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Bus Stop Detection

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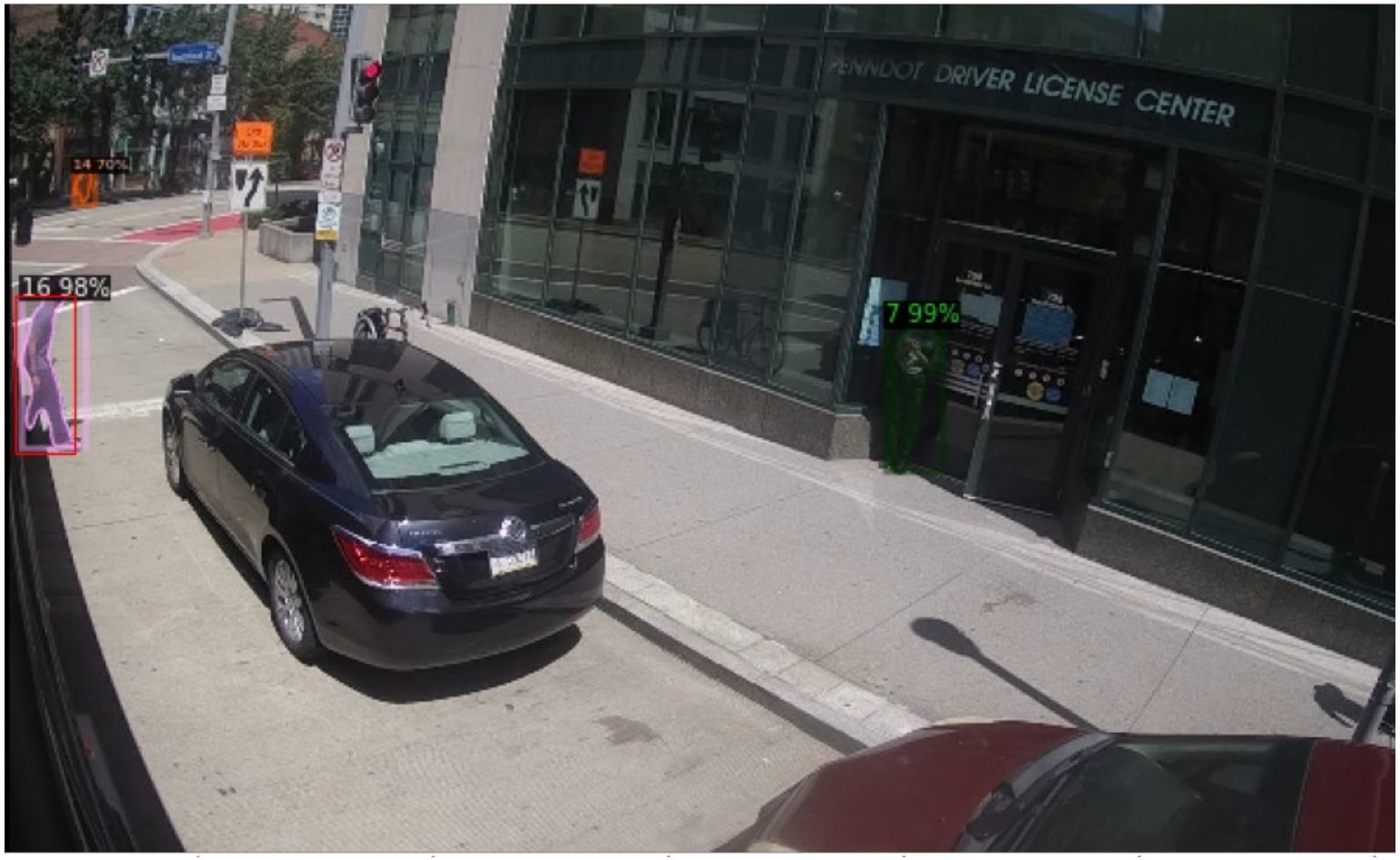
Overview

- Analyze data from bus between Washington and Pittsburgh
- Detect places where people enter and leave the bus
- Compare detected stop locations to GPS data of the listed bus stops



