INTEGRATED PLANNING APPROACHES IN HIGHER EDUCATION:
COLLABORATIVE EDUCATIONAL PROTOTYPE TOWARDS
INTEGRATED APPROACHES IN THE PLANNING OF INCLUSIVE,
PEOPLE-CENTRIC AND CLIMATE-RESILIENT CITIES

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Project: 2022-1-EL01-KA220-HED-000089374 Erasmus+
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AESOP

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Evidence-Based Design and Planning: Predicting effects of design and planning interventions - Urban Mapping: Sensing Public Spaces

Date (to be modified by partners)

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Noumena

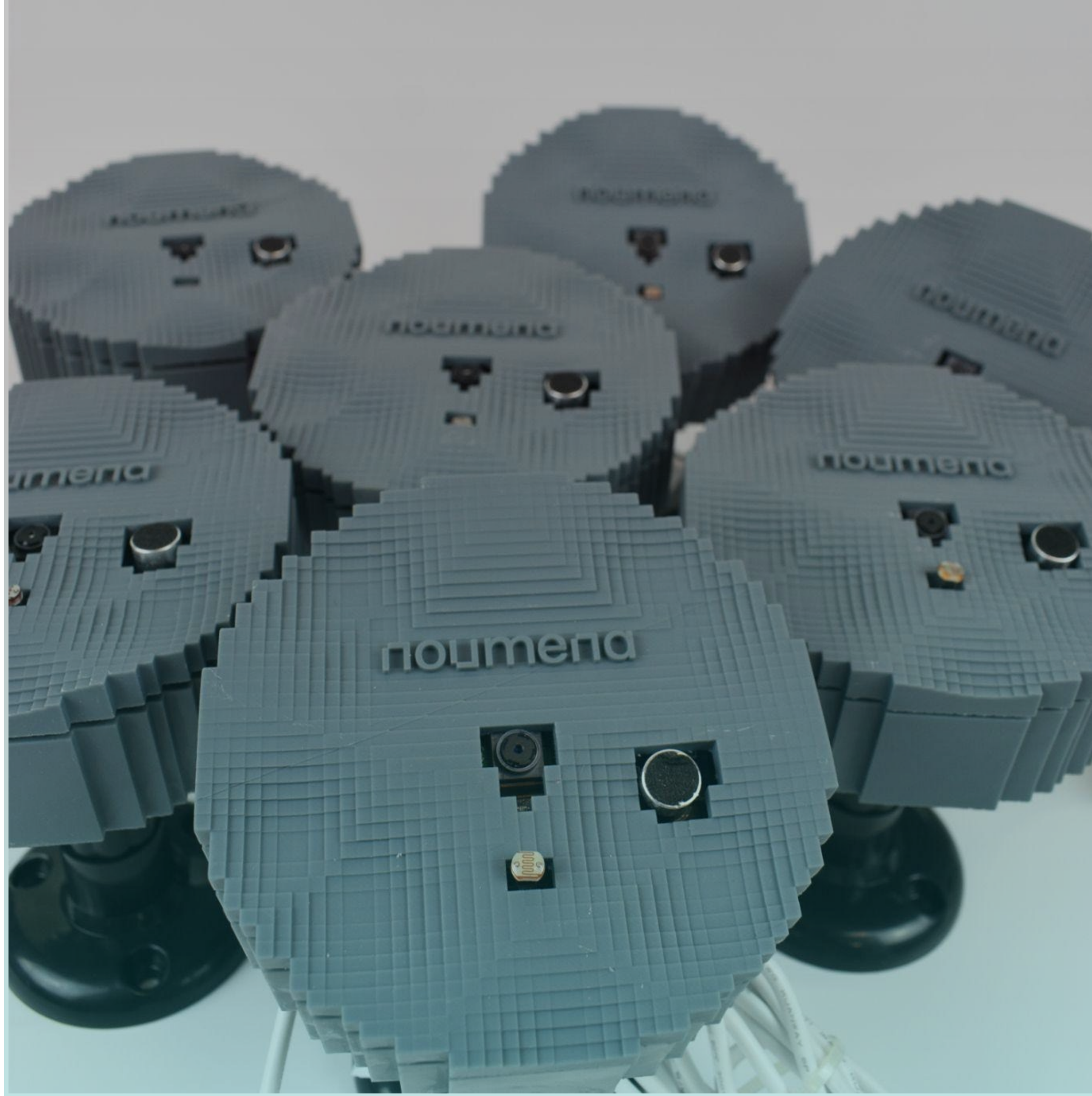
About

Since 2011, Noumena has developed practice integrating cutting-edge technologies to study and analyse spatial dynamics. Founded by Aldo Sollazzo, Efilena Baseta and Chirag Rangholia, Noumena's mission is to develop metrics and instruments to empower decision-makers towards more efficient, resilient and sustainable spatial solutions.

Noumena have been involved in multiple initiatives, operating in the built and environmental scale to define design protocols driven by data and machine learning.

DATA COLLECTION
Autonomous systems to capture reality

NOUMENA digitizes the physical environment, introducing devices as tools for spatial observations. We implement autonomous systems to collect data, detecting and monitoring the physical characteristics of a site through cameras and on-board sensors. Our goal is to integrate optical data to establish criteria for spatial decision making.



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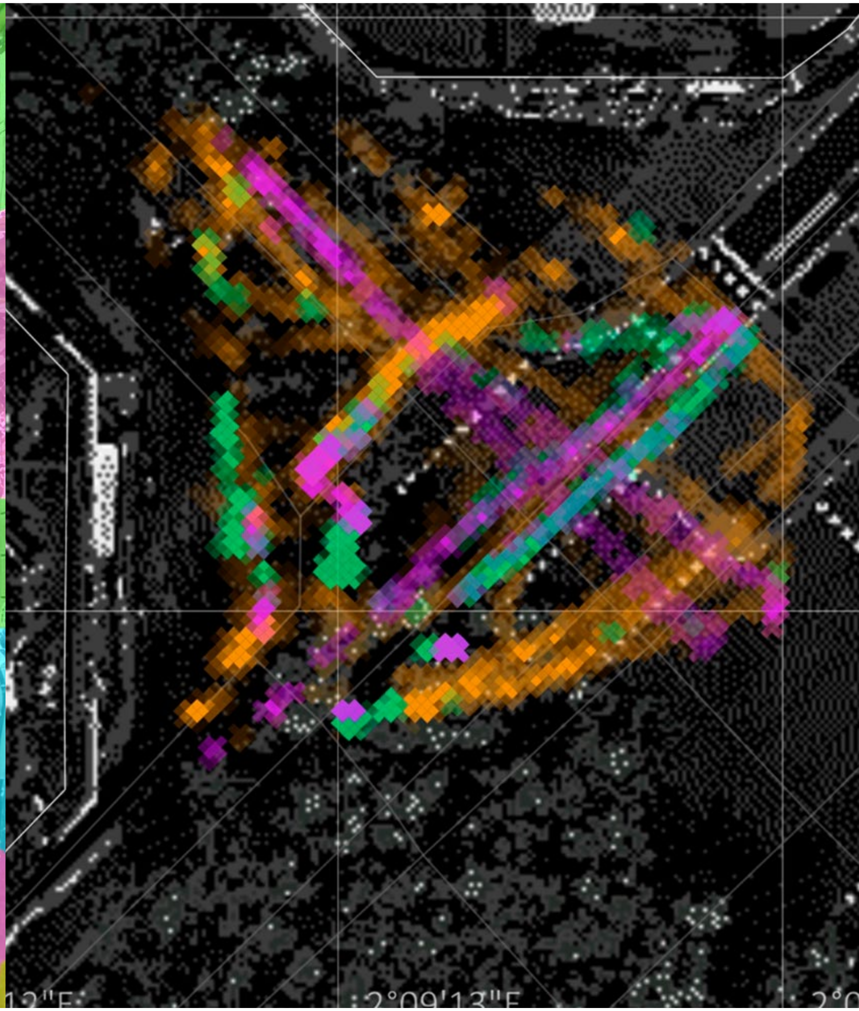

DATA COLLECTION

DATA PROCESSING

SPATIAL MONITORING

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DATA PROCESSING
Digitize physical environments

We are experts in reconstructing built environments and convert physical components into data. We are adopting state-of-the-art technologies to digitally reconstruct faithful spatial representations.
Noumena develops digital twins to optimize the maintenance operations of physical assets, systems and manufacturing processes.

Image: Object detection urban dynamics, Barcelona and Rome.
Source: Noumena

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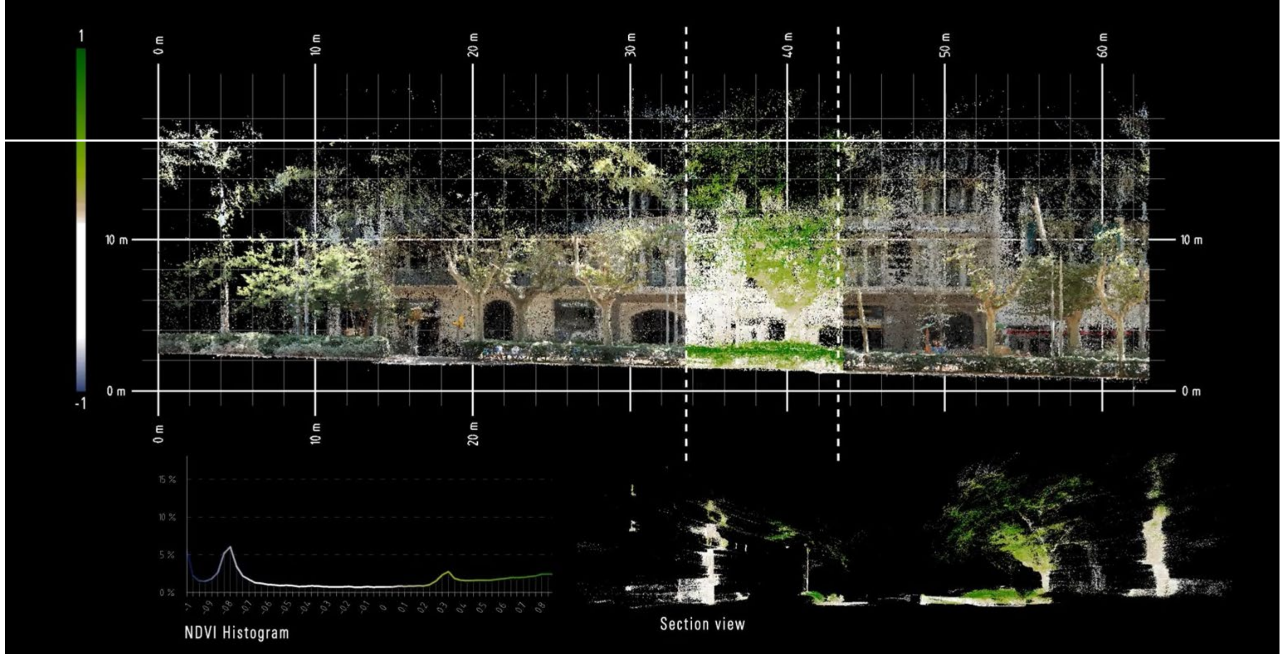
SPATIAL MONITORING

AI driven spatial analytics

We develop spatial algorithms to reveal invisible patterns of human behavior and its spatial expression.

Through computer vision and machine learning, NOUMENA implements strategies to track and monitor spatial dynamics, uncovering associations between each individual component. Our aim is to produce informative geographical representations of spatial occupancy to drive strategies such as energy building consumption, urban analytics, farming practices or management for on-site construction.



