wireframe or solid model, like a sculpture, that exists in a hypothetical 3D space or volume. Virtual 3D objects and the spaces they occupy are described as collections of points, given attributes of width, height and depth according to their location as Cartesian coordinates (x,y,z), stored in the computer's memory. Three-dimensional solids modeling software allows artists to create objects that can be placed within an environment which the computer models in three dimensions, applies surface features such as colors and textures, and can render or display from any point of view on the monitor. Such an environment might be referred to as a *virtual space.*

One distinctive characteristic of the computer is that artists can interact with its function in real-time and real-motion. Artists can select options from among those presented by the computer program and the computer immediately executes them to produce results. Two-dimensional images or 3D objects can be altered in shape/form instantly in multiple ways, or shifted in position. Animation software provides artists with the means to deform or metamorphose (morph) objects from one shape/form to another. With 3D animation software, artists can create a 3D model of an environment and the objects placed within it, apply color and texture to the surfaces, add lighting and select a camera point of view by which the scene will be viewed and displayed on the monitor, render each frame or picture of the scene — then animate or move the 3D object through the virtual environment it inhabits, in real-time and real-motion.[15] This is accomplished by mathematically describing the changing positions of the points that comprise the object and its location in its virtual environment.

Similarities to Traditional Tools, Media, Products, or Processes of Art

As a computer can be equipped with hardware and software that enables artists to use it in art production, what features of computer art as a product and process are similar to traditional forms of art?

We know that all kinds of images may emerge as end products of computer processing. The term "computer graphics" usually is applied to any type of visual image or text produced with a computer, deriving as it does from the Greek term, *graphikos* which when translated means "written or drawn."[16] Is "computer art" a subcategory of computer graphics? Common sense tells us this may be so. However, there may be criteria we can use to distinguish between computer graphics and computer art. Perhaps we can hypothesize, echoing Dickie, that computer graphics can be produced by artists, engineers, or anyone, but computer art must be made by artists with the *intention* of offering it to audiences for their consideration to regard it as art. The term "computer art" is a general one that can be applied to any of the fine and applied arts where an artist has integrated use of a computer in art production.[17] But just as the medium and process of painting includes subcategories such as the watercolor versus acrylic paint medium, and scumbling versus glazing painting processes, computer art contains subcategories as well. We can deduce that attributes of hardware and software used in the process of art production can be used to classify subcategories of computer art. But what other criteria might be considered to stake out subcategories of computer art?

As noted, artists can *interact* with or use the computer to intervene in the art production process. Computers can be integrated with the art production process in five different areas, in: (1) production of images output to 2D surfaces such as paper, film, or videotape; (2) cybernetic sculptures; (3) environmental art works; (4) optical or video disks; and (5) telecommunication

events.[18] Computer art, when used here, refers primarily to the first and fifth areas: *the visual imagery created by artists who have used the computer to create images or objects that can be output to 2D media or transmitted to other computers.* In this respect, the computer can be integrated with the artistic process in two ways: as a design tool, and as a medium or means of fabrication, to result in an art product.[19]

The computer can be used as a design tool in the sense of assisting the artist to achieve some other end, such as creating design ideas that subsequently are executed in another medium. For example, if artists use a computer to generate many design possibilities in order to arrive at a design solution, but they execute the design in another medium, we can say that they are using the computer as a tool — as a means to augment human capabilities for completing some other task. When utilized this way in art production, the computer permits artists to exercise a wide range of options in appropriating, storing, manipulating and reproducing imagery in ways that save time and eliminate drudgery.[20]

For other artists, the computer serves as a medium or means of fabrication. They use the computer as a primary means for creating an image completed on the computer and displayed on the monitor, and then output onto some other medium. Such artists use the computer like a drawing or painting medium, as a means to create, display, and embody an image. As such, they are "painting" not with chemical pigment, but with light.[21]

Like other traditional art tools and media that create a distinctive "mark" when wielded by artists, might there be a causal relationship between the type of computer hardware and software artists choose to use as a tool and medium, and the resulting computer art product that emerges? What criteria might we use to compare similarities between computer art and more traditional forms of art? Aesthetic factors can be used to compare the similarities and differences between novel and more traditional art forms.[22] Aesthetic factors of art encompass three general areas: art media or materials used, visual design that results from arrangements of art elements and principles, and art content, or subject matter. Applying these as criteria, others have found that computer art in many ways exhibits similarities to traditional forms of art.[23]