Human detection on bus camera footage

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Goals

Find locations where people enter without a bus stop

Goals

Find errors in the data sheets with bus stop data

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Goals

- Gain information about the usage of the bus stops
- Gain live information about how full the bus is
- Gain information about passenger numbers
- Gain data about which hours are especially busy
- Gain information how utilization is influenced by external factors

Symbols of the Deutsche Bahn to indicate the utilization of the trains

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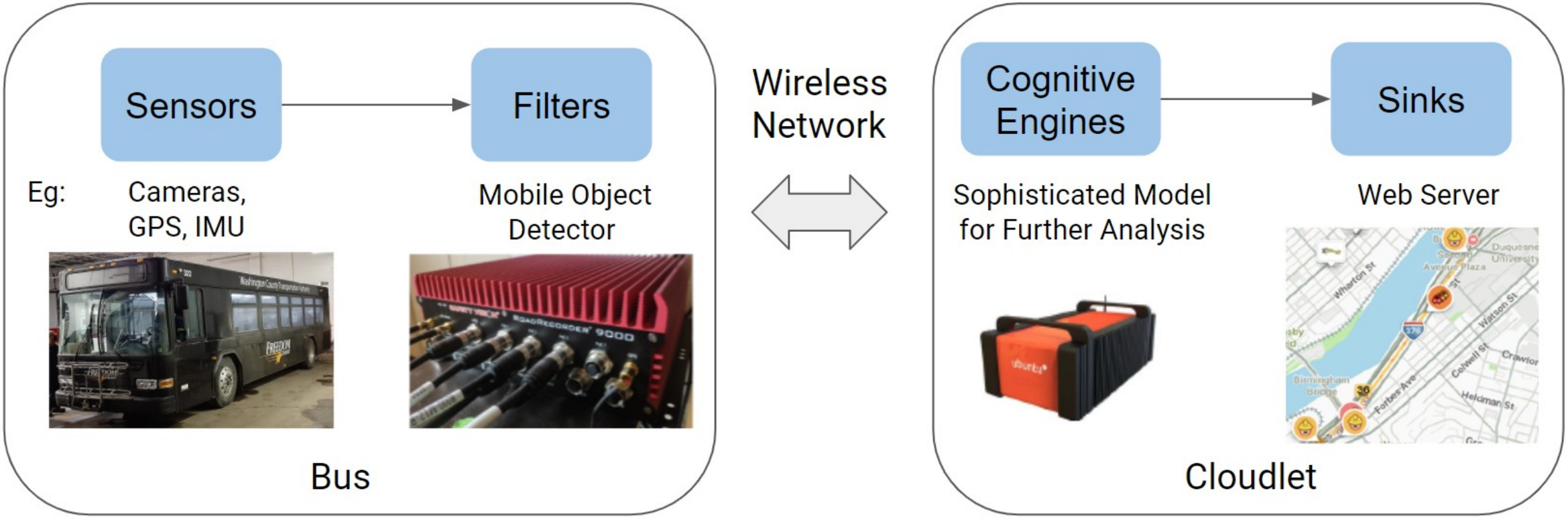
How it is done

- Bus is equipped with cameras
- Humans in camera images get detected with DL / CV
- Humans get tracked
- Human positions get analyzed (e.g. proximity to door)
- Compare GPS data of detected bus stops with GPS data of official bus stops