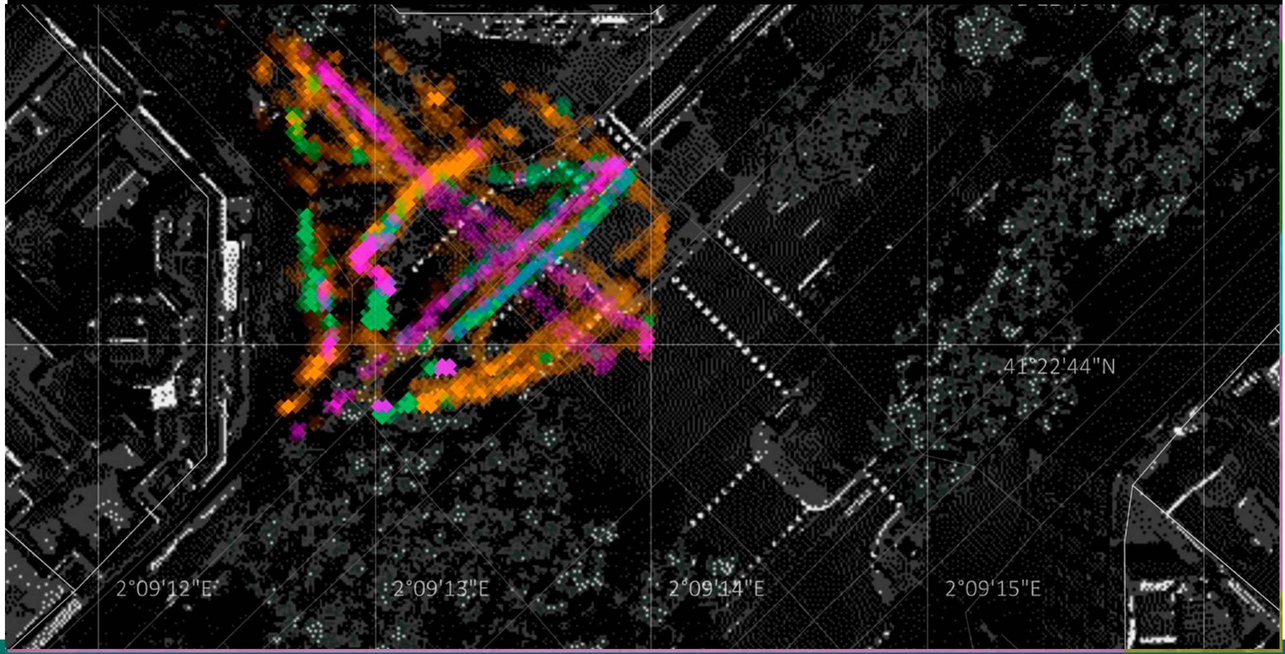


Image: Fig.1 urban vegetation analysis; Fig.2 Mobility studies in Barcelona. Source: Noumena

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URBAN ANALYTICS

PRECISION AGRICULTURE

COMMERCIAL SPACES

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URBAN ANALYTICS

Image analytics to build better cities

Noumena implements machine learning and computer vision to provide accurate estimations of actual spatial dynamics occurring in the public scene. The integration of vision-based technologies allows to inform data-driven decisions and the application of urban solutions for:

- Traffic and mobility surveillance
- Classification of urban components
- Land use classification
- Analysis of environmental conditions
- Infrastructure monitoring

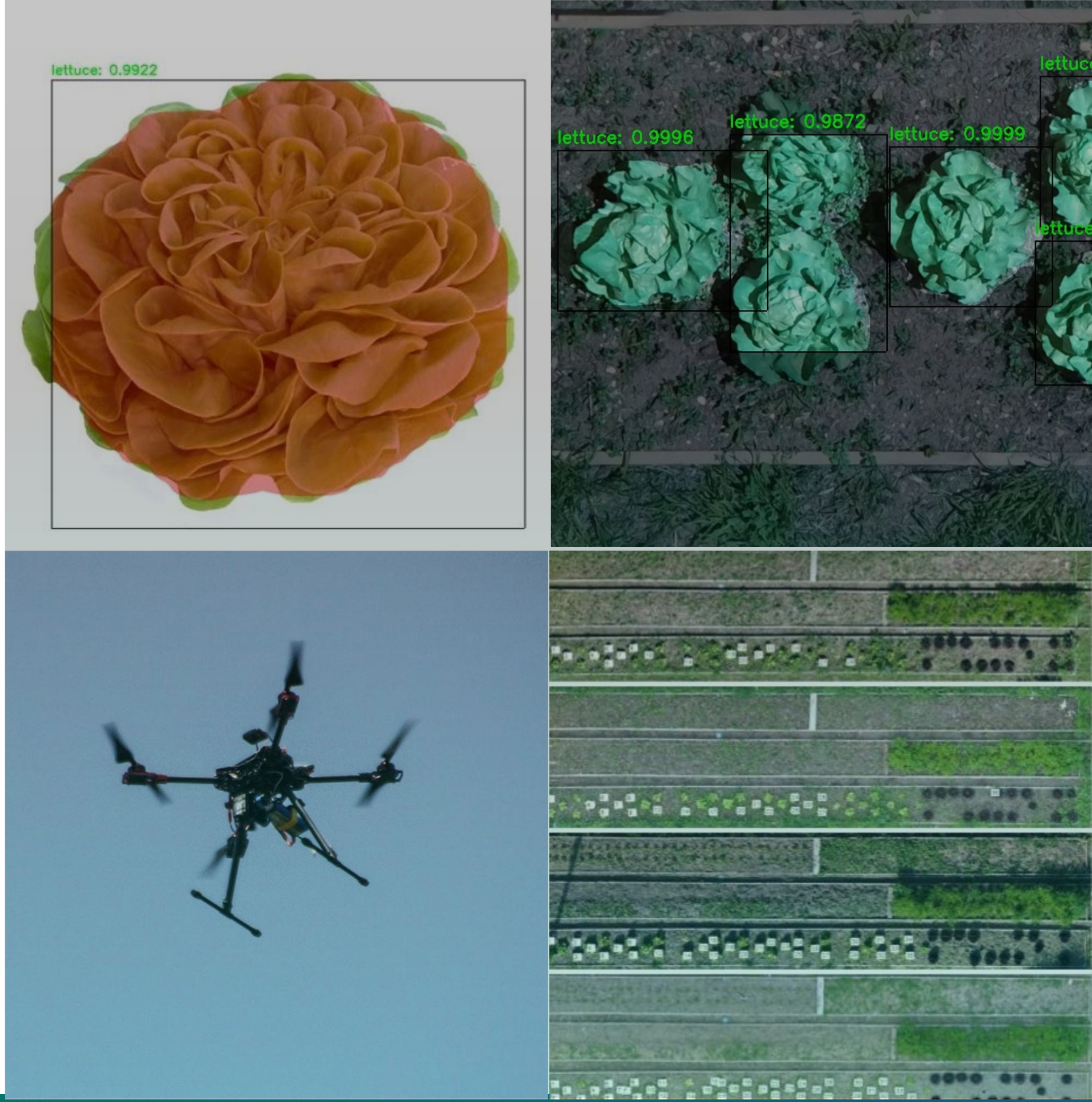
Images: Fig.1/4 urban data analytics in Barcelona, camera installations, video tracking, mapping and object detection results. Source: Noumena

FARMING

Precision Agriculture

Noumena leads the integration of vision based applications in the farming sector, introducing autonomous systems to facilitate the integration of technology for food. The services provided targets mainly:

- Crops monitoring
- Spot-spraying pesticide
- Yield management
- Weeding
- AI farming tools



Images: Fig.1/4 object detection algorithms and drone data collection Source: Noumena

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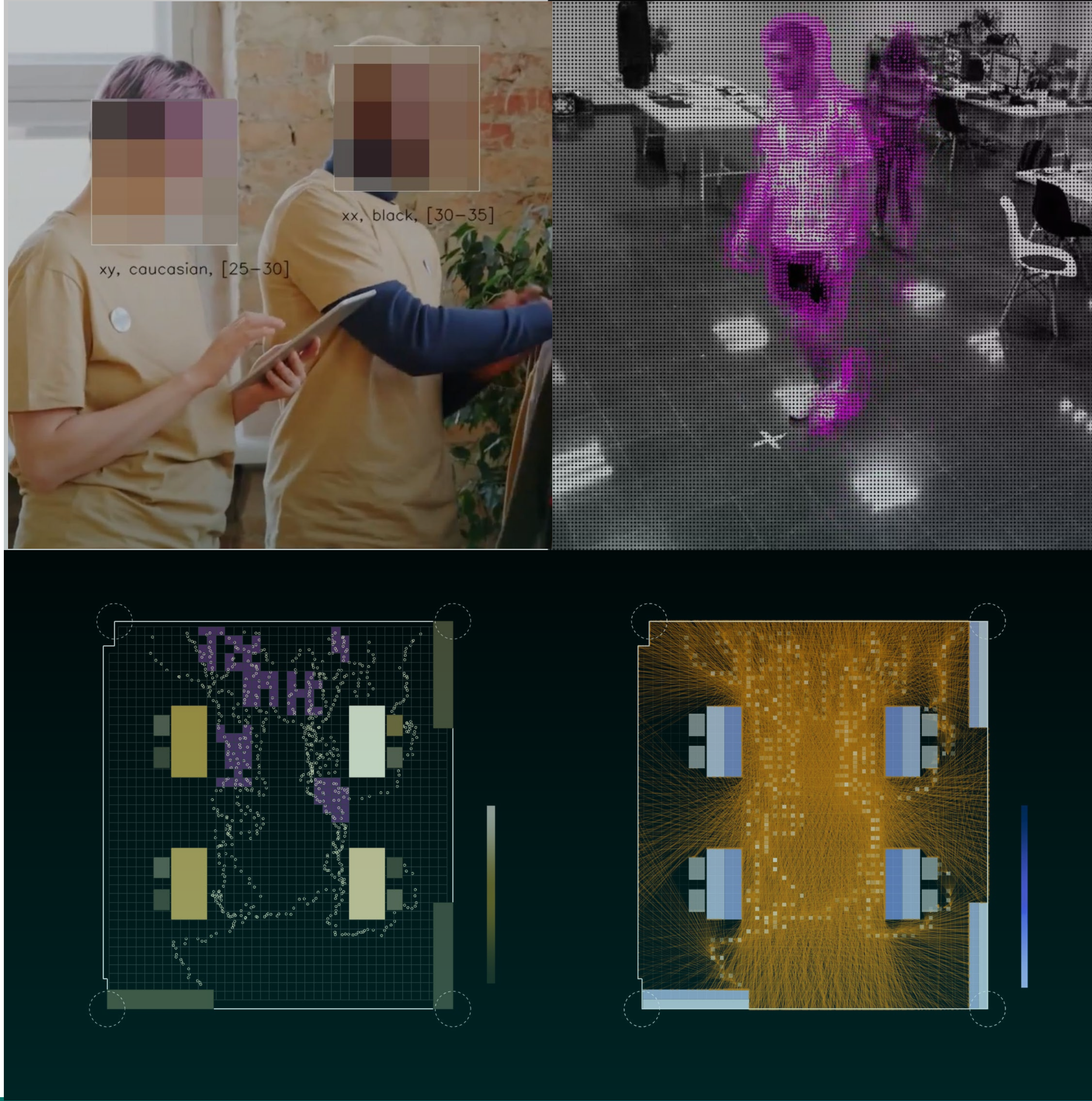
COMMERCIAL SPACES

Data-driven business growth

Noumena integrates software and hardware solutions to **capture, analyze and process store data**. Our infrastructure includes sensing devices to collect information from the physical space, artificial intelligence algorithms to process data, and an online platform to access, visualize and monitor the results.

- Customers analysis
- Product placement
- Product interactions
- Store layout
- Target campaigns



Images: Fig.1/4 retail analytics. Source: Noumena

URBAN MAPPING
SENSING PUBLIC SPACE

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Images: Fig.1 Urban photograph by Matthew Ball. Source: unsplash

SENSING PUBLIC SPACE

Qualitative urban studies

Cities serve as the backdrop for the majority of our days, shaping our visual environment - the imagerial background of our lives.

What insights can we gain when we delve into the visual aspects of cities that go beyond mere architectural style and urban design?

Is the visual representation of cities a comprehensive reflection of the concealed social and spatial dynamics and principles at play?

This line of investigation gained significant traction in the latter half of the 20th century, as prominent urban scholars observed and responded to swiftly transforming urban environments.