From the standpoint of art history, computer art can be considered a legitimate art form emergent from the hands of artists engaged in pursuit of traditional aesthetic concerns — concerns that have preoccupied all artists throughout time. The development of computer art placed within the context of art history has been well-documented.[24] Additionally, artists have always appropriated technology as media, form and content in their work and computer artists are no exception.[25]

Computer art can be evaluated according to aesthetic standards used in art criticism. Artists can produce images with the computer that are rich in literal, design, and expressive aesthetic qualities.[26] This indicates not only

that computer art may meet ontological criteria for being considered as "art," but also may be representative of an artist's style — most particularly in the case of artists who write their own computer art programs.[27] Using the computer as a tool or medium, artists who prefer one aesthetic style to another can create images that emerge from and reflect their sensibilities. Thus, as computer art cannot be said to have a style unto itself, it can be judged to have validity as an art form.[28]

In light of these similarities, the computer could be judged to be like any other art tool or medium, and the computer art that results could be accorded validity equal to any other art form in that it measures up to several standards of art history and criticism.[29] But others disagree with this point of view. What might they invoke as criteria?

Differences from Traditional Tools, Media, Products or Processes of Art

Some claim that by virtue of its attributes and function the computer is *not* like other art tools and media, therefore computer art *cannot be compared to other forms of art*.[30] What aspects of the computer and its function when used in the process of art production by artists makes it different from traditional art tools and media? What features of computer art, if any, are different from those of traditional artworks?

The differences that distinguish the process and product of computer art are not inherently obvious. These include: (1) attributes of the computer programming language, (2) mathematical principles that guide outcomes, (3) unique aspects of computer hardware and software that enable the computer and artist to function interactively in real-time and real-motion, resulting in ease of data manipulation and duplication due to the means of an interface, and (4) the computer's role as a "creative partner" for the artist. These are discussed individually below.

Computer programming languages differ in structure and syntax and in how easily they can be applied to perform tasks. Subsequently, there are restrictions imposed on how they can be used in application to the task of creating art images and objects. Thus, the limitations of the programming language used to author a computer program that enables artists to create art, ultimately exerts an impact, however invisible, on the types of choices available to artists and the degree of complexity that can be achieved in the resulting art work.

The computer's function is supported by numerical logic, and mathematical principles, operations, and procedures known as algorithms, embedded in the software of a computer program. Artists who author their own programs are familiar with these procedures because they must write the program instructions to guide the computer in performing them. However, most artists who use commercially developed application paint, draw, or solids modeling programs are not aware of these mathematical procedures

because they rely upon selecting their command options from a menu presented to them in the form of the GUI. The selected GUI menu icons or text in turn direct the computer on another level to synthesize or combine graphic *primitives* according to procedural calculations based on algorithms. In paint programs these primitives are the pixel and the curve, with attributes of color (hue, luminance, and saturation). In draw programs, these primitives are vector points that form lines and shapes such as rectangles, circles, and ellipses, which also may have attributes of color, width, and style. In 3D solids modeling, the primitives fall under two broad categories to include area primitives for defining a shape, or volume primitives for defining a form.[31] The artist makes arbitrary choices from those presented on the menu of the GUI to manipulate graphic primitives according to basic operations. These operations allow the artist to move, incorporate, alter, locate, define, group and ungroup, remove, copy, scroll, scale, rotate, flip, and image warp a primitive. Although these basic operations are founded upon mathematical procedures called geometric transformations and deformations, and other similar types of mathematical operations, their mathematical basis remains invisible to the artist.[32]

However, artists who write their own programs acquire familiarity with writing and using the mathematical algorithms that direct computer function. An algorithm is a procedure that is written in the form of numbers to define a procedural calculation. Algorithms written into software direct the computer in the calculations it must execute in order to execute an artist's instructions to create an image or an object.[33]

In conclusion, much of what the computer "does" to aid the artist in creating and manipulating images and objects is conceptually based upon mathematics, remains invisible to the eye, and generally is not apparent in the resulting art work.

The major difference between computer art and other forms of art becomes apparent when we stop to think about just where the "art" of computer art resides. Is it in the software instructions of a program, or the data that results? If so, is it only "art" if an artist writes the program? Or is computer art in the image that appears on the monitor or printed onto a hard copy of paper or film?