The BusEdge System



https://github.com/CanboYe/BusEdge

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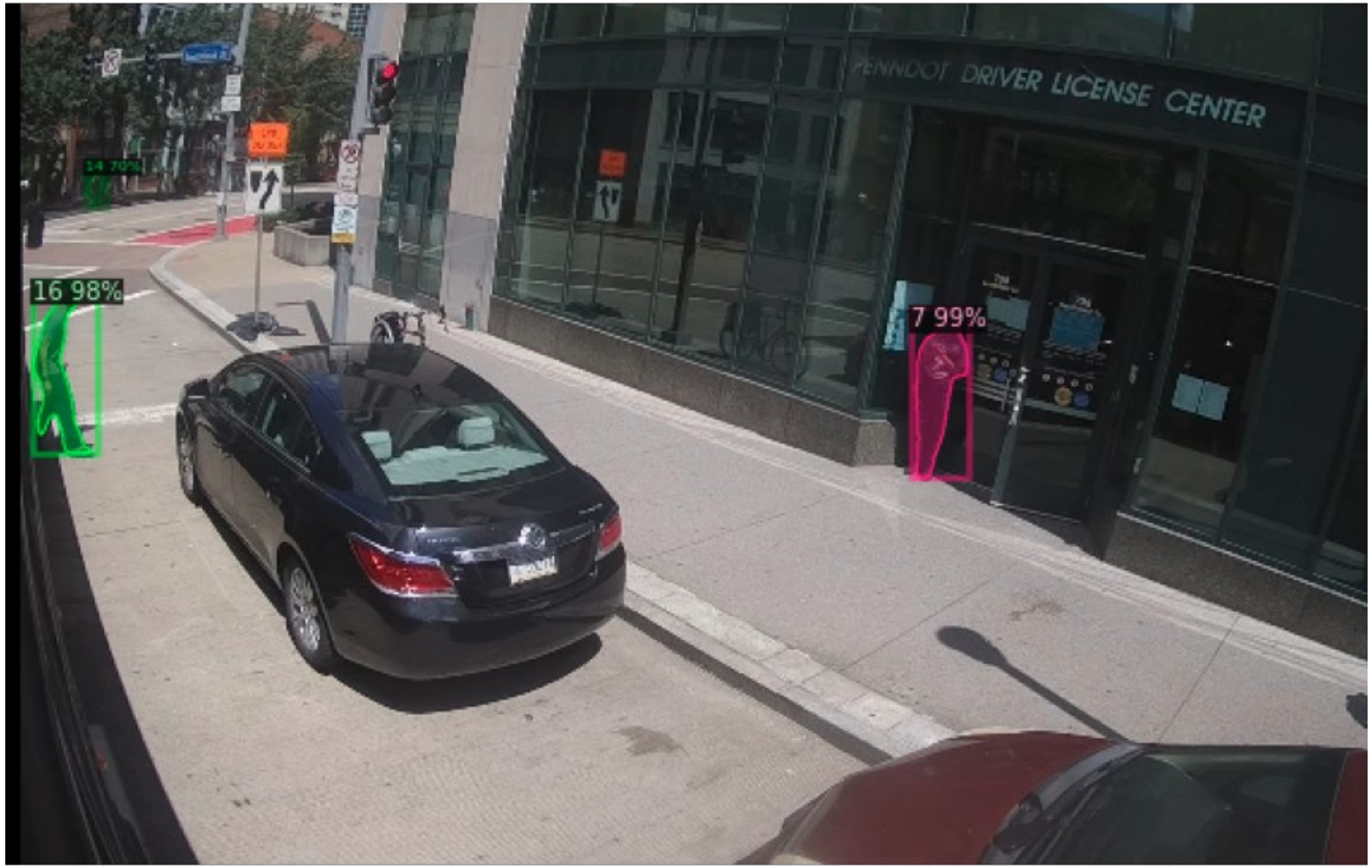
Human Detection

- Using Detectron2
- Algorithm detects 81 different classes and segments the instances
- Using R-CNN Network
- Detection is applied on each image individually
- Often Bus mirror or window of bus detected as human