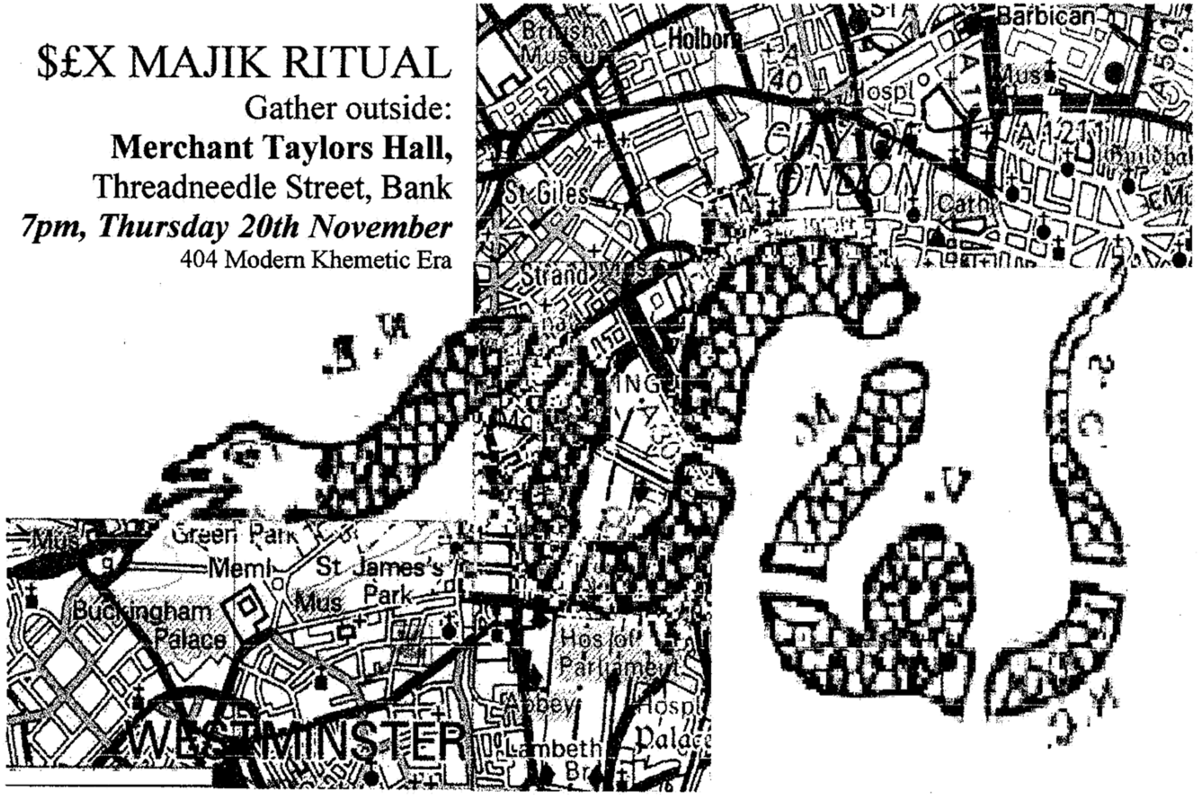
Images: Fig.1 Plaça Reial Barcelona. Source: unsplash

SUBVERSIVE APPROACHES

An ever-ongoing investigation of the urban

This line of investigation gained significant traction in the latter half of the 20th century, as prominent urban scholars observed and responded to swiftly transforming urban environments. The work of Guy Debord and the International Situationist brought an innovative methodology to approach the complexity of the urban through first-person perspective.

Seeing the effect of traditional urban planning and consumer culture towards the homogenization of urban landscape, the approach of ***the dérive*** (drift) mostly consisted in aimlessly wandering through the city, allowing oneself to be guided by the landscape and one's own intuition rather than a predetermined route or destination.



Images: Fig.1 A 2004 poster announcing a large -scale dérive in London, Source: Wikipedia

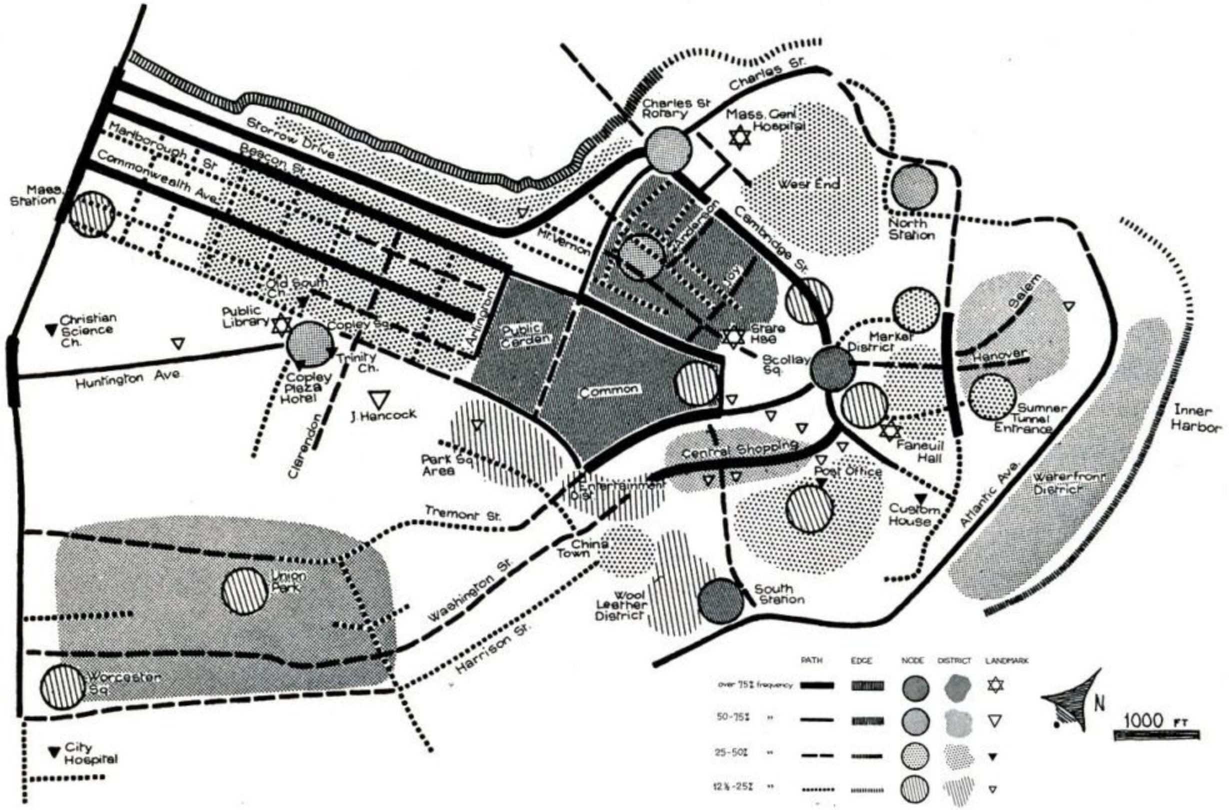
THE IMAGE OF THE CITY

The pioneering work of Kevin Lynch

Bringing forward concepts such as ***psychogeography***, strategies like the one of Debord inspired many scholars in the following years. It is however since Kevin Lynch's pioneering work in "The Image of the City" (1960) that urban scholars have increasingly turned to visual and sensory methods for studying the complex life of cities in a more scientific manner.

There, it explored how people perceive and navigate urban environments through ***mental maps*** by analyzing key urban elements (paths, edges, districts, nodes, and landmarks).

Although offering valuable insights into urban navigation and design, this approach faced criticism for prioritizing physical aspects of the cityscape at the expense of the underlying social dynamics.



Images: Fig.1 Mental map of Post -war american suburbia. Source: The Image of the City, K. A. Lynch

PEOPLE FIRST
Cities and communities

On the contrary, Jane Jacobs favoured the messy vitality of the street and its complex **intermingling of uses and users** as key elements to address the representation and usage of public space.

She expanded sensory approaches in “The Death and Life of Great American Cities” (1961), advocating first-hand observation of communities and neighbourhoods as key resources for urban studies.

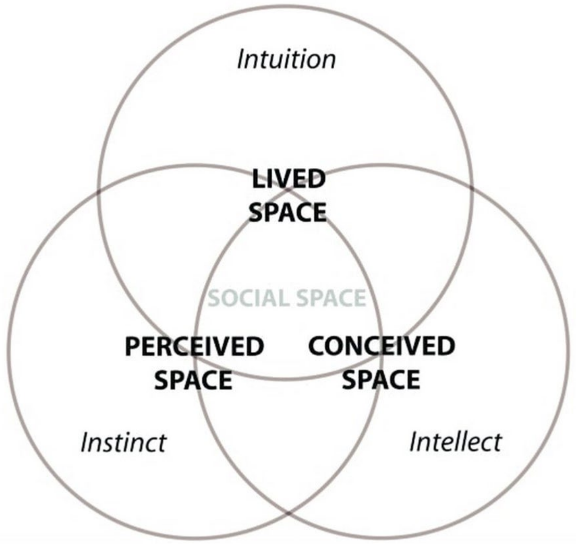
Images: Fig.1 Jane Jacobs during a manifestation. Source: milwaukeeturners.com