Several scholars note that there are characteristics of computer hardware, software, and function that differentiate computer art from any other art tool, medium, or form. Focusing upon these features, they note that: computer artists create art that in nascent form originates in a computer as *conceptual information*; using a computer, artists can process, duplicate, and change the presentation of this information by outputting it to different media through the means of an *interface*; working *interactively* with the computer in real-time and real-motion, artists can manipulate this information and transfer it onto other media, or *transmit* it to remote site locations.[34]

Computer artist Timothy Binkley philosophizes that the fundamental characteristic of digital images is that they consist of conceptual, ephemeral information. A computer image is not a physical material nor an event, but is an intangible collection of numbers organized in computer code and manipulated according to mathematical operations and algorithms. The numbers which the computer uses to direct its function are not perceptual objects but conceptual ones: "Numbers have a meaning independent of their expression in any particular medium because they are concepts, and not objects or events." The computer's image actually is not an image at all, but exists as an array composed of binary digits, translated by the computer as electronic impulses. Therefore, a computer image has "no characteristic look, sound, or smell because it is a concept, not an object." If a computer image actually exists as a conceptual idea — a file of numbers retained in the memory of a computer — then an image created with a computer is very different from an image that exists as a visually and physically perceptible mass of colored paint spread on canvas. Binkley asserts that a medium embodies its messages in an inseparable union of form and matter, but a computer encodes its information in an abstract conceptual form; therefore the computer is *not* a medium (*CNM*, 158; *DAC*, 94).

Another computer artist, Joan Truckenbrod, notes that because the computer encodes images as electronic impulses, such conceptual information is easy to process and duplicate, and as a result it is malleable, transformable, and transmittable. An artist can use computer hardware and software to process or convert any image to digital information. Artists can appropriate images, alter them, then duplicate them endlessly in other media for a second life as "borrowed images." Then, the computer can transmit or route this digital information anywhere in the world. The receiver in turn can work with an image and return it to the sender.[35]

Binkley contends that because the computer can transmit data through an interface, the ephemeral array of its digital images can travel as electronic impulses shuttled from one medium to another, to be rendered as a visible image. The information in a computer is conveyed through an interface, from "one place to another, and is never permanently fused with any particular material," and "can readily be transported into many different" forms of media Binkley notes that while an interface connects a computer to a medium, it also keeps it from becoming one (*CNM*, 158-59).

Based upon the computer's capability for performing calculations in real-time and real-motion, the artist and the computer can interact with one another in the process of creating computer-assisted images. Binkley notes that interactivity is a unique element that computers add to art production. Artists can initiate a dialogue with the machine as part of the creative process. Due to the interactive nature of computer function, artists can obtain relatively complex feedback "which surpasses any surprise one might

encounter by the novel placement of patches of paint together on a canvas" (*DAC*, 95).

With an eye to the unique features of the computer function and to these remarkable potentialities, all of which can be harnessed in art production, several philosophers and artists conjecture that the computer's role in art production exceeds that of an art tool or medium. Some think that the computer should be defined as a *meta-tool*, because the computer can perform a wide variety of functions for the artist. The computer could be considered also *as creative partner or assistant* (*CNM*, 165).[36]

If the computer can extend an artist's function, what are the possible levels of such an extension? On one level, this can consist of augmenting the artist's creative behavior (*CNM*, 161).[37] Because of its interactivity and capability for duplicating information and executing repetitive functions, the computer enhances the artist's capability for divergent production in art, identified by Guilford in 1957 as fluency, flexibility, originality, and elaboration.[38] Divergent production can be construed as creativity. If the computer can enhance an artist's capabilities for divergent production, then it extends the artist's capabilities for engaging in the creative process, as well.[39]

Computer Characteristics Define the Ontology of Computer Art

What are other unusual attributes of computer function that artists might integrate in their work? What about the processes for creating simulation or virtual reality? What relationship might these aspects of computer function have with regard to artists and computer art?

The computer, as an instrument of technology, can be harnessed *to extend aspects of the artist's body and mental capabilities*, as well as function as the artist's "mirror of the self."[40] In this respect, other unique aspects of computer function used by artists in art production include: (1) virtual worlds, (2) simulation, (3) virtual reality, (4) artificial intelligence, and (5) interactivity that connects artist and audience.[41]

The most unique aspect of the computer lies in the opportunity it presents to artists to use it for creating virtual worlds. A virtual world is a hypothetical location, space, or environment created by virtue of computer function. These can be conceived of as either imaginary spaces or environments, or, those that replicate "real-world" phenomena and environments. Virtual worlds can simulate real-worlds — aspects of the material world which may or may not be perceptible to the human eye (such as gravitational pull or weather pressure zones).