  → window got set to black and mirror detections get ignored



Detected and segmented humans in an image

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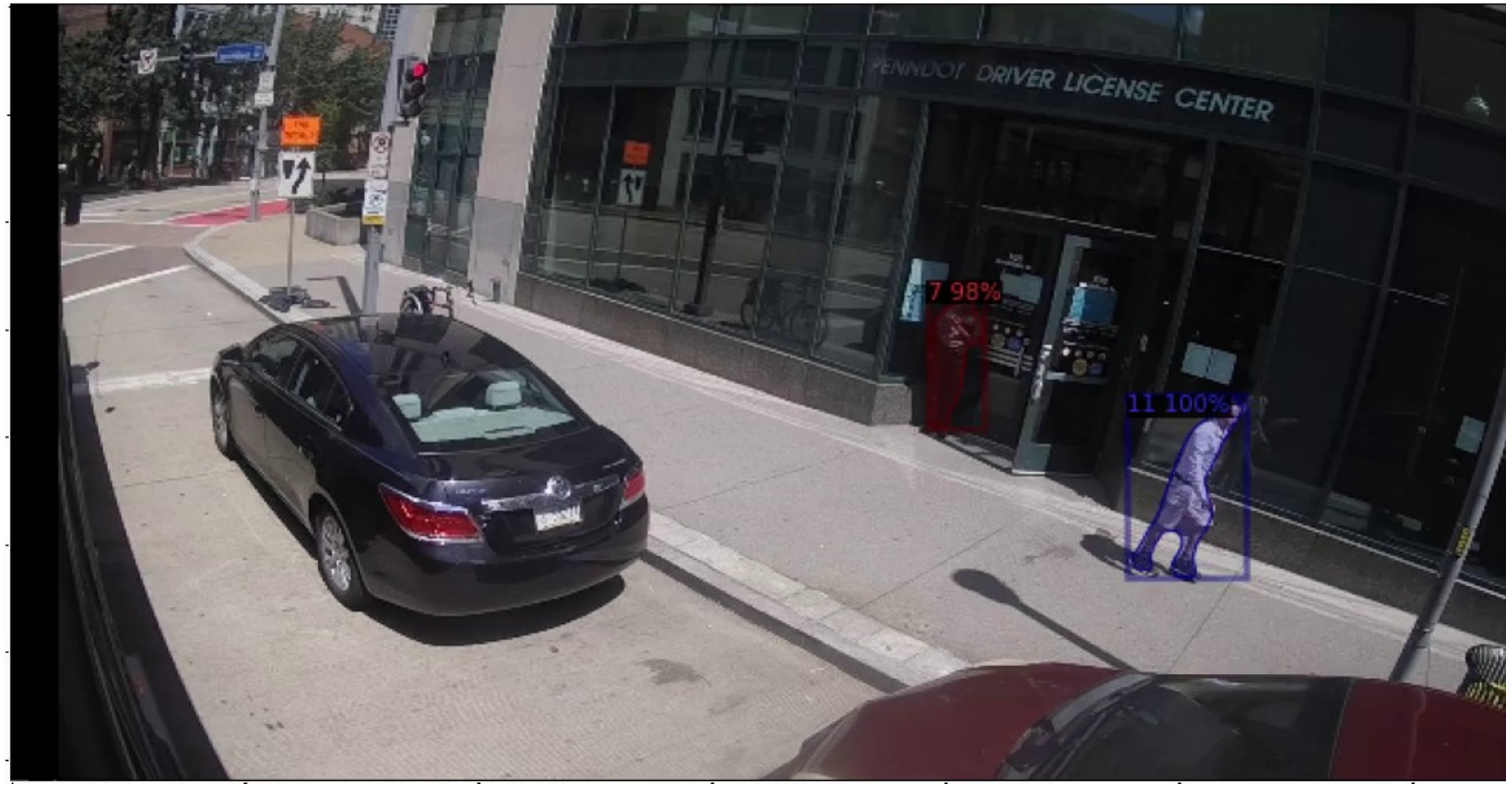
Human Tracking