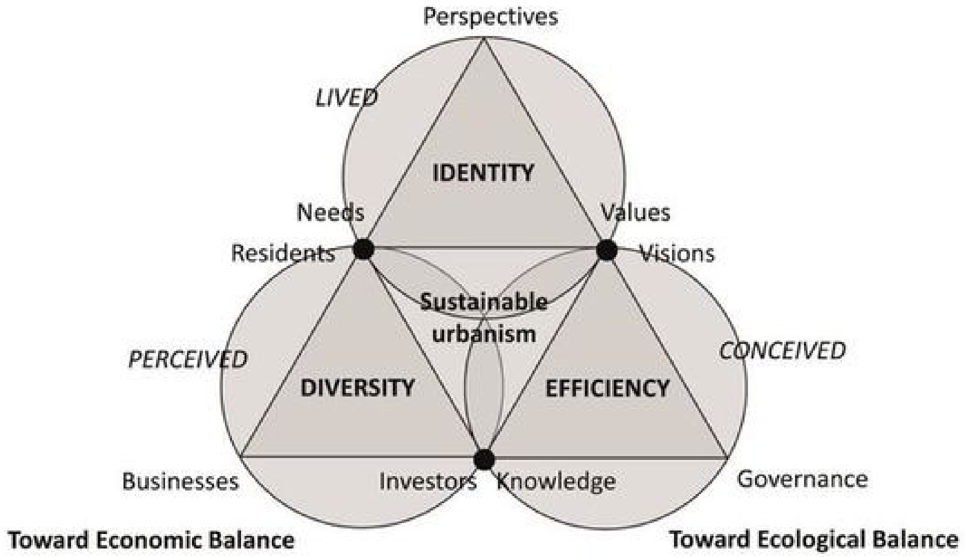
MULTIFOLD DIMENSIONS

Towards the right to the city

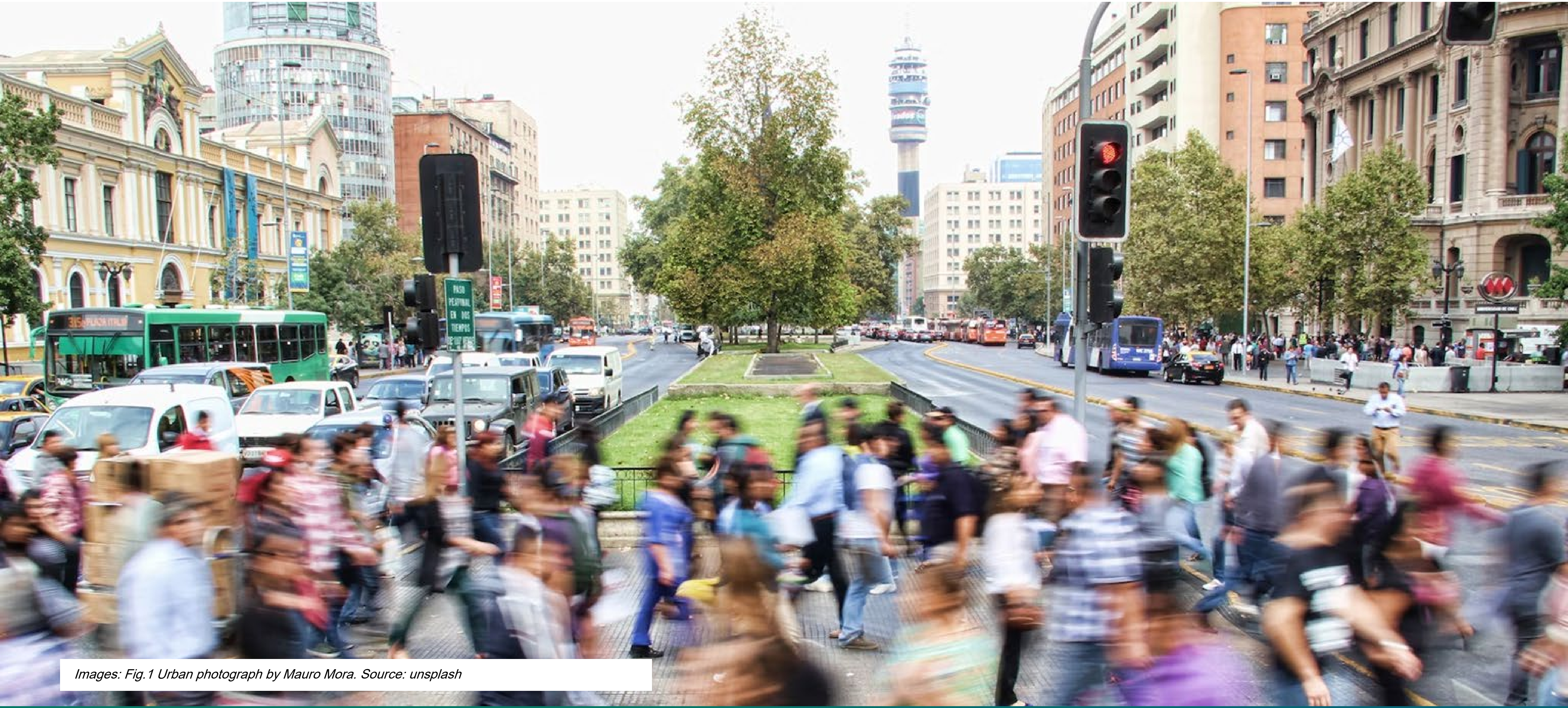
In "The Production of Space" (1974), Henri Lefebvre presents a thought-provoking perspective on the nature of space. He presented **space as a dynamic socially constructed entity** as opposed to a passive, container.

To be addressed through the categories of "conceived," "perceived," and "lived," cities become multidimensional experiential places, Highlighting the role of power structures in shaping space, particularly through urban planning and design, he called for more holistic understanding to the urban considering not only the physical aspects of space but also its social and cultural dimensions, as well as its governing forces.





Images: Fig.1 Levebvre's traid of space. Source A. M. Salama.
Fig.2 A consequent triadic framework for sustainable urbanism. Source: F. Wiedmann



Images: *Fig.1 Urban photograph by Mauro Mora. Source: unsplash*

SENSING PUBLIC SPACE
Quantitative urban studies

In parallel, more quantitative approaches were emerging, opening the door to groundbreaking technologies and city scale disaster.

Urbanists like William H. Whyte and Jan Gehl played pivotal roles in this shift **by incorporating innovative technology**, particularly video cameras, to revolutionize the way we analyze and comprehend urban environments pacing the way to empirical urban studies.

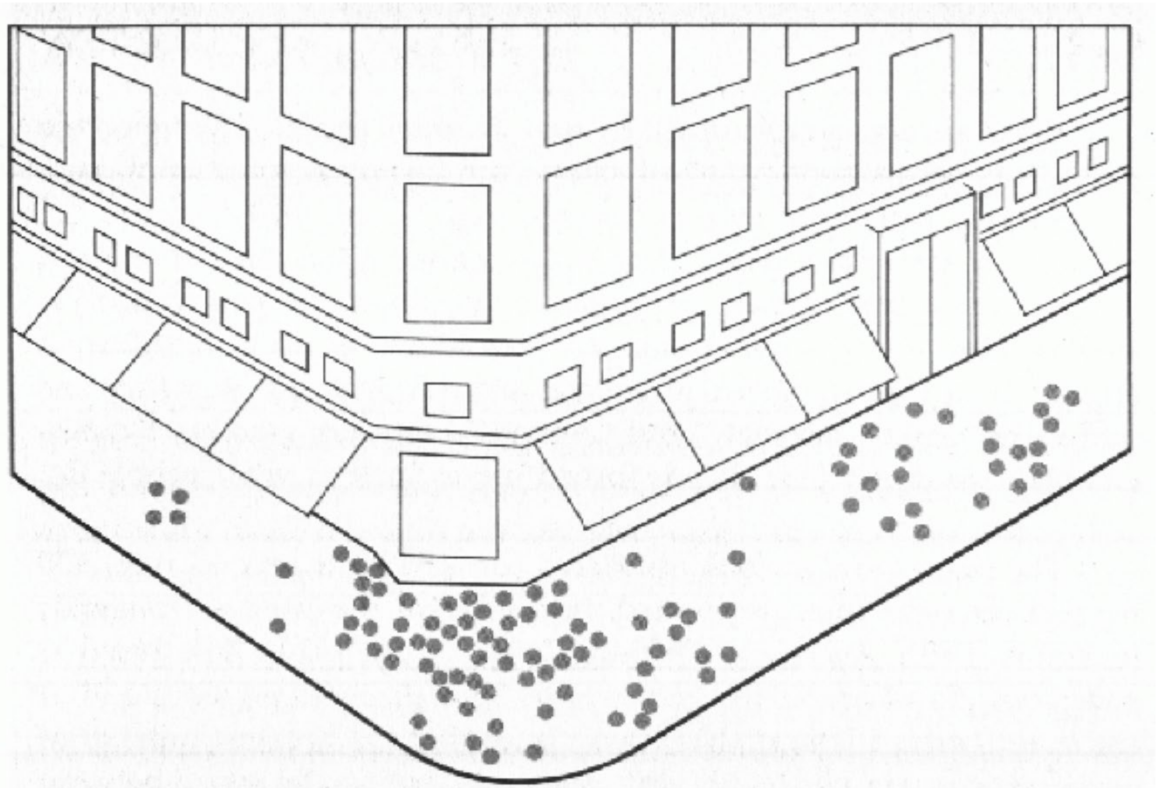
Images: Fig.1 William H. Whyte. Source: Projectforpublicspace

BUILDING URBAN DATASETS

The birth of data gathering

In his most influential 1980 book, "The Social Life of Small Urban Spaces," William H. Whyte established the basis for empirical urban research by emphasizing meticulous firsthand observations and underlining the significance of **data collection** in comprehending and efficiently managing urban environments (Whyte, 1980).

While Whyte's approach offered an effective and replicable method for analyzing human-space interactions, it demanded extensive time spent in public spaces, painstaking recording, and annotation, and soon became impractical for large scale studies.



Location of street conversations lasting two minutes or more at Saks Fifth Avenue and Fiftieth Street. Cumulative for five days in June. Note main concentration at corner, secondary one outside entrance.

Images: Fig.1 Street usages. Source: The Social Life of Small Urban Spaces, W.H.Whyte

THE SMART CITIES PROMISE

Unlocking cities through data?

Over time, the rise of data science and advancements in computing technology placed a growing emphasis on data in various fields, including urban studies.

This shift gave rise to concepts like smart cities, driven by the potential of data to optimize complex urban environments and attract economic interests in city planning.

Around the turn of the 21st century, cities worldwide began adopting IoT technologies, utilizing sensors for air quality and traffic monitoring and CCTV cameras for security, transforming into city-scale information systems.

Images: Fig.1 Photo of Songdo city at daylight by Daesun Kim. Source: unsplash

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THE SMART CITIES PROMISE

Unlocking cities through data?

Around the turn of the 21st century, cities worldwide began adopting IoT technologies, utilizing sensors for air quality and traffic monitoring and CCTV cameras for security, transforming into city-scale information systems.

While proven insufficient in inherently leading to a conclusive understanding of urban life due to heavy reliance on corporate interests, and issues of data ethics and privacy, **these experiments offered fertile ground for data analytics to thrive**.

Images: Fig.1 Photo of Songdo city at night by Daesun Kim. Source: unsplash

COMPUTER VISION MODELS
harnessing the computational eye

Among other data streams, the extensive data collected from CCTV cameras and sensors deployed worldwide has significantly contributed to the development of modern computer vision models. Capturing diverse real-world scenarios,these datasets provided the foundational material necessary for training advanced algorithms.

By analyzing this wealth of visual information, computer vision researchers were able to refine their models, enhancing their accuracy and robustness. The diverse array of data points enabled the algorithms to recognize and process various objects and scenes in real-time, making YOLO and similar models highly proficient in tasks such as object detection and enumeration.

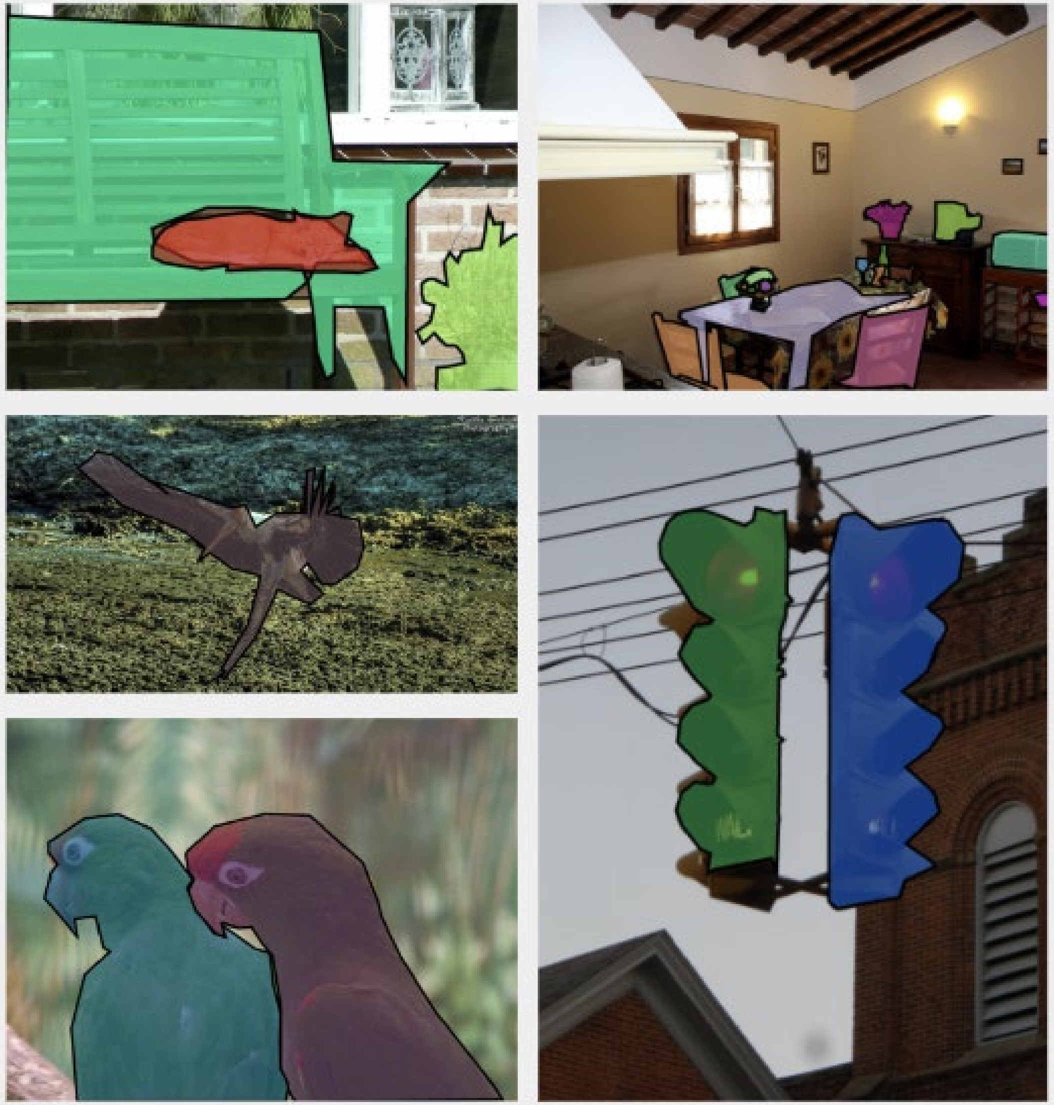

Image: Set of labelled images from COCO dataset: Source: COCO dataset

Computer Vision
Definition

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What is computer vision? How can computers understand videos?