Virtual world models that mimic real-world phenomena (objects, environments, events) and engage artists in the principle of interactivity in order to alter the conditions within them, are called *simulations*. Robert Rivlin noted that computer graphics imagery is distinctive as an art form in that it is marked by conceptual aesthetic differences. [42] As opposed to paintings

that may only imitate the appearance of real objects, computers can be directed by artists to create actual simulations of them. Although a simulation of a phenomenon from the material world can be created in a virtual world, virtual worlds can also encompass products of an artist's imagination. Unlike simulations, virtual worlds do not necessarily "bear the ontology or the semiology of one object parading as another" (*QOG*, 239).

If these are the subtle ontological differences between a virtual world and a simulation, then what do we mean by the term, "virtual reality"? The difference may be one based upon *interactivity*. If an individual can make choices from among options presented within an imaginary construct of an artificial world, or a simulation of a real-world, and interact in real-time and real-motion with objects placed within that virtual world — then we call such a phenomenon a virtual reality.[43] Only the computer allows artists to interact within a world that either may be an imitation of reality or one conjured from their own imagination.

> The computer [should be regarded as] more than a fancy picture maker; its powers are versatile enough to carry us into the virtual worlds it conjures up with it computational algorithms.…[The] luminous screen under computer control can transport us — like Alice through the looking glass — into the virtual worlds it displays. We can, in a sense, live in these created environments and interact with them (*WEP*, 19).

We have seen that the computer may serve the artist as a creative partner to facilitate divergent visual solutions and realize the products of imagination — and hence to function as an extension of the artist's mind.[44] But we could go one step further to say that the computer not only enables artists to extend their capabilities — but to expand their reaches and powers of their consciousness, and to even function as an adjunct site for their mind.[45]

Can we simulate a mind? In the future, computer art may prove to be fertile ground for exploring aspects of aesthetic decision-making by both humans and machines, since a computer can be programmed to simulate many aspects of human thought and behavior in creating art.[46] This exploration takes place in the field of Artificial Intelligence (AI). Harold Cohen, a painter, professor emeritus at the University of California at San Diego, has been engaged in that very quest. He has authored and continuously developed for twenty years a computer program he named Aaron. Aaron is known as an expert system,

> a problem-solving and decision-making system that uses a computer representation derived from the knowledge and experience of a human expert. An expert system consists of two parts; the domain or database of factual knowledge about the subject, and a set of rules that provide a method of using that knowledge.[47]

Cohen provided Aaron with factual knowledge about the real-world, and a set of rules about picture-making that Aaron could select from to generate pictures. When Aaron is loaded into a computer, it guides and directs the computer autonomously to generate images with a plotter onto paper without the need for an artist's intervention. Cohen's work with Aaron exemplifies a pioneering investigation into analyzing the decision making procedures an artist undertakes when engaged in the creative process of executing an art work — so that a computer could be taught to make similar decisions in order to create art on its own. In this respect, Cohen is a pioneer in the area of AI.[48] And Aaron is unique in that produces "original," one-of-a kind computer-generated images, none of which are the same. Is what Aaron generates — art? Cohen as well as many others think so. To their way of thinking, not only is an artist's individually authored program the actual work of art in computer art, but Aaron is an extension of Cohen's mental processes and therefore is a mirror of a human mind at work — Cohen's mind.[49]

We have noted before that the computer and the artist can work interactively to make computer art. But the concept of interactivity can extend beyond individual artists to an audience. The interactive nature of the computer gives artists the capability to create images and objects that exist in a virtual world and can be altered by an audience with access to the computer. Artists and audience can collaborate to create a work of computer art that they develop through interaction with one another. Through the means of the Internet, artists can electronically transmit their images to audiences. Audiences in turn can adopt the role of artist to alter the image they have electronically received, then transmit them back to the originating artist.[50]

What Then, Is the Nature of Computer Art?

If the computer is not a tool or medium, but more like a creative partner, creative assistant — or an extension of a human mind — then what is it? Is it some sort of other thing like a "polymorphous beast"? (*CNM*, 166). Is what an artist creates with it, something we can call "art"?

