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

# Tools From Practice: Data Analytics for Evidenc based urban planning

Date (to be modified by partners)

InPlanEd

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# BEYOND THE FRAME:
# USING COMPUTER VISION TO UNLOCK THE POTENTIAL OF VIDEO DATA


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# Computer Vision

## Definition

*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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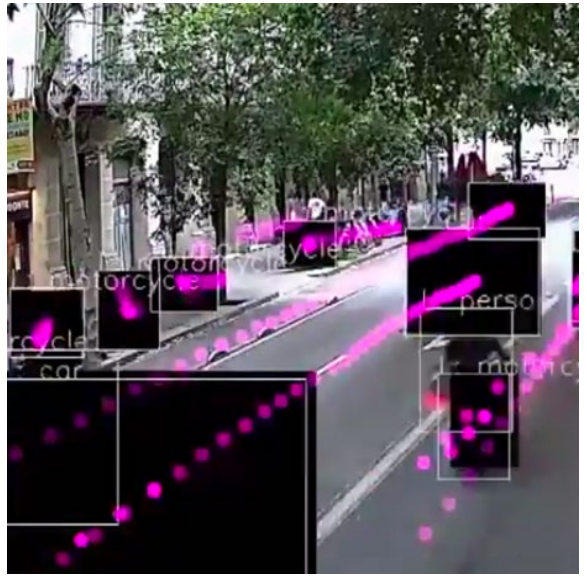
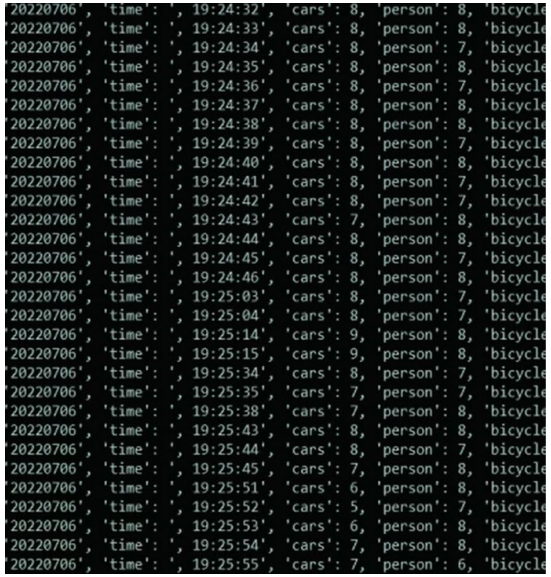
# Workflow