Computer vision is a field of artificial intelligence and computer science that focuses on enabling machines to interpret and understand visual information from the world around us.

These algorithms **analyze the visual content**, **including shapes**, **colors**, **motion and extract features**.

These features can be labeled and then used to train AI models to recognize objects, actions or scenes within a videos using ML techniques.

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How can computer vision models sense public spaces quantitatively and qualitatively?

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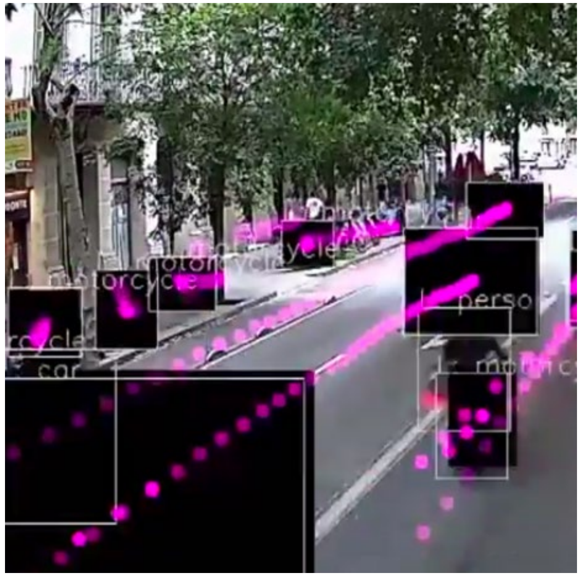
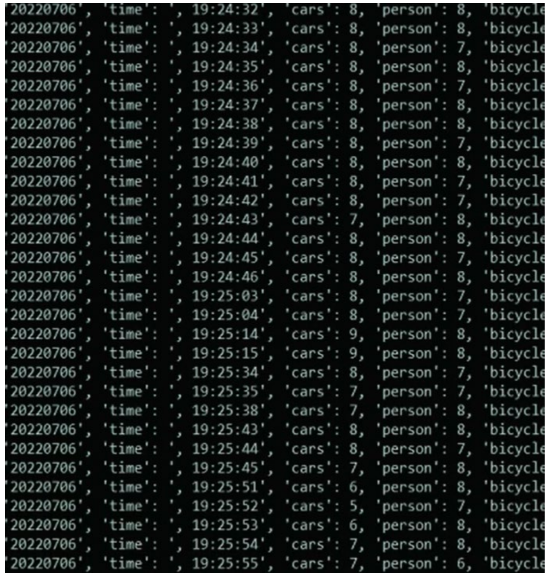
Workflow

Data Collection

Data Pre-Processing



AI Algorithm



Data Post-Processing

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DATA COLLECTION
Importance and requirements

- Key factor for the final performance of the algorithm.
- Why is it so important?
  - Training
  - Specific project data

- Dataset requirements:
  - Large amounts
  - Variety
  - Balanced
  - Representative
  - Well labeled

→ VERY EXPENSIVE

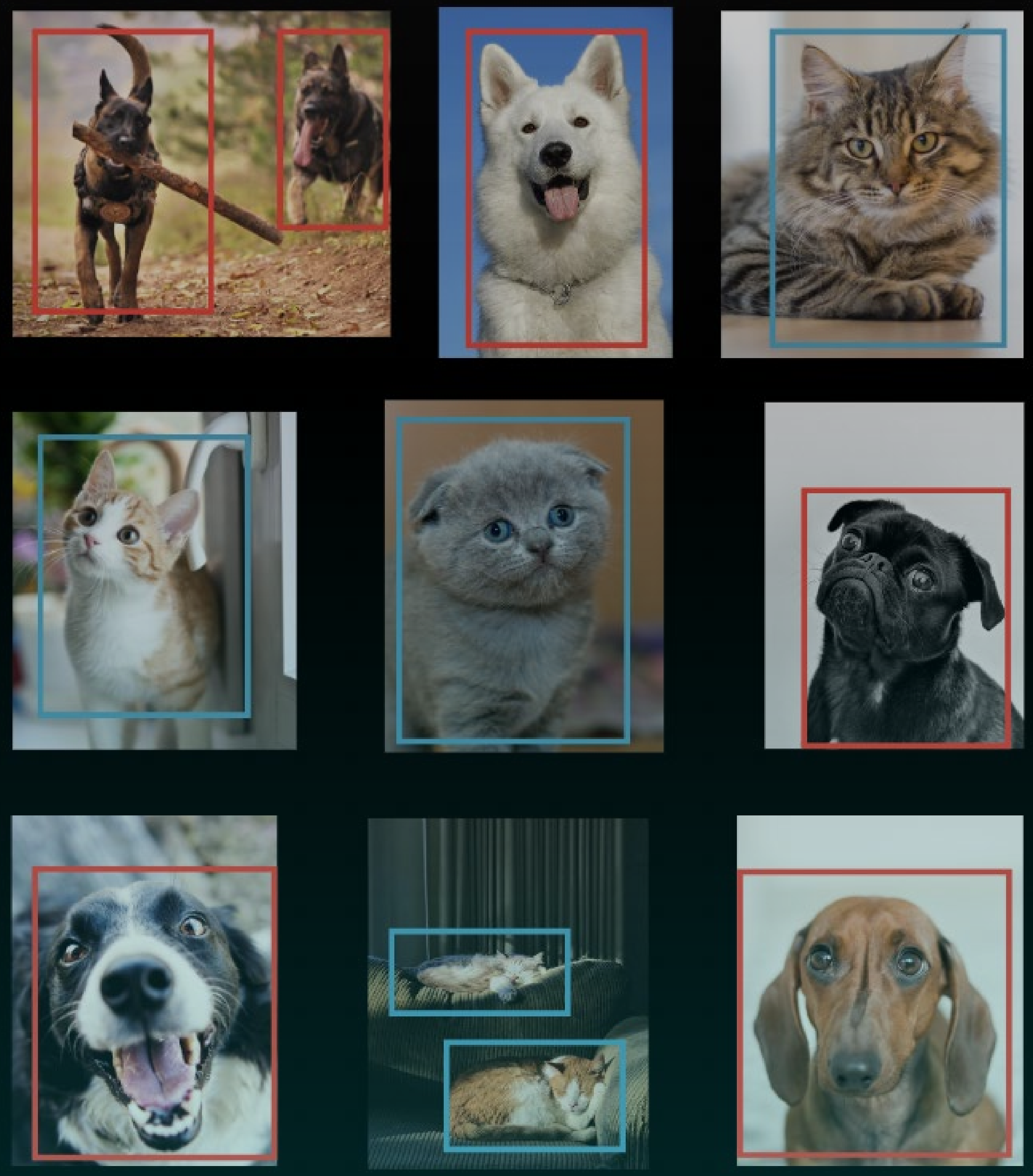

Image: Cats and dogs dataset
Source: Pexel

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DATA PRE-PROCESSING

Image and Video processing

The purpose of data preprocessing is to clean, transform, and restructure data to make it suitable for analysis.

- Image processing
- Video processing:
  - Video sampling
  - Video rescaling
  - Video Normalization
  - Video Encoding
    - Stacking frames into 3D tensor with dimen (#frames, height, width)
    - 2D CNN to capture spatial dependencies
    - 3D CNN to capture spatial and temporal dependencies

Image: Car image
Source: Pexel

Image Segmentation: Binary

Image Enhancement

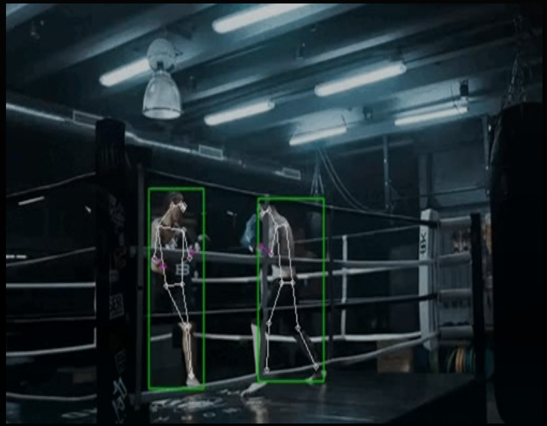
Image Filtering: Laplacian

Image Restoration

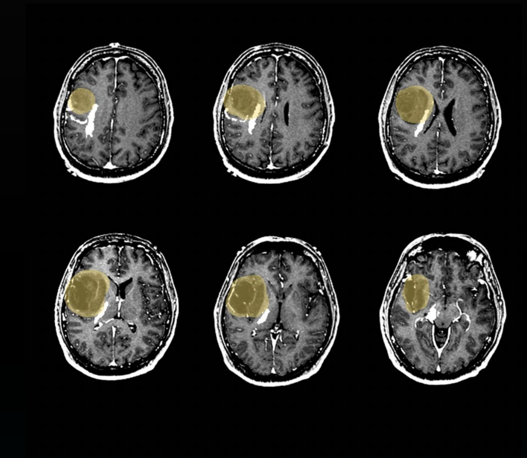
ALGORITHM
Types of algorithms

Deep Learning Algorithms:

- Object detection
  - Class identification
  - Disease detection
- Pose estimation
  - Pose recognition
- Semantic Segmentation
- Instance segmentation
- Face recognition
- Object tracking