We have noted that some characteristics of computer hardware and software enable artists to use the computer like another art tool and medium. But does that make an image produced with or by a computer necessarily "art"? To this we might answer, "No," asserting that just because the computer functions like an art tool or art medium does not necessarily make its output or product art, as "media alone do not a make art."[51]

Is computer art — "art"? We have seen that computer art, when output as hard copy onto a 2D medium withstands scrutiny under the test of applying standard criteria we might use to evaluate the merits of traditional forms of art. But, some have proposed that computer art should be classified

as a new form of art.[52] Others have suggested that the integration of the computer with art production may even change the ontological criteria that traditionally have been used to define the nature of art (*QOG*).[53] Perhaps the solution is to follow Weitz's suggestion and use the ontological criteria of art theory as a guide to see if in fact it can direct our attention to unique features of computer art.

Plato and Bell held object-centered definitions of art. What is the material form of computer art? Is the artwork the hard copy of an image output to paper or film? Or is it in the computer program? Or is the artwork something or somewhere else? Due to the ephemeral nature of digital data conveyed by means of electronic impulses across interfaces and shuttled from one form of medium to another, it appears that it is difficult to ascertain what, exactly, the computer art object is, much less where it is (*CNM*, 158). If Plato and Bell felt that the essence of an art resided in an art object, and if a computer image actually exits as a conceptual idea — a file of numbers retained in the memory of a computer — then perhaps there is no computer art "object" per se (*CNM*, 158).

As noted, according to some scholars, only an artist's self-authored program can be considered a work of art. By extension, with regard to the conceptual nature of computer programs, and the ephemeral nature of digital images it has been said that

> if the art created with computers is so ephemeral that it is gone in the instant the power is turned off, if it is so dependent on some other medium to exhibit it, and especially if it does not extend itself into time and into the minds and spirits of those who see it, then perhaps we cannot really call it art.[54]

From this perspective, it appears that computer art may embrace a broader concept of art than that of existing merely as an art object.

We have seen that as part of its more far-reaching implications, computer art can consist of simulations and virtual worlds. If Plato said that art must imitate reality, then what of art works created as simulations, or as virtual reality? After all, we might say, "How much closer to an imitation to reality can we get than in the form of computer art created as a simulation or as a virtual reality?" Perhaps we can use Plato's theory of art as a springboard to take our inquiry still further—to discuss how computer simulation and virtual reality might alter our notions about the nature of reality.

Bell was concerned that art embody significant form. Bell's theory suggests that one unique aspect of art may be signaled by the presence of the aesthetic qualities of design. What aesthetic form does computer art assume? As noted, when computer art is output as an image on paper or film, we can use traditional standards to evaluate its merits. But do these standards apply to other forms of computer art that are *not* output onto 2D media? Some artists have claimed that computer art should be considered a

new art form because it harbors several unique features that set it apart other art media, such as: (1) interactivity, (2) artificial intelligence, (3) networking capability for dispersing imagery, and (4) animating images and objects in real-time and real-motion.[55] But can we say that these are *aesthetic* attributes of computer art? Why or why not? Perhaps we should consider revising our list to include other types of criteria when we consider the merits of computer art.

Mandelbaum noted that the essence of art may lie in unexhibited properties. As Binkley pointed out, the major difference between computer art and other forms of art executed in more traditional media is not "the aesthetic presentation which the computer offers but the conceptual presence it brings to bear in the artist's mental function and art production" (*CNM*, 156). This conceptual presence could be thought of as an unexhibited property. And there is another unexhibited property which computer art harbors: the underlying mathematical basis that forms the foundation for creating computer art images and objects. It has been said that the "mathematical and geometrical patterns (used to create computer art) have a profundity to them due to the fact that they describe laws of nature."[56] If we recall Bell's position, that art must have significant form, and tie that in with Mandelbaum's assertion that the essence to art is a unexhibited property, then perhaps we might see that the significant form that lies at the heart of computer art is an unexhibited property consisting of mathematical principles. Could that be the essence of computer art?

Tolstoy, Croce, and Collingwood believed that it was not the art object that held importance; instead, it was the mental process or form of communication that transpired during the artist's process of creation. We have seen that a computer provides artists with the capabilities to create virtual worlds and simulate human mental processes with artificial intelligence. Computer art thus can exist as an extension of the mind of the artist. Also, due to the interactive nature of the computer, artist and audience alike can participate in the creation and sharing of an image. From Cohen's work, it seems that the potential to create virtual realities and simulate human thought may prove to be the most breathtaking frontier of all in computer art. If so, it may be that in the case of computer art, the art theories of philosophers Croce and Collingwood hold the most weight: the nature of art may be embodied in the mental processes of the artist, and not necessarily bound up in material aspects of an object. If that is the case, then the computer provides a powerful vehicle to enable artists to conceive, create and wander through virtual art worlds of their own imagination — worlds that Binkley would attest exist only as conceptual information.