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

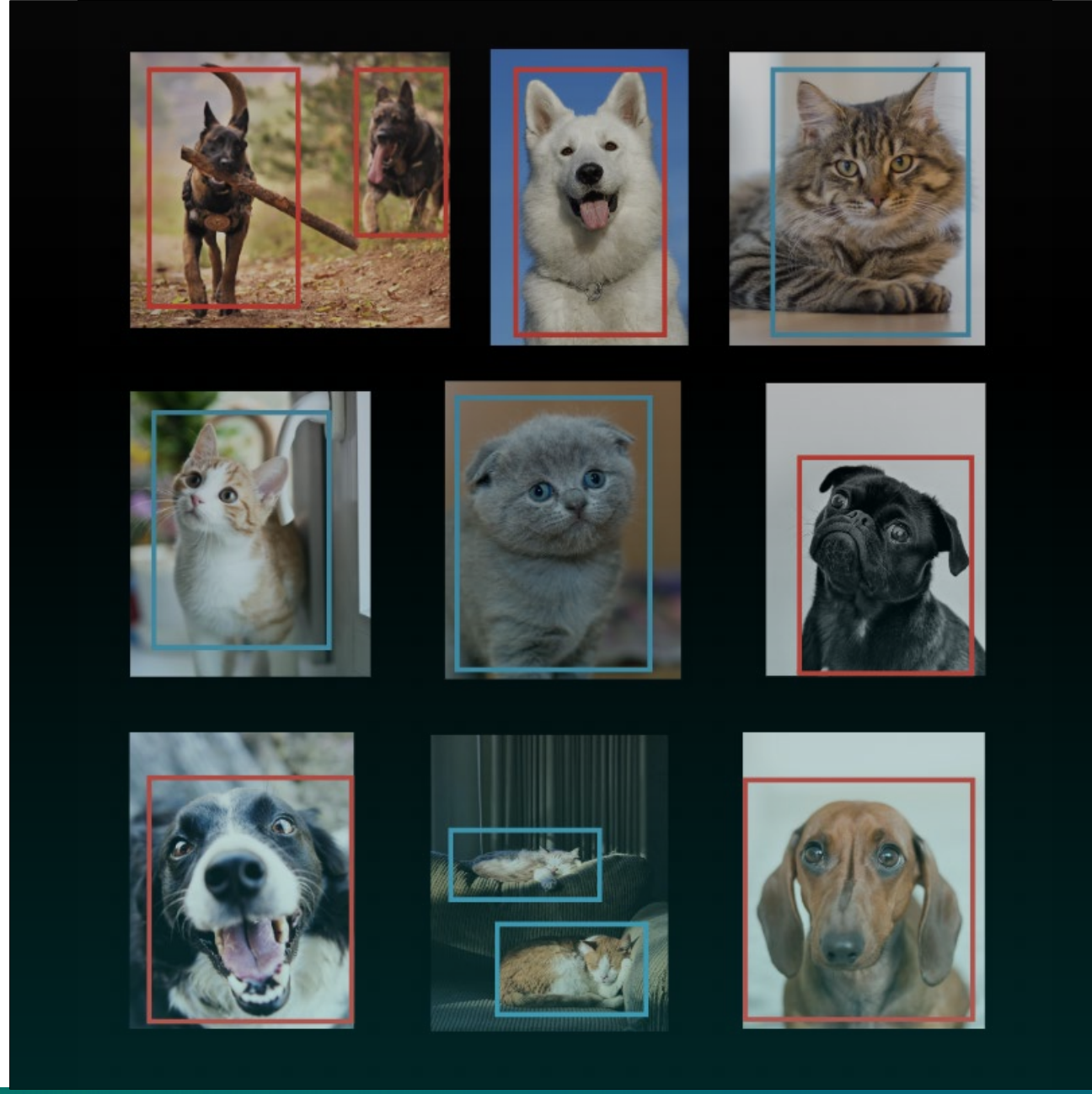

*Image: Cats and dogs dataset*
*Source: Pexel*



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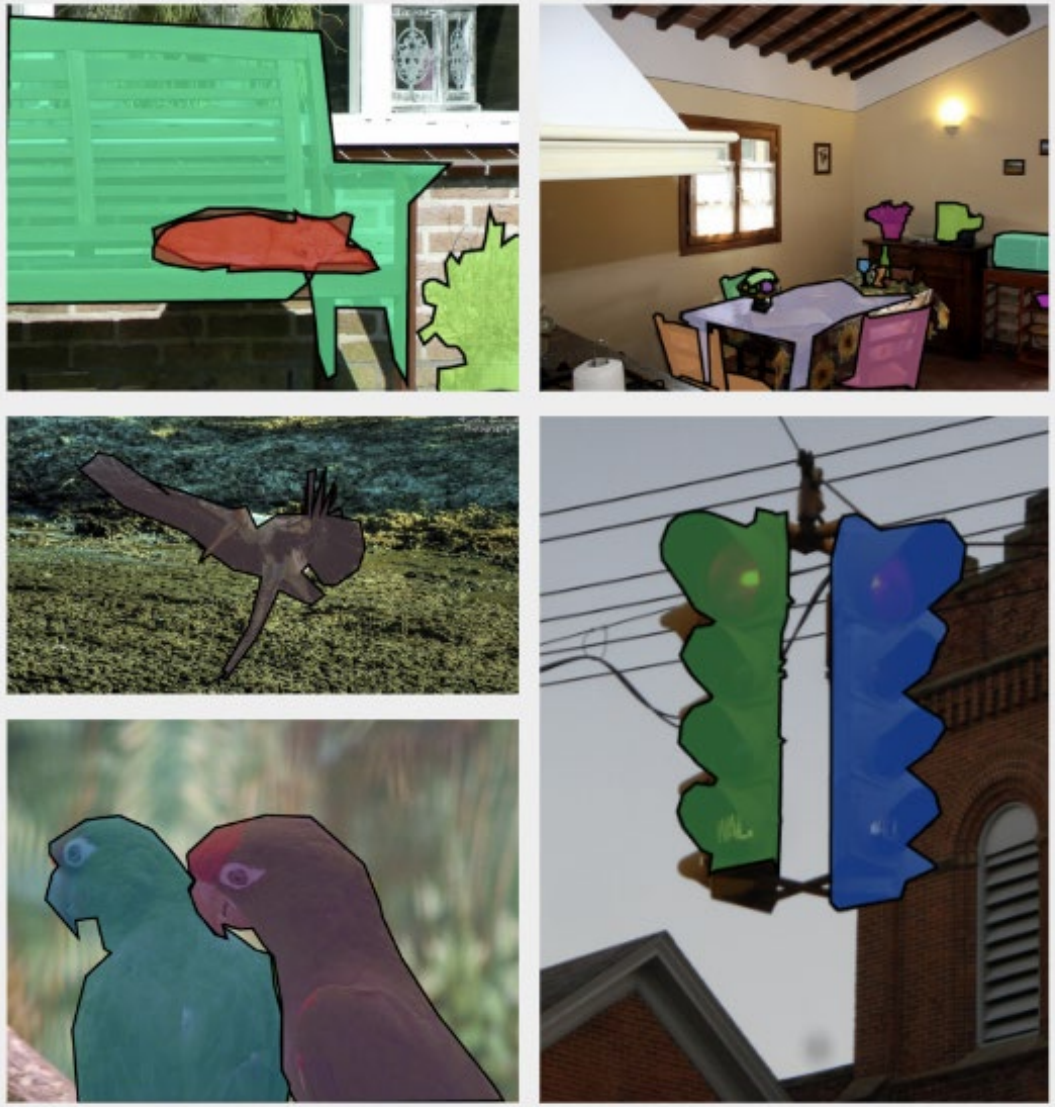

*Image: Set of labelled images from COCO dataset*
*Source: COCO dataset*

# DATA COLLECTION

## Open Source Datasets

Common datasets and licences:

- **ImageNet:** data is available for free to researchers for non-commercial use
  - 1,281,167 training images, 50,000 validation images and 100,000 test images
  - 1000 classes
- **Kinetics:** Creative Commons Attribution 4.0 International License
  - 500k video clips of human actions
  - 600 different human actions labelled
- **COCO:** Creative Commons Attribution 4.0 International License
  - >200.000 images labelled
  - 80 classes
- **Youtube-8M:** Creative Commons Attribution 4.0 International (CC BY 4.0) license
  - 6.1 Million videos, 237K human label verified,
  - 1000 classes



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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



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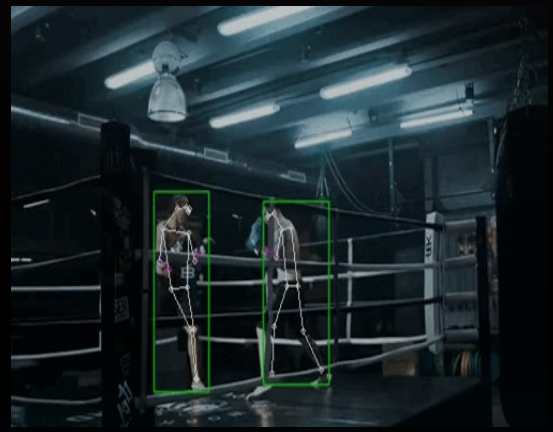
# ALGORITHM

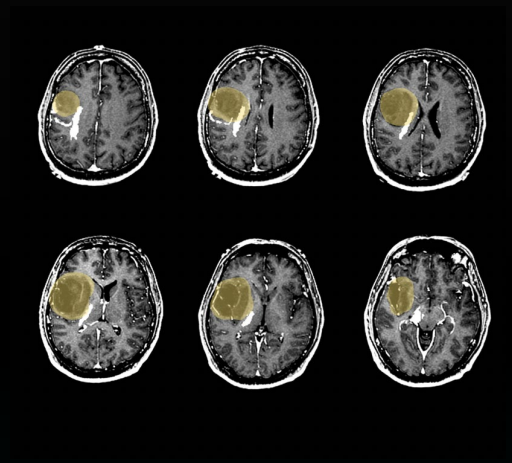
## Types of algorithms

Deep Learning Algorithms:

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

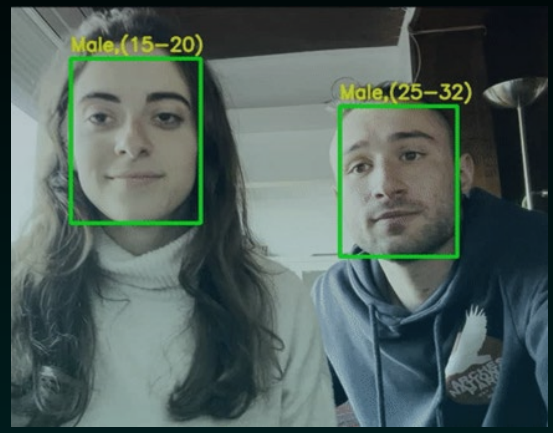


HUMAN POSE ESTIMATION



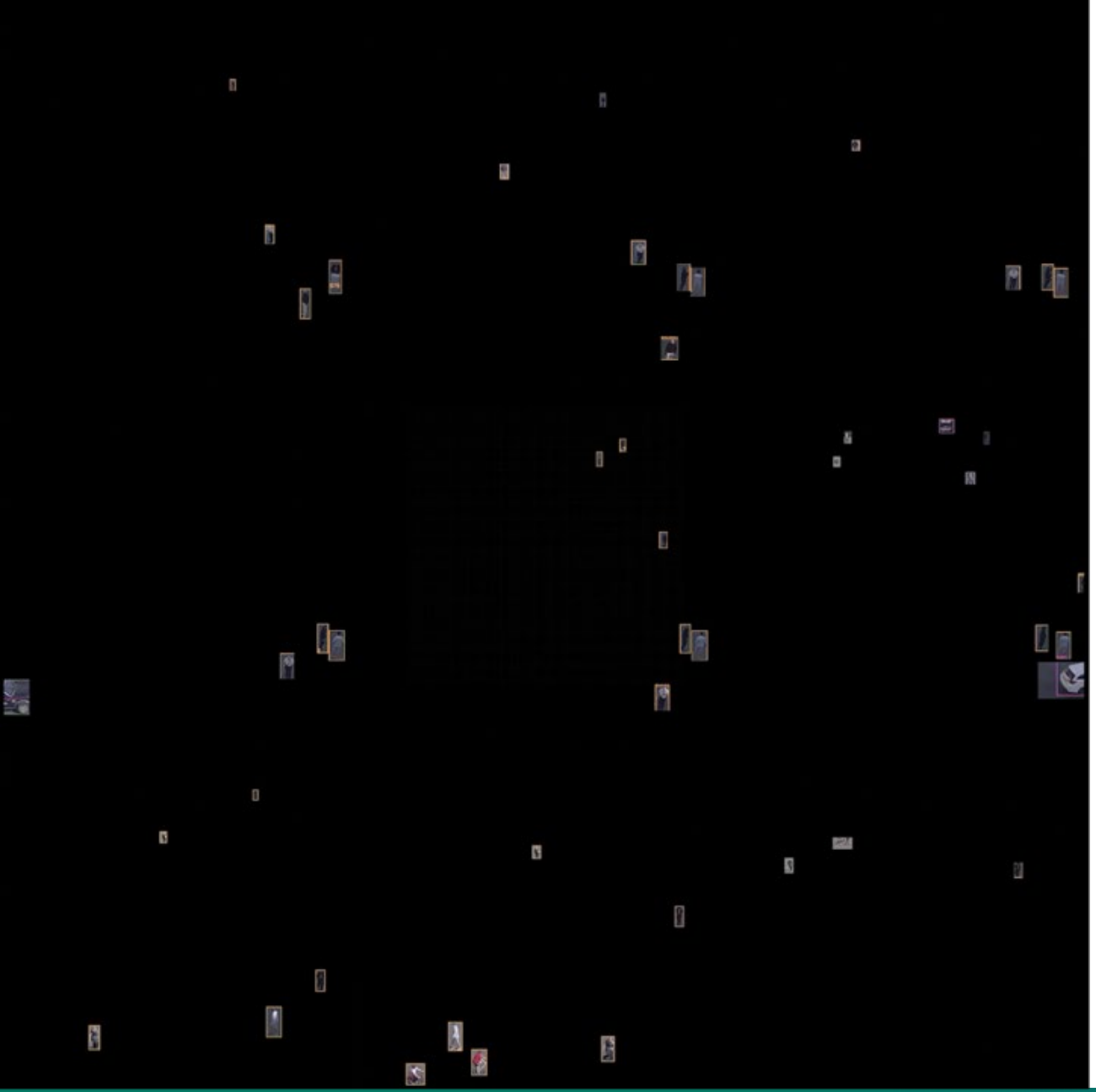
DISEASE DETECTION

SEMANTIC SEGMENTATION AND TRACKING




FACE DETECTION: GENDER AND AGE

*Image: Different Computer Vision applications*
*Source: Pexel*



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# DATA POST-PROCESSING

## Reduction of stored data

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

Website: noumena.io



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REAL CASE SCENARIO

# URBAN MAPPING



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# URBAN MAPPING

## Monitoring Public Spaces

Analyse spatial dynamics from video data recorded by the urban municipality of Barcelona, specifically the Department of Urban Development, Barcelona Regional.
The scope of this research is to **understand spatial dynamics in a public space, informing urban transformation and future planning decisions.**

**Client:** Barcelona Regional
**Data Analytics:** Noumena.
**Noumena credits** :
Aldo Sollazzo, Soroush Garivani, Oriol Arroyo, Cosme Pommier, Paula Osés, Salvador Calgua



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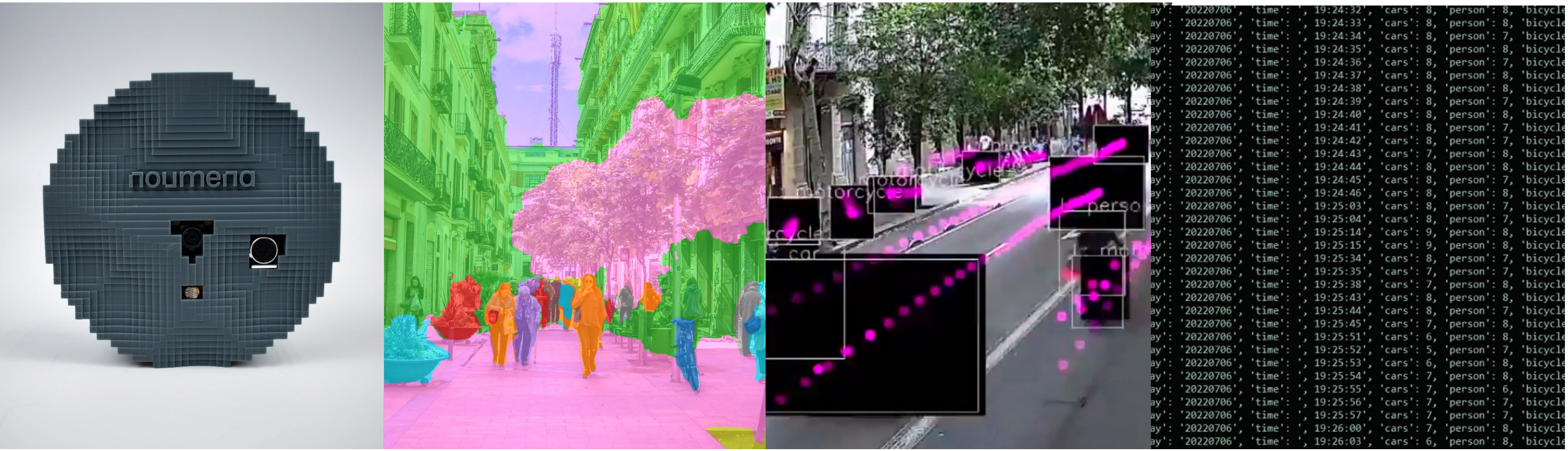
DATA COLLECTION
DATA PRE-PROCESSING
AI ALGORITHM
DATA POST-PROCESSING