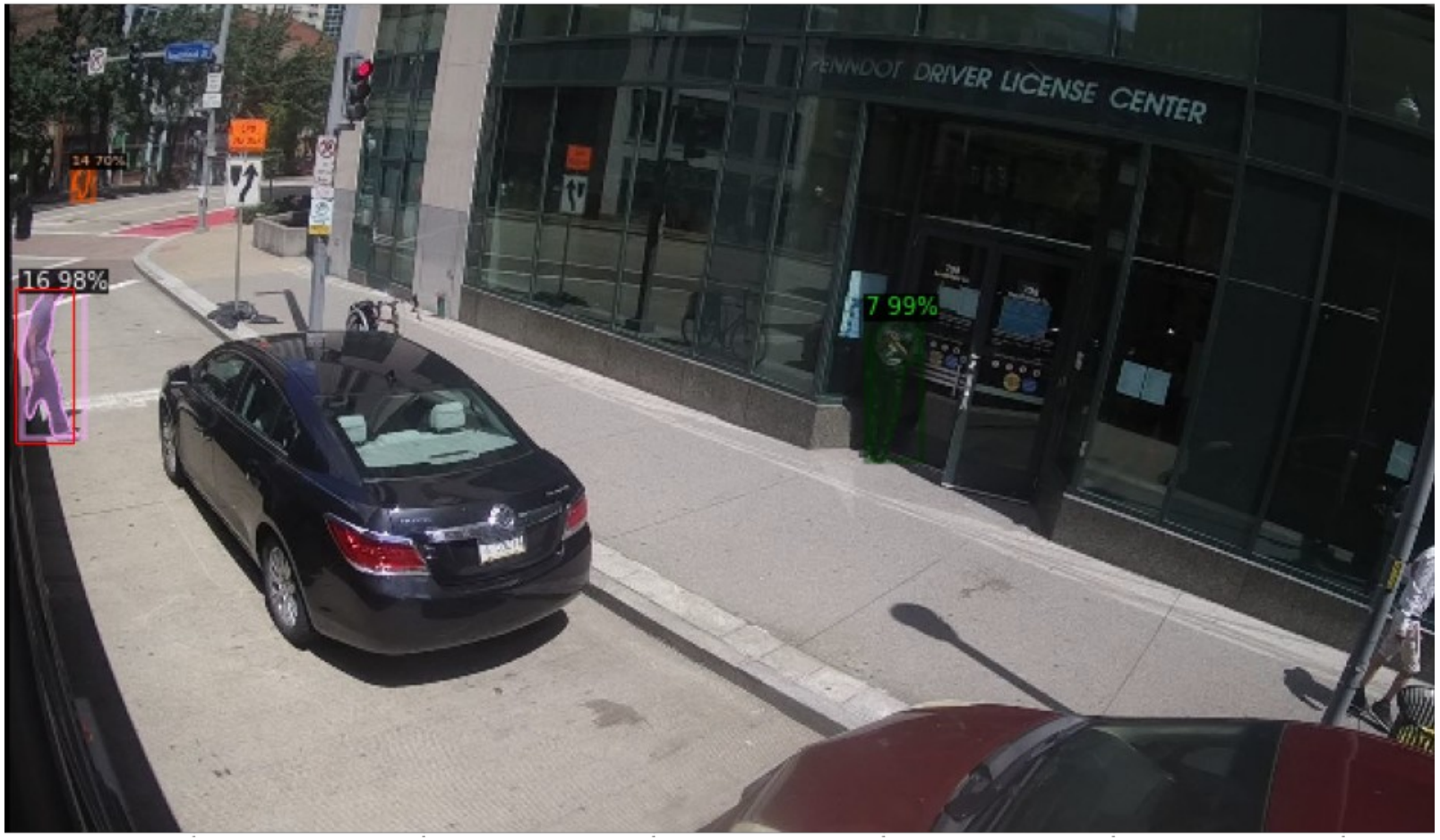
- Tracking based on Hungarian algorithm
- Using IoU (Intersection over Union)
- Reidentification possible



Tracking walking pedestrians

Analyze Human Behavior

- Check if humans are near the door
- Classify humans based on if they enter or exit the area near the door