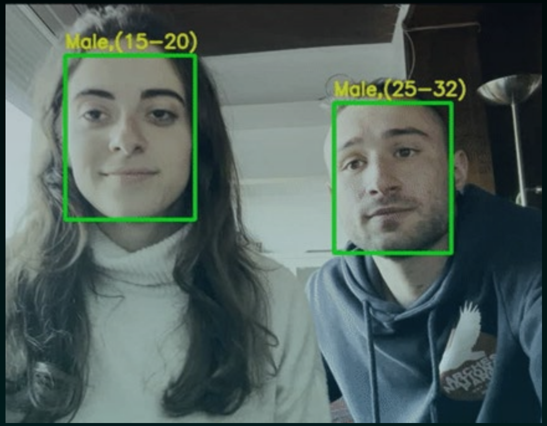


HUMAN POSE ESTIMATION



DISEASE DETECTION

SEMANTIC SEGMENTATION AND TRACKING



FACE DETECTION: GENDER AND AGE

Image: Different Computer Vision applications
Source: Pexel

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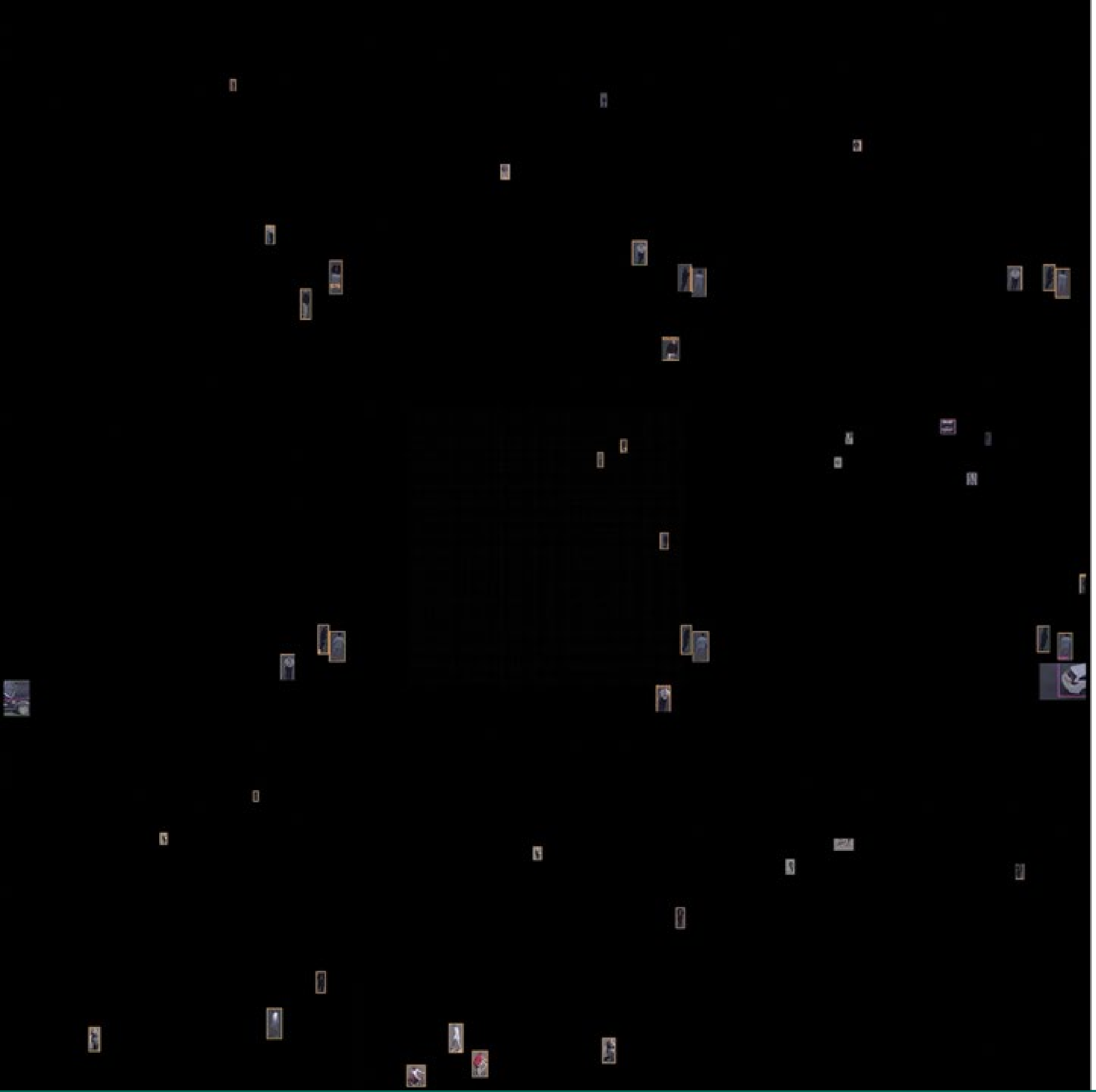

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DATA POST-PROCESSING

Reduction of stored data

- Clean output data:
  - Non-maximum suppression
  - Thresholding
  - Filtering
- Extract meaning from data
- Create visualizations

Website: noumena.io

URBAN MAPPING
BARCELONA

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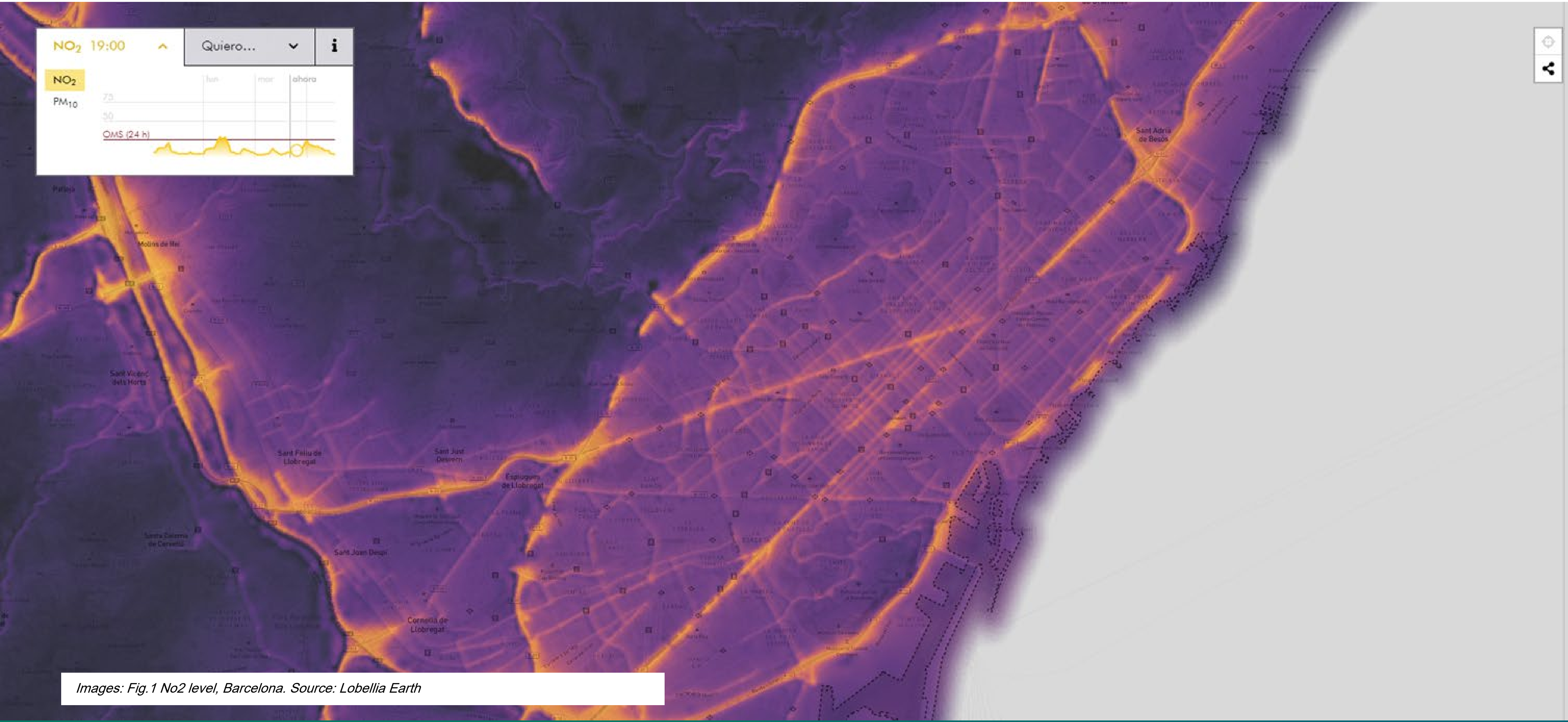
Images: Fig.1/4 retail analytics. Source: Noumena

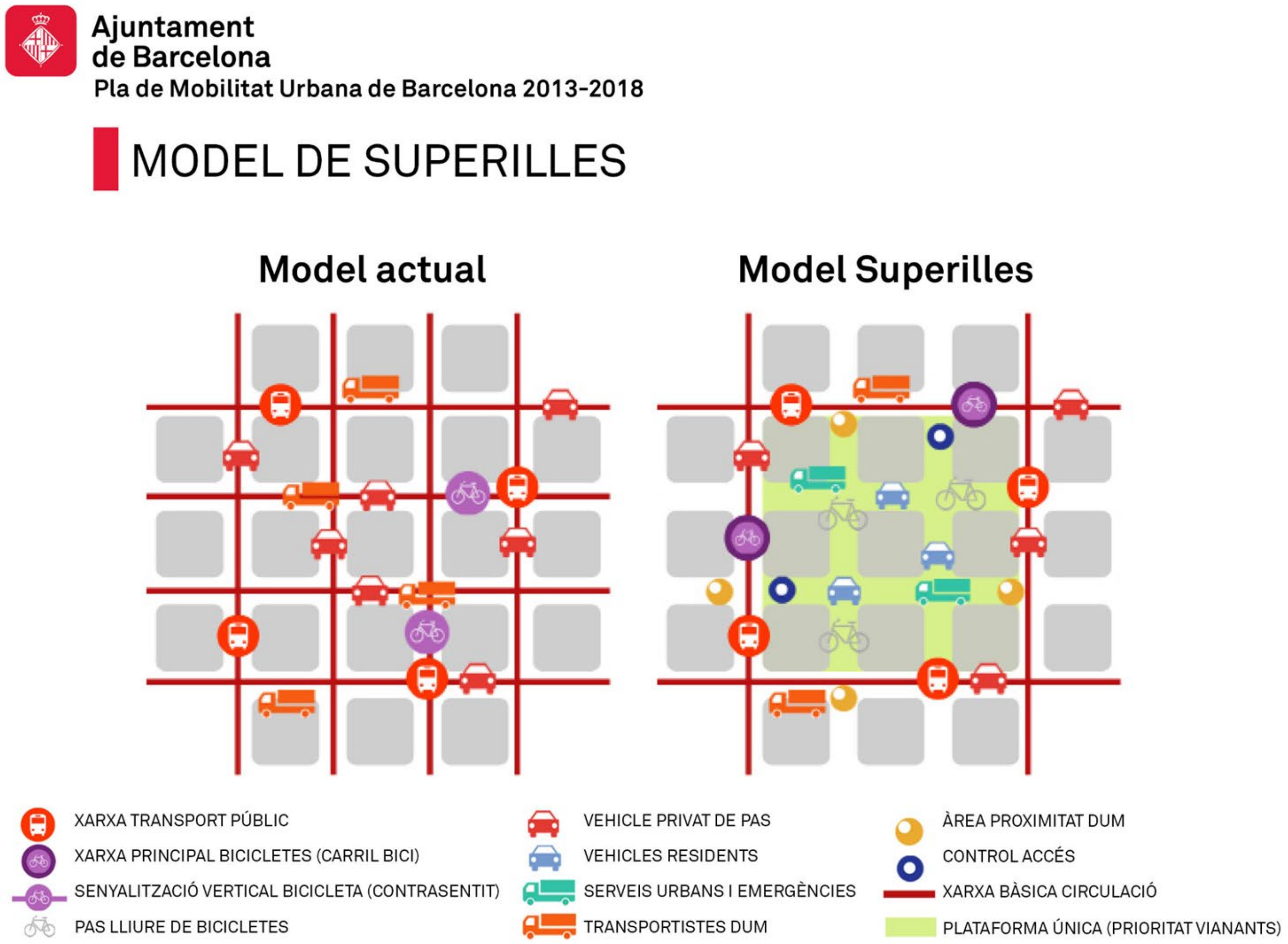


Images: Fig.1 No2 level, Barcelona. Source: Lobellia Earth

SUPERBLOCK MODEL
Towards citizens centric cities

The Barcelona Superilla project introduced in the mid-2010s, aimed to transform urban neighborhoods by reimagining city blocks into pedestrian-friendly "superblocks."

Superblocks prioritize pedestrians and non-motorized transportation, reducing traffic and improving the quality of life for residents by creating more sustainable and livable urban spaces.