# DATA COLLECTION

## General

TYPES OF DATA

TRAINING DATA

PREDICTION DATA



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# DATA COLLECTION

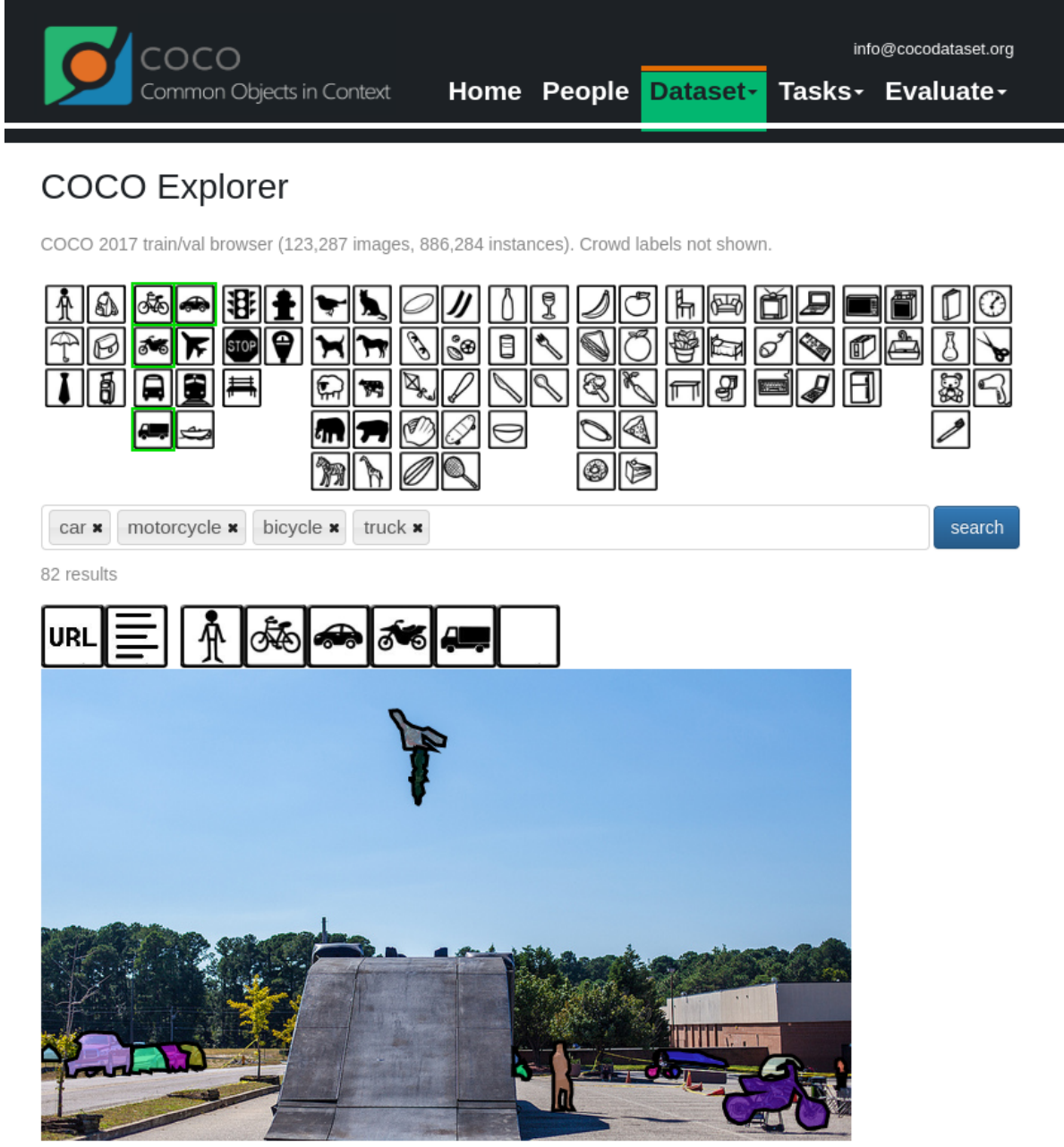
## Training data - COCO

URL: https://cocodataset.org/#explore

This is the COCO dataset webpage where you can explore the different classes and understand how the labelling is made.

Classes:

- Cars
- Bikes
- Motorbikes
- Trucks
- Pedestrians



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# DATA COLLECTION

## COCO - Folder structure

In this representation, the top-level directory is **coco/**. Within this directory, there are three subdirectories : **annotations/**, **train2017/**, **val2017/**, and **test2017/**.

The **annotations/** directory contains **JSON** files that specify the annotations foreach image in the dataset, including the object detection and segmentation annotations, as well as annotations for captions and person keypoints .

The **train2017/**, **val2017/**, and **test2017/** directories contain the images for the training, validation, and test splits of the dataset, respectively . The images are stored in JPEG format and are named according to their image IDs.

Finally, there are two additional files in the top-level directory : **licenses.txt**, which contains the license agreements for the dataset, and **READMEtxt**, which provides a brief description of the dataset and instructions for using it.

```
coco/
├── annotations/
│   ├── instances_train2017.json
│   ├── instances_val2017.json
│   ├── instances_test2017.json
│   ├── captions_train2017.json
│   ├── captions_val2017.json
│   ├── person_keypoints_train2017.json
│   └── person_keypoints_val2017.json
├── train2017/
│   ├── 000000000009.jpg
│   ├── 000000000025.jpg
│   ├── ...
│   └── 000000581921.jpg
├── val2017/
│   ├── 000000000139.jpg
│   ├── 000000000285.jpg
│   ├── ...
│   └── 000000581921.jpg
├── test2017/
│   ├── 000000000001.jpg
│   ├── 000000000002.jpg
│   ├── ...
│   └── 000000581929.jpg
├── licenses.txt
└── README.txt
```



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# DATA COLLECTION

## COCO - JSON Annotations

The annotations field:

- id: A unique identifier for the object annotation.
- image_id: The identifier of the image that the object belongs to.
- category_id: The identifier of the category that the object belongs to.
- bbox: A list of four values that specify the bounding box of the object. The values are [x, y, width, height]

The images field:

- id: The identifier of the image.
- width: The width of the image in pixels.
- height: The height of the image in pixels.
- file_name: The file name of the image.