Danto and Dickie suggested that art may be defined in part by the institutions or social construct within which it is created. If they are correct, then that may mean that an audience as well as all of society can participate and

interact with the computer art created by artists in virtual worlds within the context of a simulated society.

In the future, computer artists may use computer art to become more immersed in exploring the problem of analyzing and questioning our conceptions of the nature of knowledge and the nature of reality itself, particularly when experienced as virtual reality.

> In the face of electronic reality, art, having once been a problem of materials, now has become a digital problem. From questioning our views of the world, art has moved on to *questioning the world itself* .[57]

Conclusion

The most interesting aspect of guiding students through the challenge of examining the ontology of computer art lies in the difficulty entailed in separating out computer process from computer product. This similarly reflects the aesthetic dilemma faced in formulating a theory of art, because it is not clear whether the nature of art resides in the art object or the subjective sensibilities of the artist and the responding audience. But it is also clear that a journey taken to examine the ontology of computer art may lead to another avenue of exploration — an examination of epistemology, or the nature of truth and reality manifested in computer art, particularly with respect to virtual reality. The surprising conclusion students may reach through an aesthetic inquiry into the nature of computer art is this: it may not so much that we may need to alter our ontological criteria for art in order to properly assess the attributes of computer art; instead, an exploration of the frontiers of computer art may lead to the discovery that we need to modify our notions of *epistemology* — our knowledge of reality and what it is or *could be* — inherent in the unlimited possibilities of virtual reality.

NOTES

1. Cynthia Goodman, *Digital Visions: Computers and Art* (New York: Harry N. Abrams, 1987), 16.
2. Plato, "Book X," in *The Republic*, in *The Dialogues of Plato*, 4th ed., trans. Benjamin Jowett (Oxford: Oxford University Press, 1953).
3. Clive Bell, *Art* (London: Chatto and Windus, 1914).
4. Benedetto Croce, *Aesthetic as Science of Expression and General Linguistic,* Part II, 2d ed., trans. Douglas Ainslie (London: Macmillan, 1922).
5. Robin G. Collingwood, *Principles of Art*, Books I, II, and III (Oxford: Oxford University Press, 1935).
6. Leo F. Tolstoy, *What is Art? and Essays on Art*, World's Classics Series, trans. Alymer Maude (1898; reprint, London: Oxford University Press, 1932).
7. Morris Weitz, "The Role of Theory in Aesthetics," *Journal of Aesthetics and Art Criticism* 15, no. 1 (September 1956): 27-35 and Morris Weitz, "The Nature of Art," in *Readings in Art Education*, ed. Elliot W. Eisner and David W. Ecker (Waltham, Mass.: Blaisdell Publishing Company, 1966), 49-56.