Example how a person is detected entering

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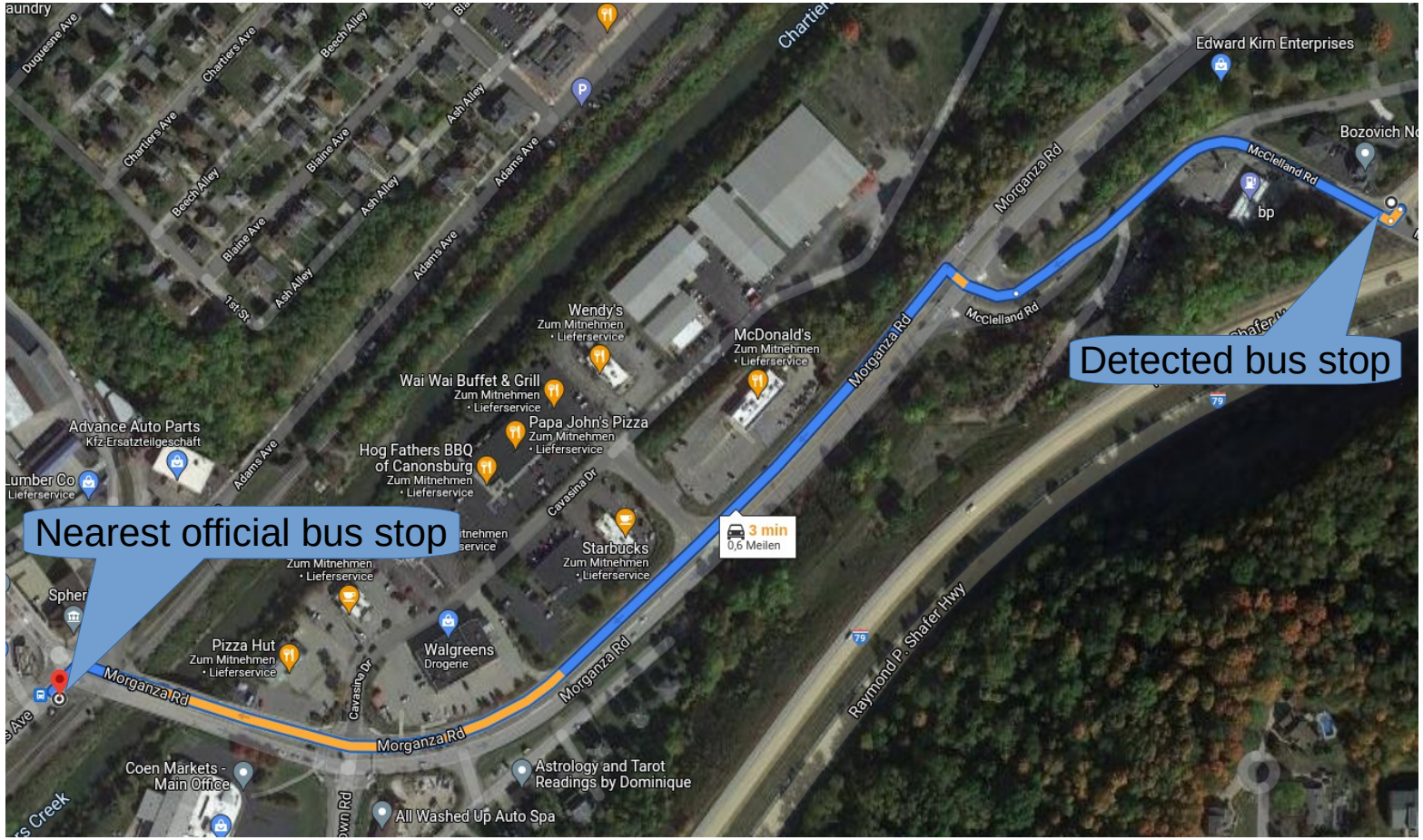
Compare GPS Data

- Read out the GPS data from detected bus stops
- Compare with GPS data from all listed stops
- Pick the bus stop with the shortest distance to the detection
- If the distance is > 100m, predict that the person is not at a bus stop