The categories field:

- id: The identifier of the category.
- name: The name of the category.
- supercategory: (Optional) The name of the supercategory that the category belongs to.


```
{
    "annotations": [
        {
            "id": 1,
            "image_id": 1234,
            "category_id": 1,
            "bbox": [155, 200, 65, 60]
        },
        {
            "id": 2,
            "image_id": 1234,
            "category_id": 3,
            "bbox": [320, 190, 110, 50]
        },
        {
            "id": 3,
            "image_id": 1234,
            "category_id": 2,
            "bbox": [100, 300, 100, 100]
        }
    ],
    "images": [
        {
            "id": 1234,
            "width": 640,
            "height": 480,
            "file_name": "image1234.jpg"
        }
    ],
    "categories": [
        {"id": 1,"name": "person"},
        {"id": 2,"name": "motorcycle","supercategory": "vehicl
e"},
        {"id": 3,"name": "car","supercategory": "vehicle"}
    ]
}
```




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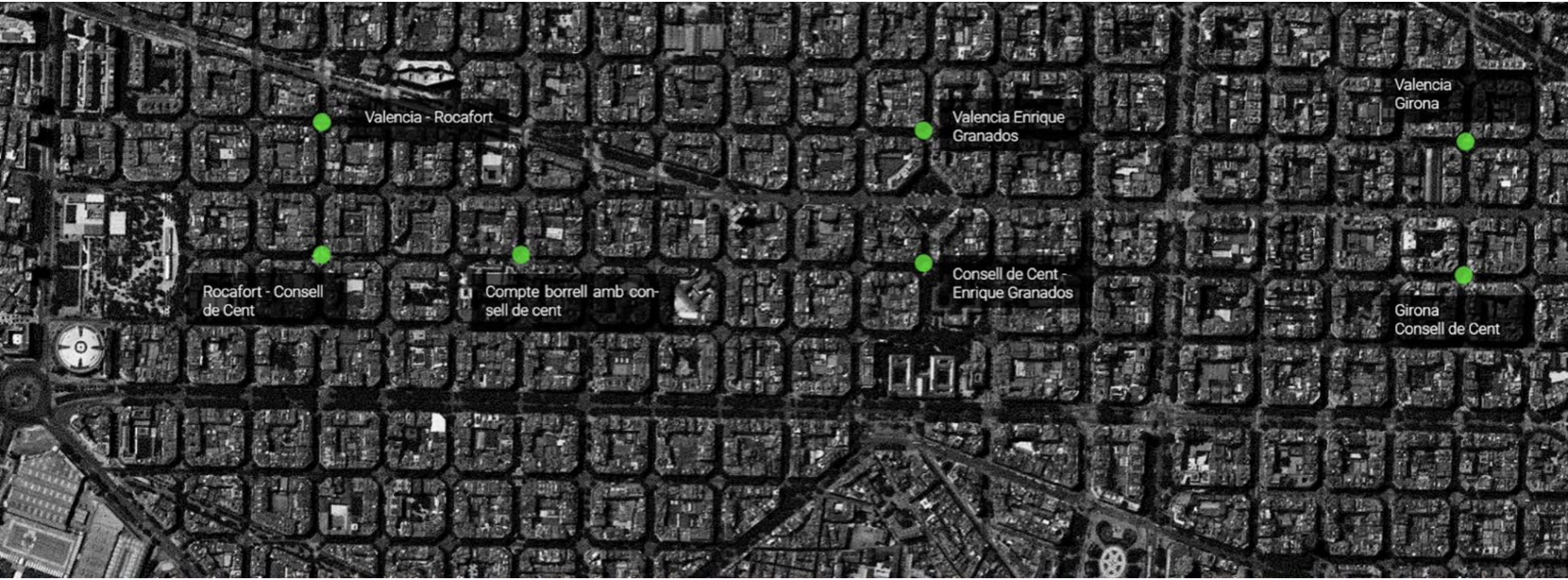


Website: noumena.io

# 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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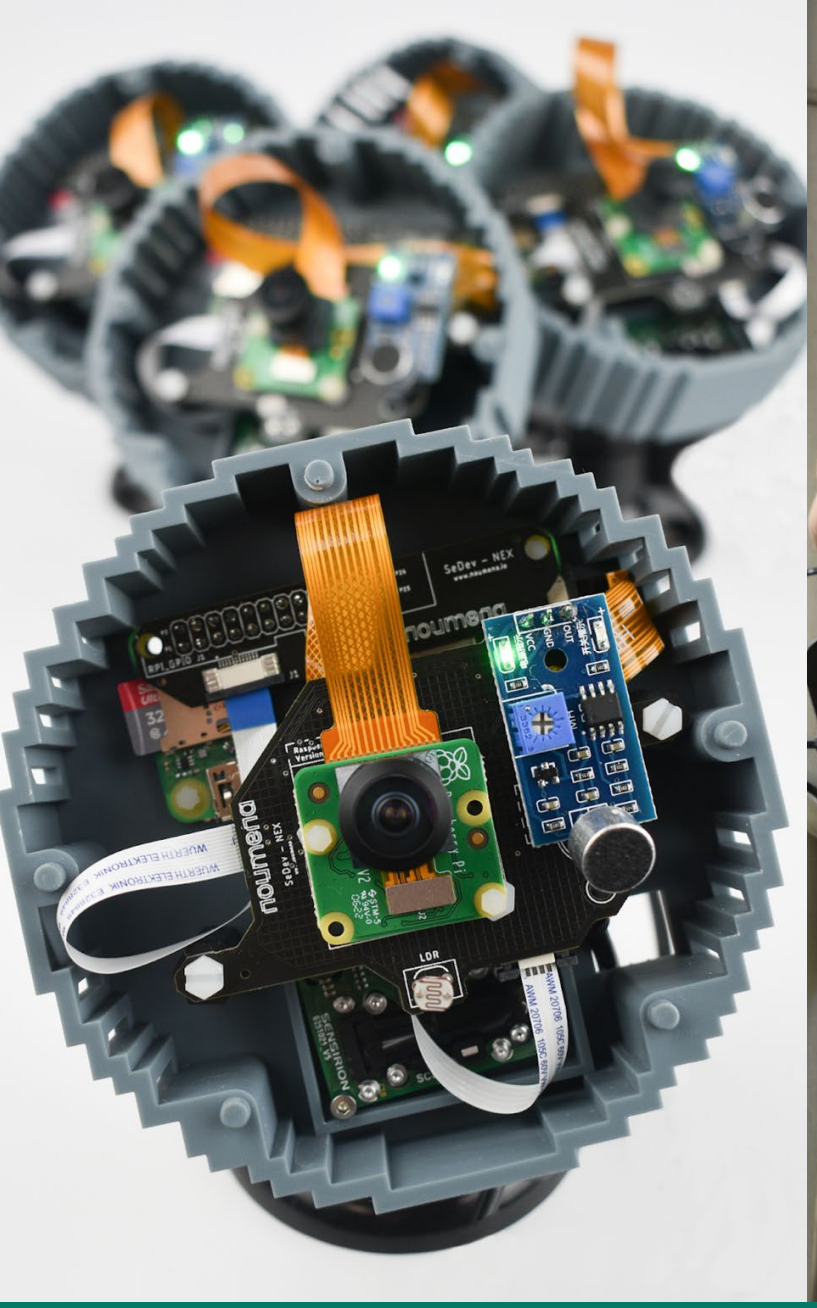