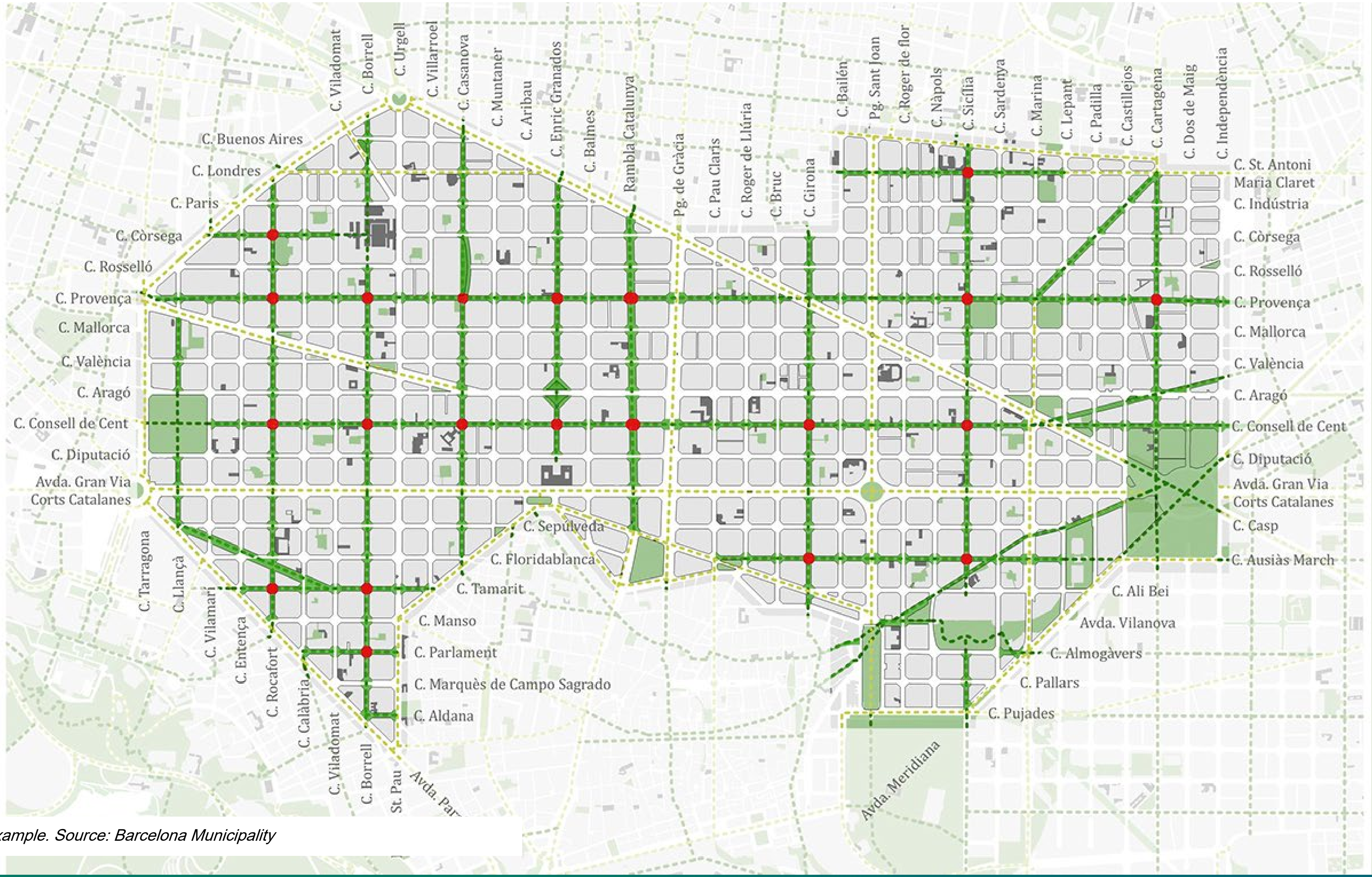
Images: Fig1 Superblock 1st iteration (2016) Source: Barcelona municipality

SUPERBLOCK MODEL
Towards citizens centric cities

The first iteration of the Barcelona Superilla project in 2016 faced significant criticism from the press and the general public. The community of San Martí, in particular, expressed their discontent, as they felt the superblock was imposed with force and criticized the top-down approach that excluded their input in the planning process.

These criticisms highlighted the challenges in implementing urban transformations of this scale and underscored the importance of community engagement and collaboration in such projects.

Images: Fig.1 Demonstration against superilla Source: PASP9



Images: Fig.1 Superilla Eixample. Source: Barcelona Municipality

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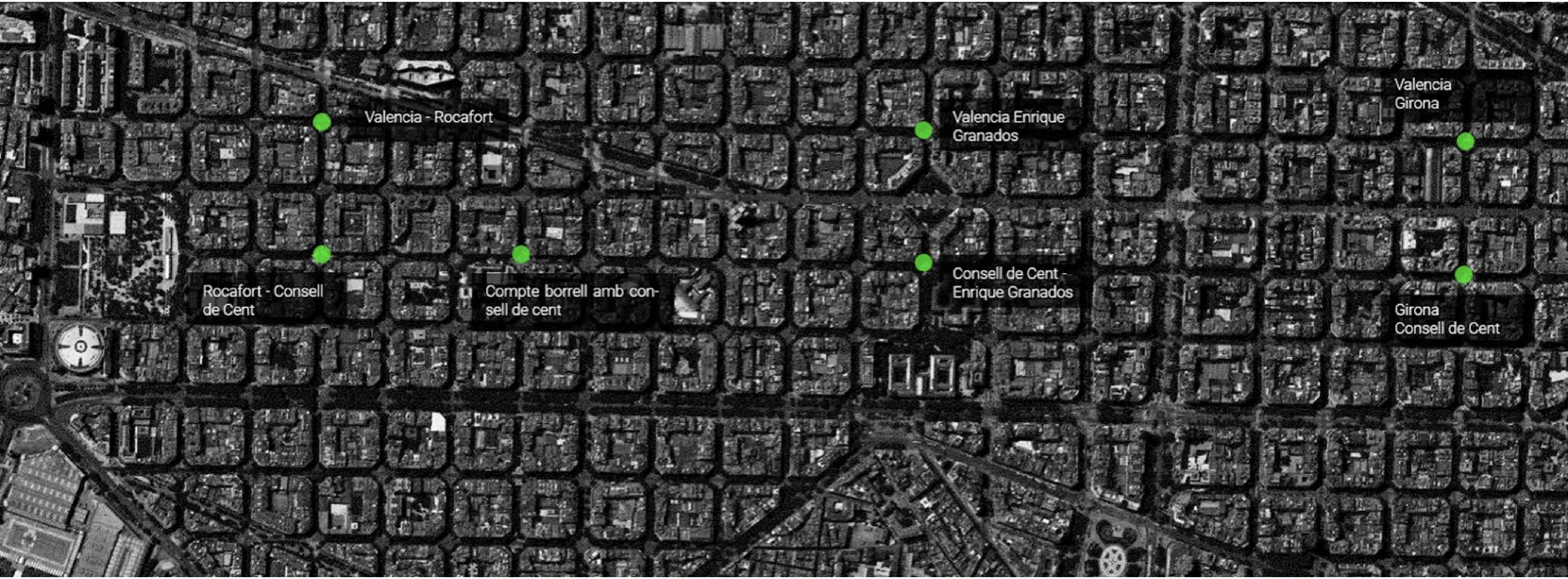
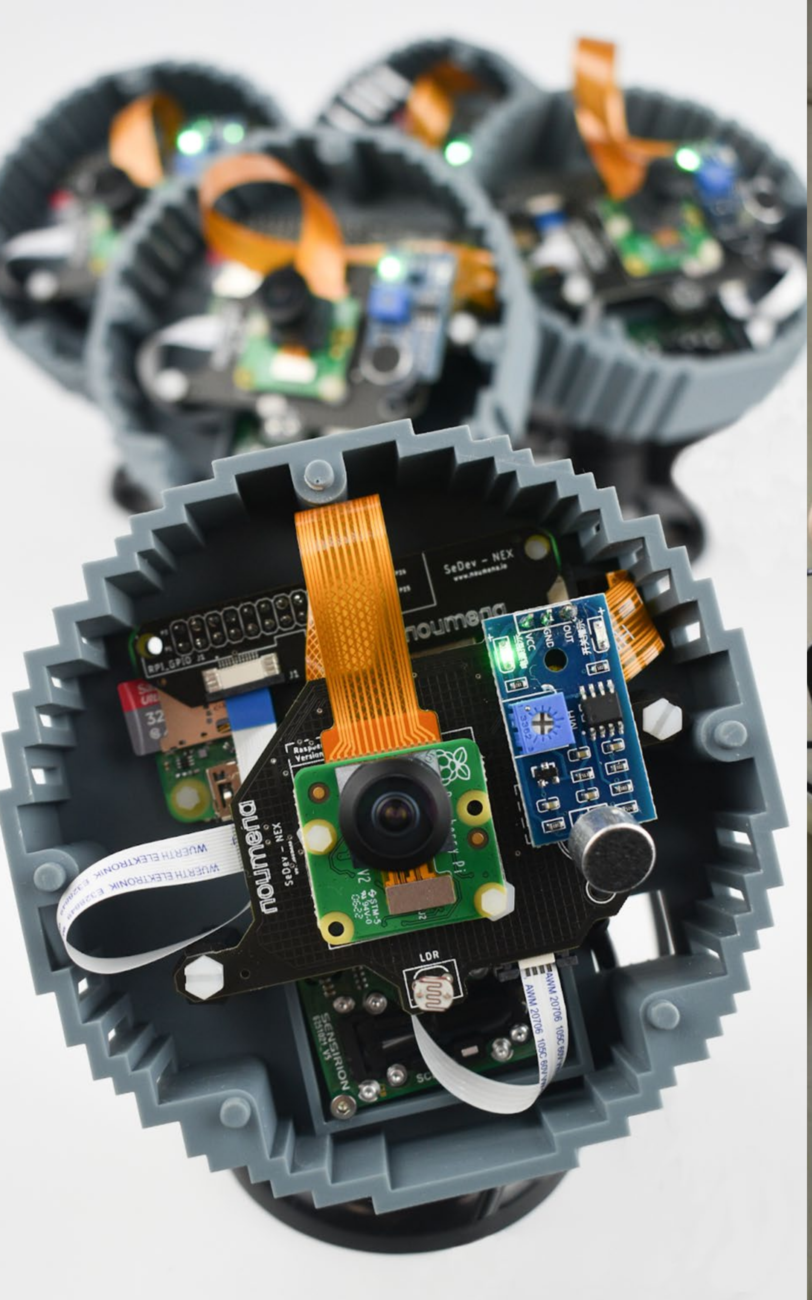


Website: noumena.io

DATA COLLECTION
Prediction data

Number of cameras: 7
Camera sensor: RGB
Time: 3 days (Monday, Thursday, Sunday) - 24 hours/day
Streets: Super illa (Consell de cent), nearby streets (valencia)
Amount of data: 600GB



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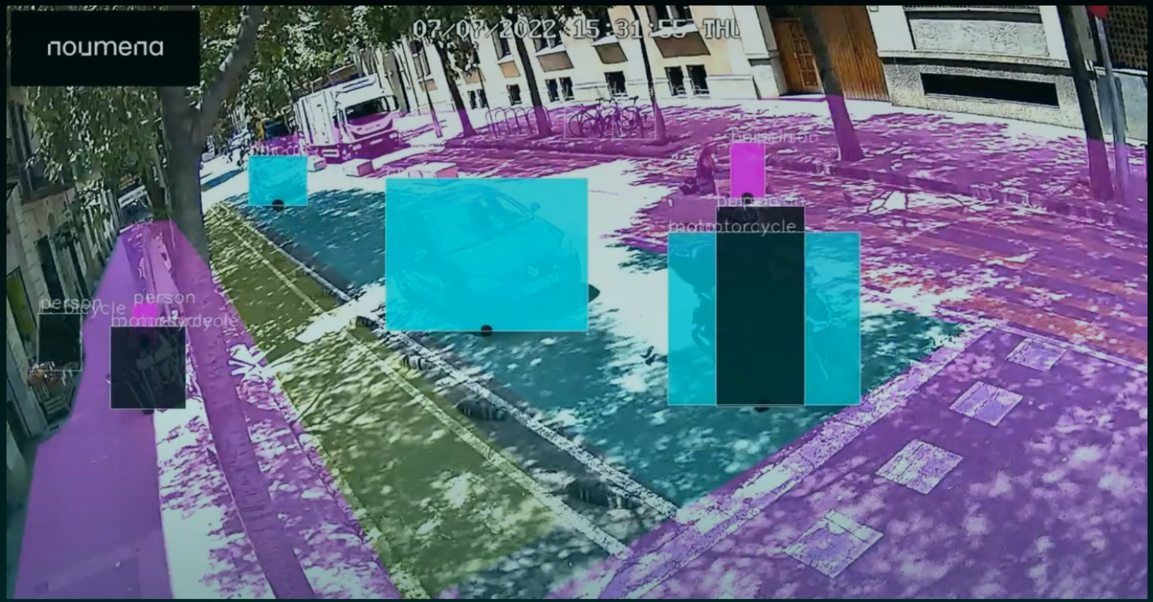
DATA PRE-PROCESSING
Prediction Data

- Reduce frame rate (fps)
- Correct distortion with image calibration
- Create Corridors



Website: noumena.io

ALGORITHM
OBJECT DETECTION AND TRACKING

Object detection algorithm: YOLOv7
- Open Source
- Developed by ultralytics
- Training data: COCO dataset
- Classes detected:
    - Cars
    - Pedestrians
    - Bicycles
    - Motorbikes
    - Small trucks

Tracker algorithm: Norfair
- Customizable lightweight Python library for real-time multi-object tracking

Custom made algorithm to extract data from the algorithms and counter implementation