Distance between a detected stop and the nearest official bus stop

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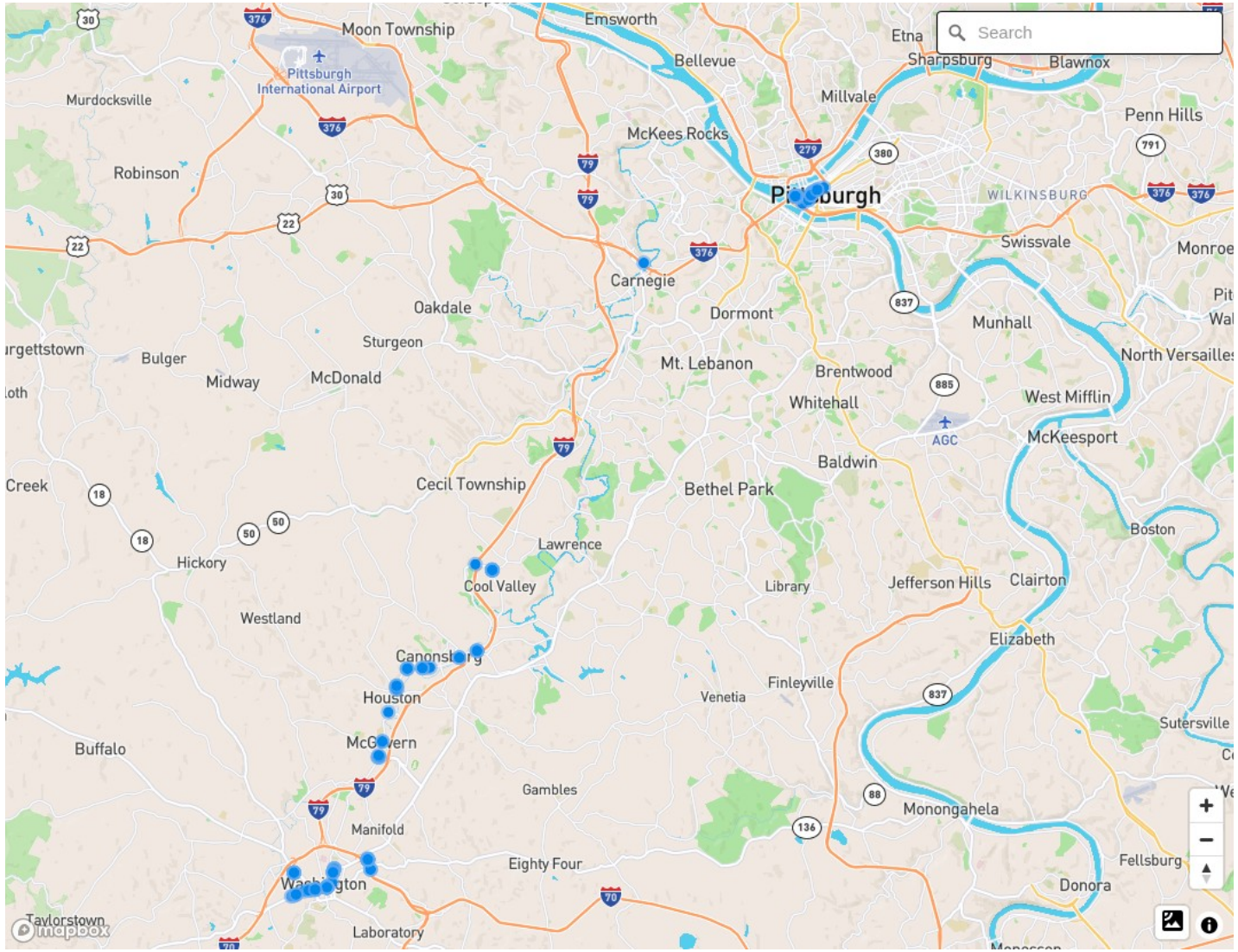
Visualize Data