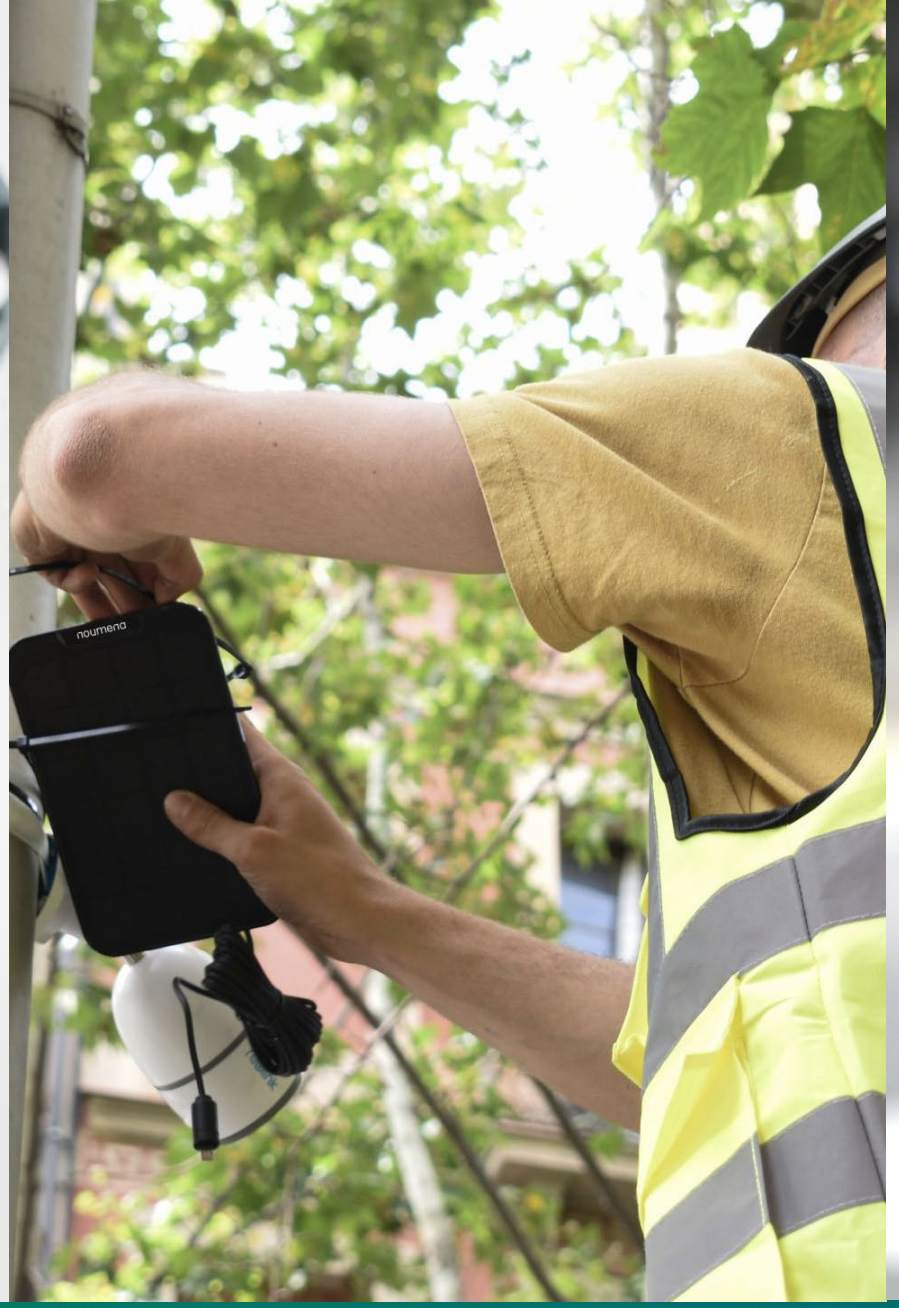





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# DATA PRE-PROCESSING

## Prediction Data

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


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# 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

# ALGORITHM
## WORKFLOW

- Input encoded videos
- Object detection algorithm
- Tracking algorithm
- Extract data from videos:
  - Type of class (cars, person, …)
  - The x,y position
  - The time
- Implement counter
- Save data into database



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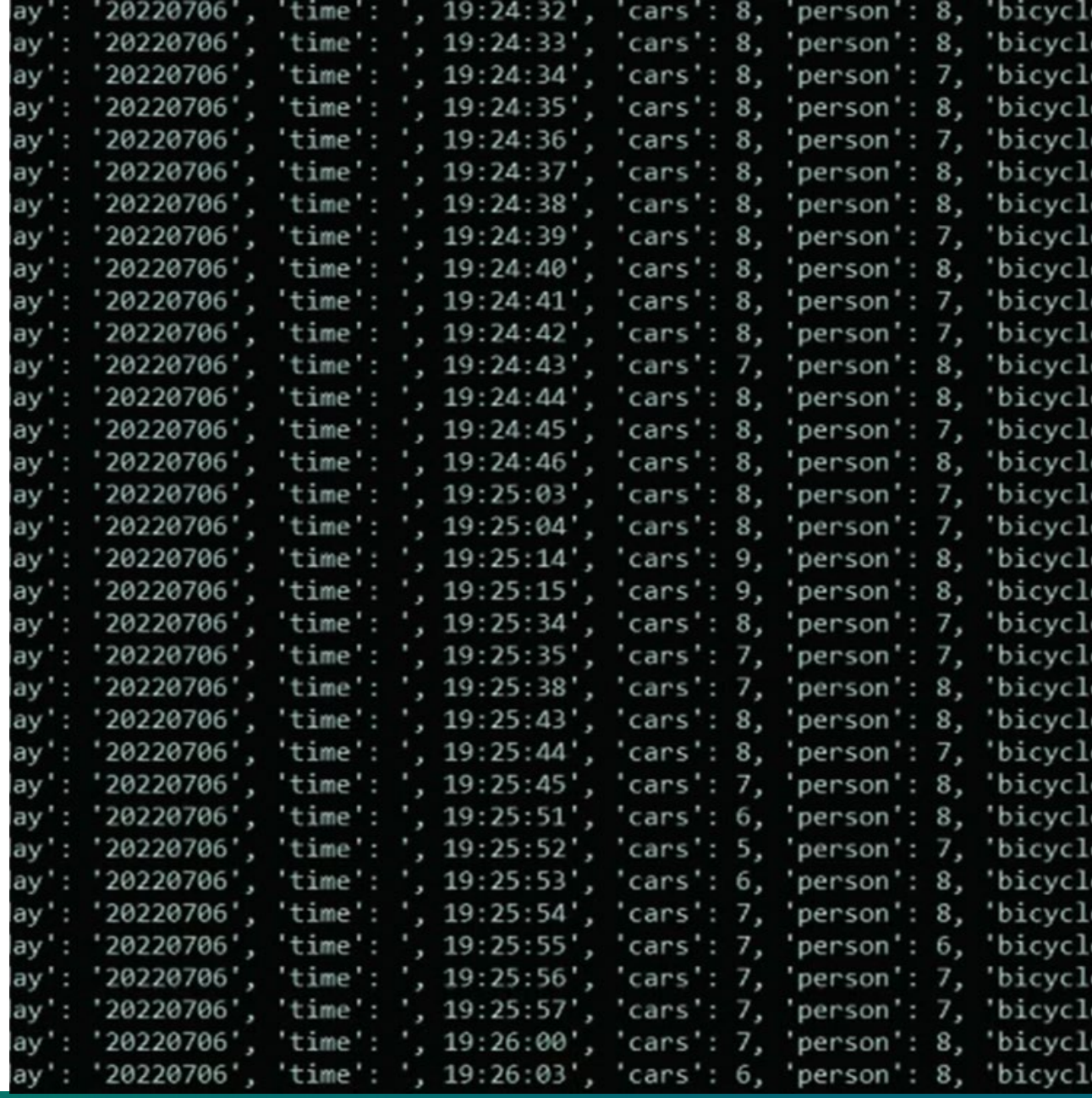
# DATA POST-PROCESSING