8. Maurice Mandelbaum, "Family Resemblances and Generalization Concerning the Arts," *American Philosophical Quarterly* 2, no. 3 (July 1965): 219-28.
9. Arthur Danto, "The Artistic Enfranchisement of Real Objects: The Artworld," *Journal of Philosophy* 61, no. 19 (October 1964): 571-84.
10. George Dickie, "The Philosophy of Art in the 20th Century," tape recording of lecture at Texas Tech University, 14 April 1994, author's archives. See also George Dickie, "Defining Art," *American Philosophical Quarterly* 6, no. 3 (July 1969): 253-56; George Dickie, *Aesthetics: An Introduction* (New York: Pegasus, Bobbs-Merrill Company, Inc., 1971); and George Dickie, *The Art Circle: A Theory of Art* (New York: Haven Publications, 1984).
11. George Dickie, Richard Sclafani, and Ronald Roblin, eds., *Aesthetics: A Critical Anthology* 2d ed. (New York: St. Martin's Press, 1989), 2.
12. Joan Truckenbrod cited by Goodman, *Digital Visions*, 16.
13. Peter Dyson, *The PC User's Essential Accessible Pocket Dictionary* (San Francisco: SYBEX, Inc., 1994), 254.
14. Isaac V. Kerlow and Judson Rosebush, *Computer Graphics for Designers and Artists* (New York: Van Nostrand Reinhold, 1986).
15. For a description of the process of solid modeling and animation, see Bob Bennet, "3D Animation," chap. 26, in *The McGraw-Hill Multimedia Handbook*, ed. Jessica Keyes (New York: McGraw-Hill, 1994), 3-16
16. *Webster's New International Dictionary*, 3d ed., s.v. "graphics."
17. Frank Popper, *Art of the Electronic Age* (New York: Harry N. Abrams, 1993).
18. Ibid., 78 and Donald Michi and Rory Johnston, *The Creative Computer: Machine Intelligence and Human Knowledge* (Harmondsworth, England: Viking/Penguin Books, 1984).
19. Stephen Wilson, *Using Computers to Create Art* (Englewood Cliffs, N.J.: Prentice-Hall, 1986) and Popper, *Art of the Electronic Age*, 78.
20. Ibid.
21. Ibid.
22. William R. Hastie and Christian Schmidt, *Encounter with Art* (New York: McGraw-Hill, 1969).
23. Holle L. B. Humphries, "A Method to Introduce Secondary Students to the Computer's Potential as an Art Tool" (Master's Thesis, Texas Tech University, 1986).
24. Douglas Davis, *Art and the Future: A History/Prophecy of the Collaboration Between Sciences, Technology, and Art* (New York: Praeger Publishers, 1973); Frank Dietrich, "Visual Intelligence: The First Decade of Computer Art (1965-1975)," *Leonardo* 19, no. 2, 159-69; Herbert W. Franke, *Computer Graphics — Computer Art*, 2d ed., rev., trans. Gustav Metzger and Antje Schrack (New York: Springer-Verlag, 1985); Goodman, *Digital Visions*; Ruth Leavitt, *Artist and Computer* (New York: Harmony Books, 1976); and Wilson, *Using Computers to Create Art*.
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27. Feldman, *Varieties of Visual Experience*.
28. Herbert W. Franke, "The Expanding Medium: The Future of Computer Art," *Leonardo* 20, no. 4 (1987): 335-38.
29. Michel Bret, "Procedural Art with Computer Graphics Technology," *Leonardo* 21, no. 1 (1988): 3-9; Franke, *Computer Graphics*; Goodman, *Digital Visions*; Humphries, "A Method to Introduce"; Richard E. Lucas, "Evolving Aesthetic Criteria for Computer Generated Art: A Delphi Study" (Master's thesis, Ohio State University, 1986); Harold J. McWhinnie, "Some Aesthetic Questions on Computer-based Art and Design," *Computers and Graphics* 15, no. 1 (1991): 139-42; James Pearson, "The Computer: Liberator or Jailer of the Creative Spirit," *Leonardo: Electronic Art Supplemental Issue* (1988): 73-80; Popper, *Art of the Electronic Age*; and Wilson, *Using Computers*.
30. Ibid.