All detected busstop locations on a map

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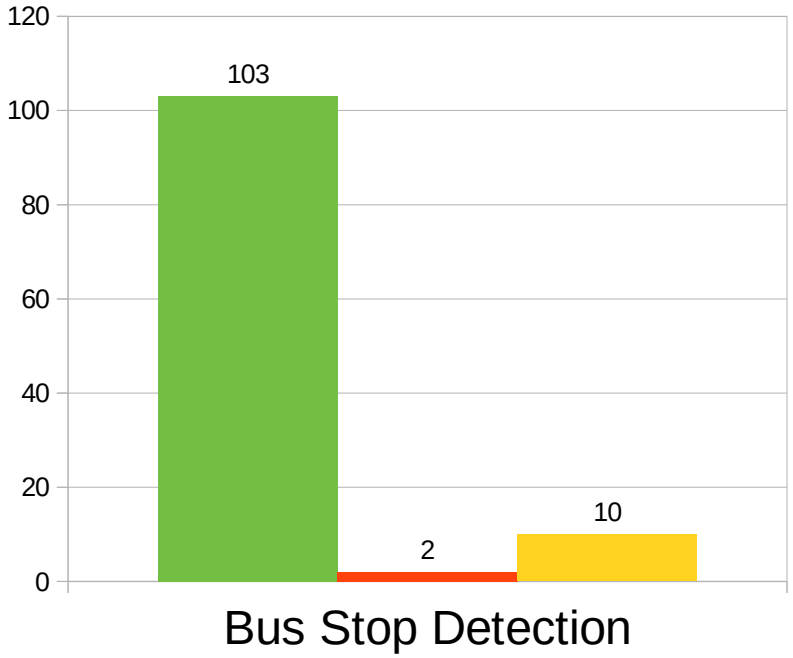
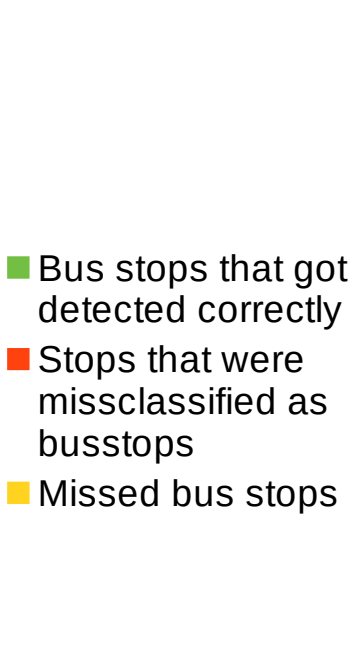
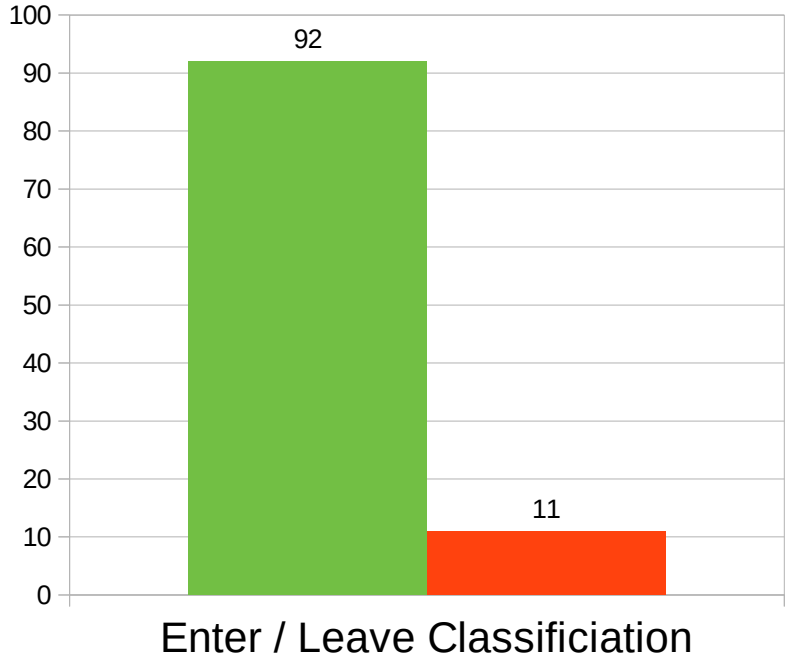
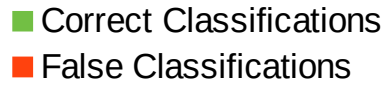
Evaluation

- 9 datasets analyzed
- 96,750 images analyzed









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Detected Unofficial Bus Stops

- Out of 146 detected bus stops, 35 are not near an official stop
- **In 3 cases the data sheet is incomplete**
- Includes stops out of regular operation hours
- Mostly people exiting the bus
- Hard to tell if anyone was waving for the bus to stop

A bus stop sign exists, but no stop is listed for this location

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Bus driver refilling gas gets detected as an unofficial bus stop

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Persons exiting without an official bus stop

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Person possibly waving at the bus

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Future Plans

- Better integrate into BusEdge system

  → Try to run human detection on MobileNet
- Run detection algorithm on more test data