## General

- Clean data
- Create visualizations
- Ground truth comparison



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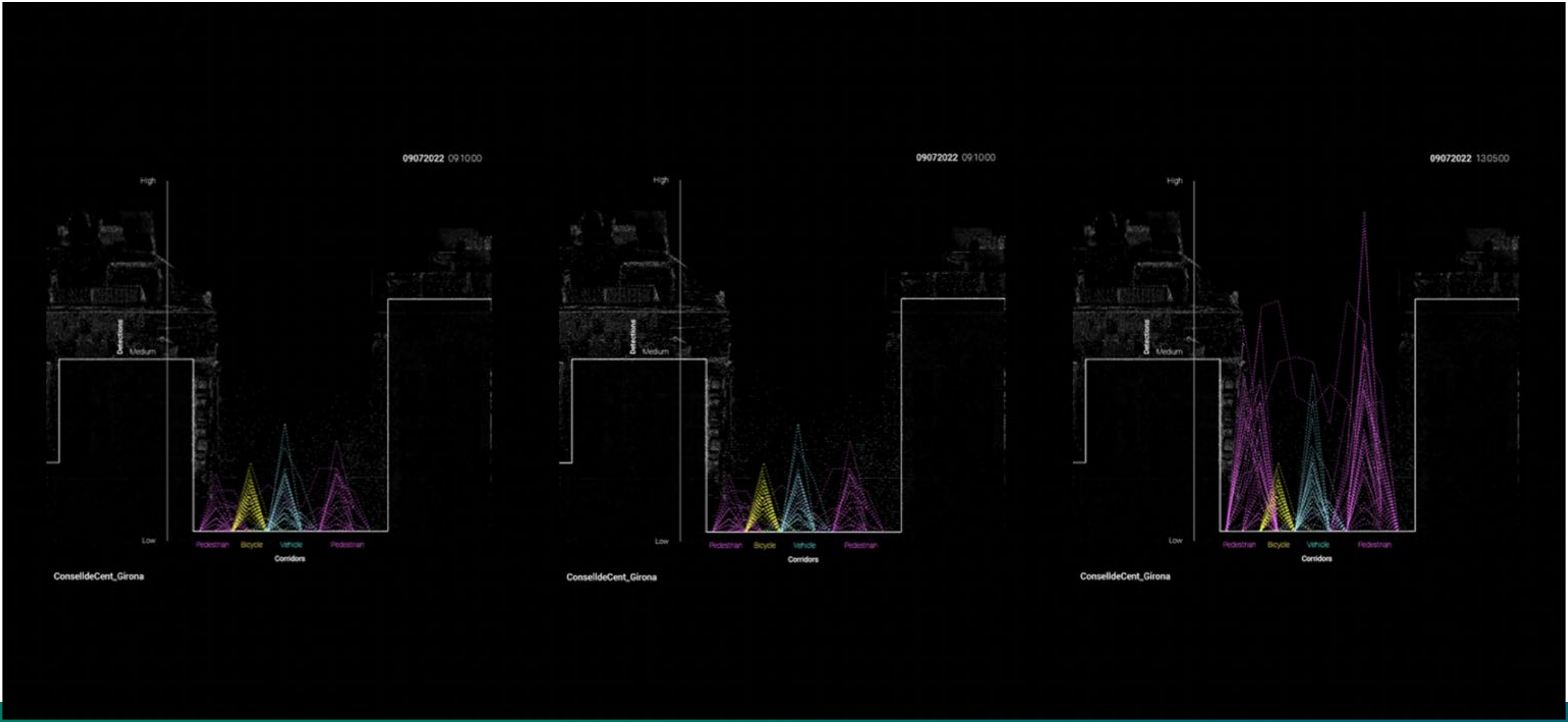
# Data Post-Processing STATISTICS - VISUALIZATIONS



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# Data Post-Processing
## GROUND TRUTH COMPARISON

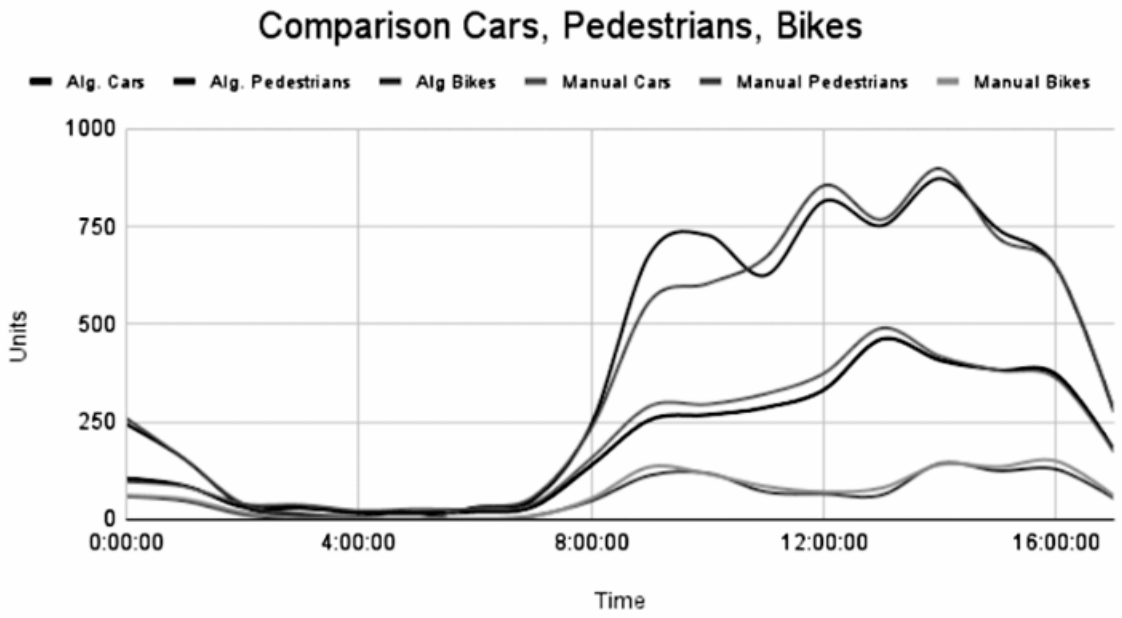


*Chart 5: Comparison of algorithm and manual count for cars, bikes and pedestrians.*