31. King, "Towards an Integrated System," 42-43.
32. Ibid.; Kerlow and Rosebush, *Computer Graphics*.
33. King in "Towards an Integrated System," 45, notes that there are two basic types of algorithms with two different computing techniques as their basis that can be used: recursive and classical. In recursive geometries, the computer proceeds to execute a calculation, then uses the output of that calculation as input for the next calculation. Some of the recursive geometries include: iterative functions, random numbers, recursive patterns fractal and graftals, particle systems, and growth models. In classical geometries, although some repetitive techniques are used, a given calculation is not based on the previous ones. The algorithms used in classical geometry include formulas for making Euclidean geometrical shapes such as parallel lines, triangles, rectangles, polygons, tessellations, and parametric curves. In addition to the classical and recursive geometries cited above, there are other mathematical principles that computer artists have incorporated in their approach to creating computer programs for creating and manipulation images and objects. Some of these include permutation, interpolation and extrapolation, and matrix calculation. See Franke, "Computer Graphics" and Kerlow and Rosebush "Computer Graphics".
34. Timothy Binkley, "Does Art Compute? The Myths, the Madness, and the Magic," *Art & Academe* 1, no. 1 (1988): 90-99; Binkley, "The Computer is Not a Medium," *Philosophic Exchange* 19/20, (1988/89): 155-73; Binkley, "The Wizard of Ethereal Pictures and Virtual Places," *Leonardo: Computer Art in Context Supplemental Issue* (1989): 13-20; and Binkley, "The Quickening of Galatea: Virtual Creation Without Tools or Media," *Art Journal* 49, no. 3 (Fall 1990): 233-40. These articles will be cited as *DAC*, *CNM*, *WEP*, and *QOG*, respectively, in the text for all subsequent references. See also George Legrady, "Image, Language, and Belief in Synthesis," *Art Journal* 49, no. 3 (Fall 1990): 266-71 and Joan Truckenbrod, "A New Language for Artistic Expression: The Electronic Arts Landscape," *Leonardo: Electronic Art Supplemental Issue* (1988): 99-102.
35. Truckenbrod, "A New Language for Artistic Expression," 102.
36. Bret, "Procedural Art"; Roger F. Malina, "Computer Art in the Context of the Journal Leonardo," *Leonardo: Computer Art in Context Supplemental Issue* (1989): 67-70; A. Michael Noll, "The Beginnings of Computer Art in the United States: A Memoir," *Leonardo* 27, no. 1 (1994): 39-44.
37. McWhinnie, "Some Aesthetic Questions"; Pamela McCorduck, *AARON'S CODE: Meta—Art, Artificial Intelligence, and the Work of Harold Cohen* (New York: W. H. Freeman, 1991).
38. Joy P. Guilford, "Creative Abilities in the Arts," *The Psychological Review* 44 (1957): 110-18.
39. Humphries, "A Method to Introduce Students."
40. Legrady, "Image, Language, and Belief."
41. Popper, *Art of the Electronic Age* and Lucas, "Evolving Aesthetic Criteria."
42. Robert Rivlin, *The Algorithmic Image: Graphics Visions of the Computer Age* (Redmond, Wash.: Microsoft Press, 1986).
43. Richard V. Kelly, Jr., defines three general forms of virtual reality (VR): through-the window, (allows participants to look into a virtual world from a seat in the real world), immersive (uses a head-mounted display and emphasizes interactivity within a virtual software-derived world to immerse participants in exploring an environment), and second-person (uses a camera to capture the image of participants and inserts them into a virtual world, where they can watch their own image on a screen interacting with objects in the virtual world). See Kelly, "Virtual Reality in a Nutshell," chap. 46, in Keyes, *The McGraw-Hill Multimedia Handbook*, 46.1-8.
44. Terry Gips, presentation at College Art Association, San Francisco, 1989, quoted in Harold. J. McWhinnie, *Computers & Graphics*, 140-41.
45. For discussions about computer augmentation of artistic consciousness, see Roy Ascott, ed., *Reframing Consciousness* (Portland, Ore.: Intellect Books, 1999); Mary

Ann Moser with Douglas MacLeod for the Banff Centre for the Arts, eds., *Immersed in Technology* (Cambridge, Mass.: MIT Press, 1996).

46. Franke, *Computer Graphics*; McCorduck, *AARON'S CODE*; Popper, *Art of the Electronic Age*; and Herbert A. Simon, *Harold Cohen*, essay in exhibit catalog (Pittsburgh: Buhl Science Center, 1984).
47. Dyson, *The PC User's Essential Dictionary*, 201.
48. McCorduck, *AARON'S CODE*, 1994; Michi and Johnston, *The Creative Computer*; Popper, *Art of the Electronic Age*; and Simon, *Harold Cohen*.
49. Mihai Nadin, "Emergent Aesthetics — Aesthetic Issues in Computer Arts," *Leonardo: Computer Art in Context Supplemental Issue*, 1989, 43-48.
50. Truckenbrod, "A New Language for Artistic Expression," 101.
51. Hastie and Schmidt, *Encounter with Art*, 224.
52. Tom DeWitt, "Dataism," 57-61; Judson Rosebush, "The Proceduralist Manifesto," 55-56; and Benoit R. Mandelbrot, "Fractals and an Art for the Sake of Science," 21-24; all *in Leonardo: Computer Art in Context Supplemental Issue* (1989). See also Terry Gips, "Computers and Art: Issues of Content," *Art Journal* 49, no. 3 (Fall 1990): 229-32; Legrady, "Image, Language, and Belief"; Margot Lovejoy, "Art, Technology, and Postmodernism: Paradigms, Parallels, and Paradoxes," *Art Journal* 49, no. 3 (Fall 1990): 257-65.
53. Gips, "Computers and Art," 229-32; Legrady, "Image, Language, and Belief"; and Lovejoy, "Art, Technology, and Postmodernism," 257-65.
54. Deborah Sokolove, "The Image in the Magic Box," *Art Journal* 49, no. 3 (Fall 1990): 274.
55. Lucas, "Evolving Aesthetic Criteria."
56. King, "Towards an Integrated System," 50.
57. Popper, *Art of the Electronic Age*, 177, italics added.