Data Post-Processing STATISTICS - VISUALIZATIONS

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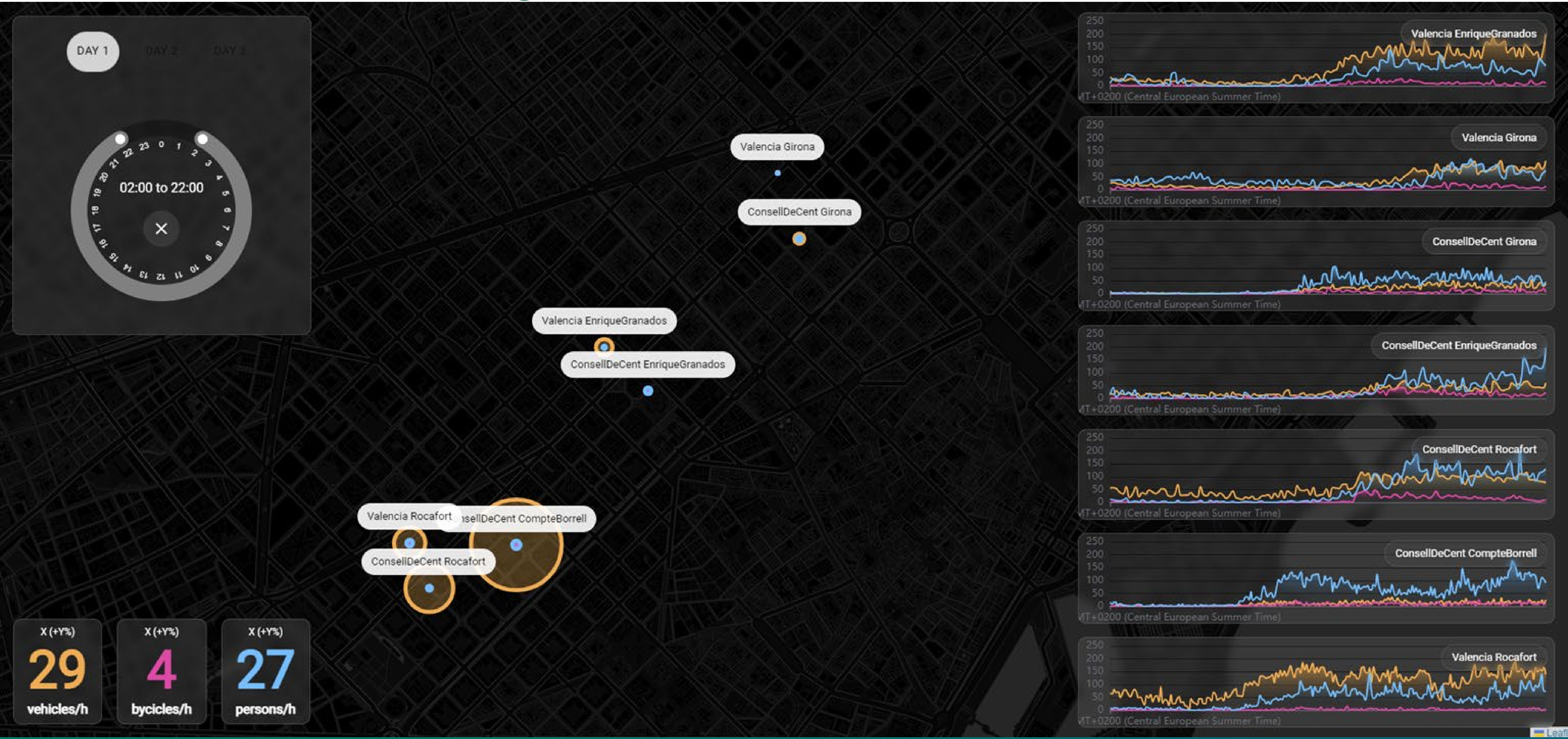

Data Post-Processing STATISTICS - VISUALIZATIONS

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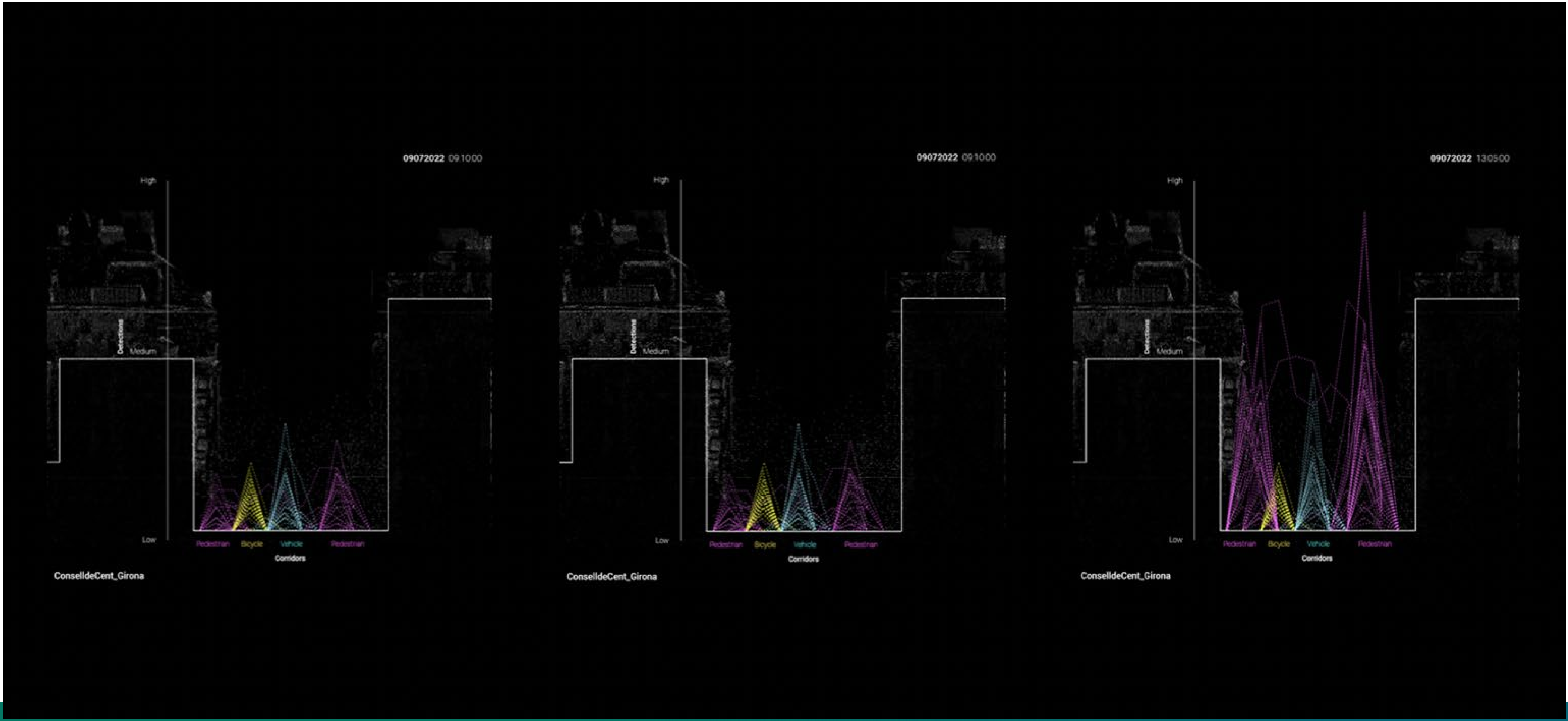

Data Post-Processing
GROUND TRUTH COMPARISON

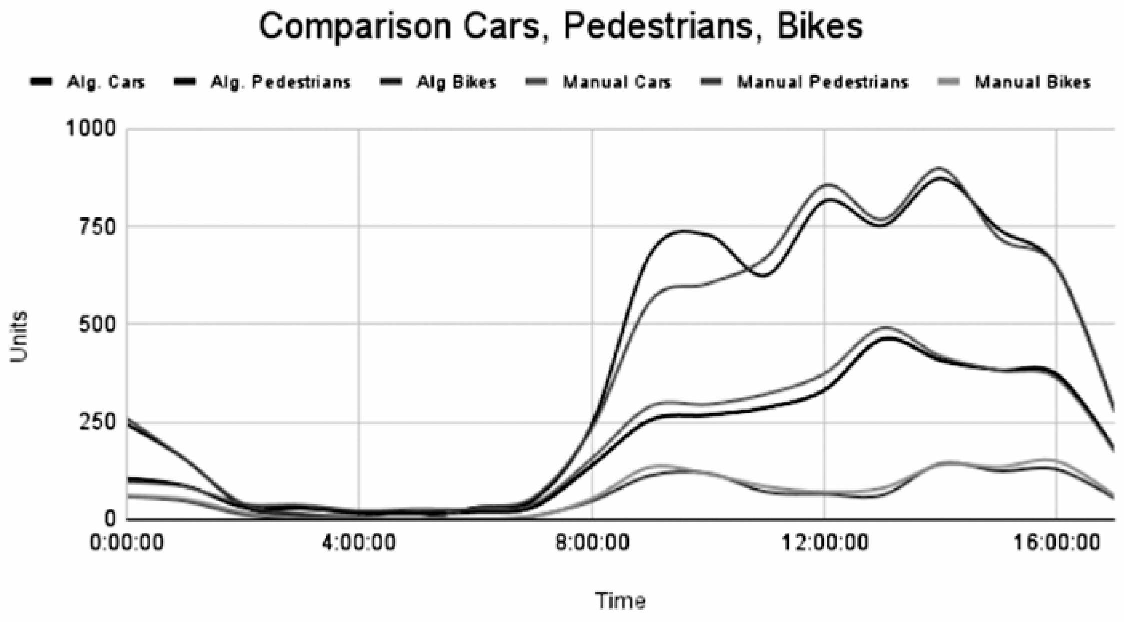

Chart 5: Comparison of algorithm and manual count for cars, bikes and pedestrians.

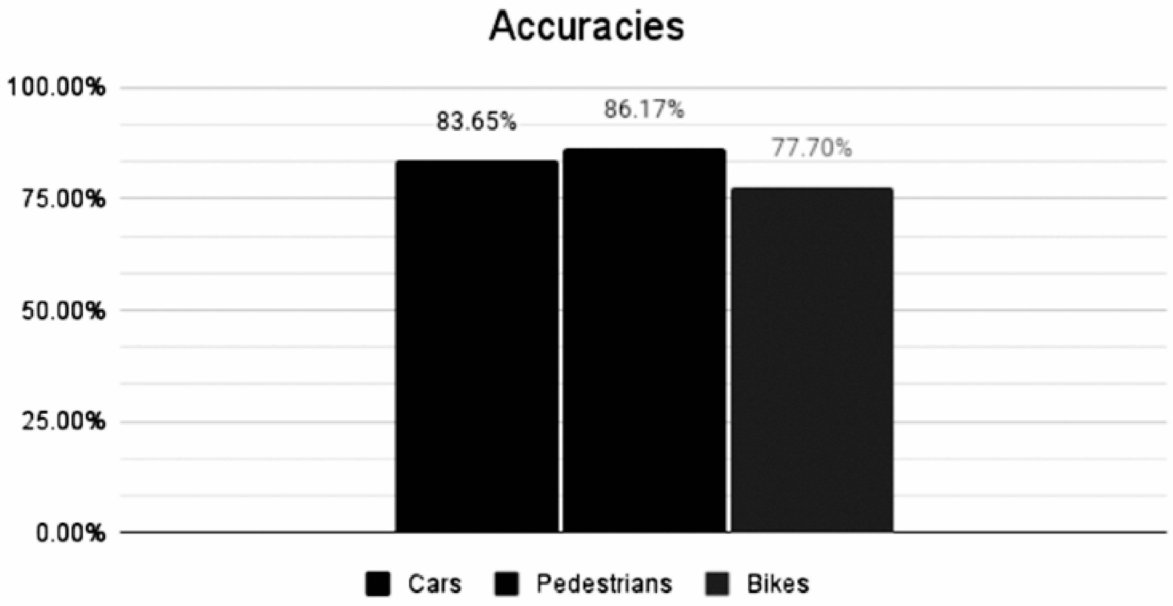

Chart 6: Accuracies for detection of cars, bikes and pedestrians.

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