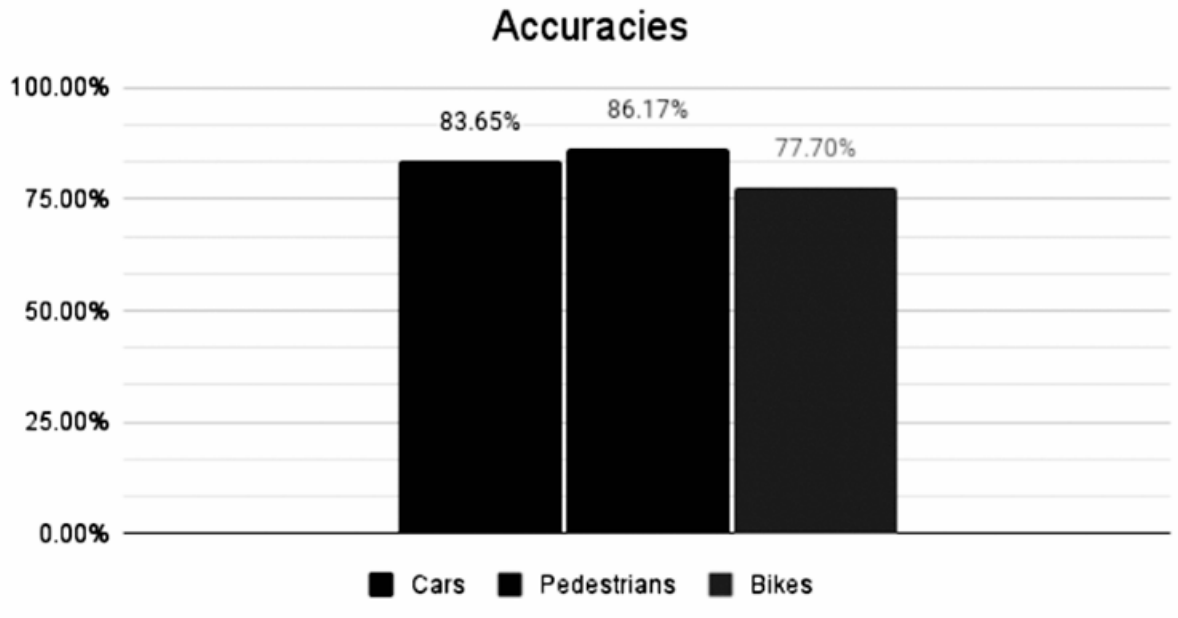


*Chart 6: Accuracies for detection of cars, bikes and pedestrians.*



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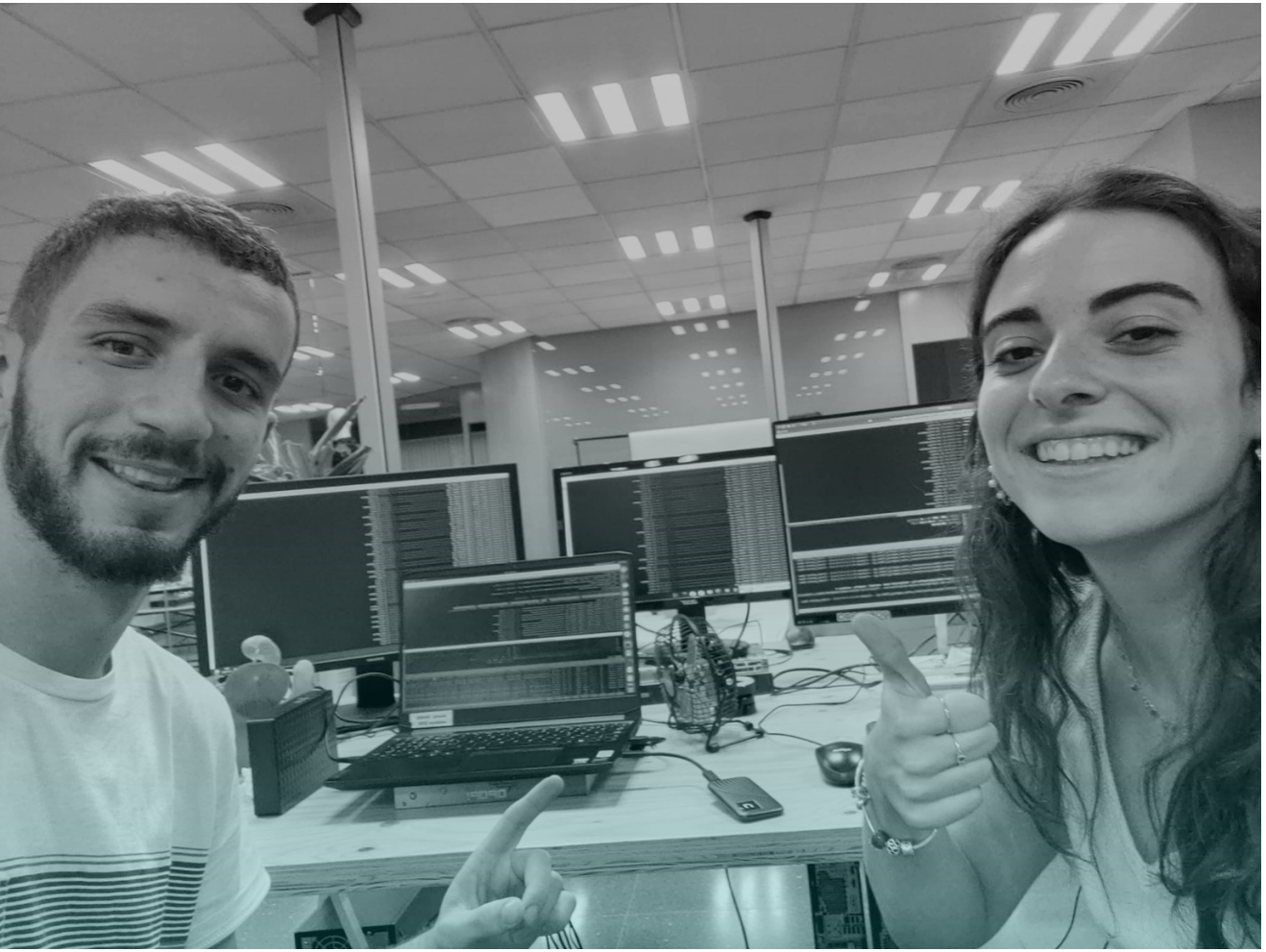

# LESSONS LEARNED

## OBJECT DETECTION AND TRACKING

- Video processing timings
- Higher camara definition
- Corridors
- Edge computing



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# thank you!

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