TEAM 3

Dynamic Traffic Light Control for Smart Cities

Dynamic Optimization Based on Real-Time Vehicle and Pedestrian Demand

Dynamic Traffic Light Control

A dynamic (or adaptive) traffic light is an intelligent intersection control system that automatically adjusts signal times based on real-time traffic data instead of fixed time cycles.

WHICH KEYWORDS DID WE USE?

Machine Vision
Machine Learning
Smart City

Why Did We Choose This Project?

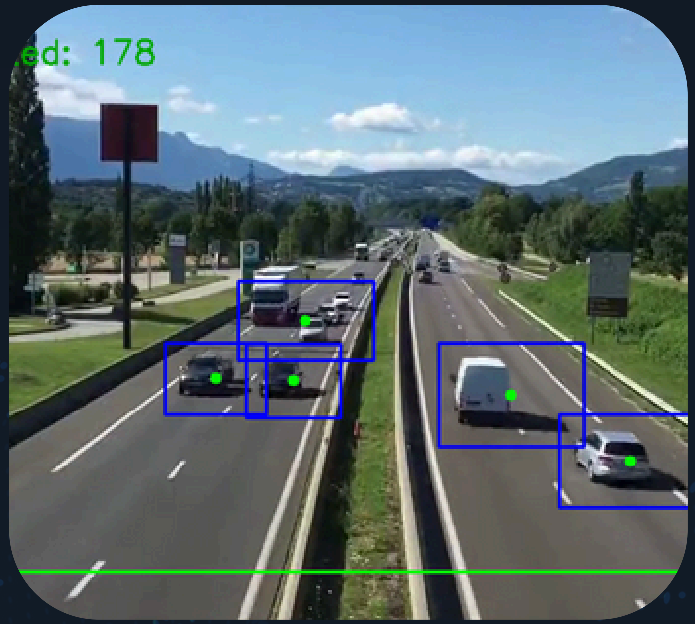
To contribute to smart city goals, we developed a system that dynamically optimizes light phases using real-time vehicle and pedestrian data.

Today, urban traffic congestion not only increases the waiting time of road users but also leads to an increase in traffic-related pollutants and accidents. Conventional traffic light systems operate in fixed cycles and therefore cannot respond to hourly or daily changes in passenger/pedestrian volumes.

Key Topics

Graph-based Road Network Modeling

Pedestrian Detection Module

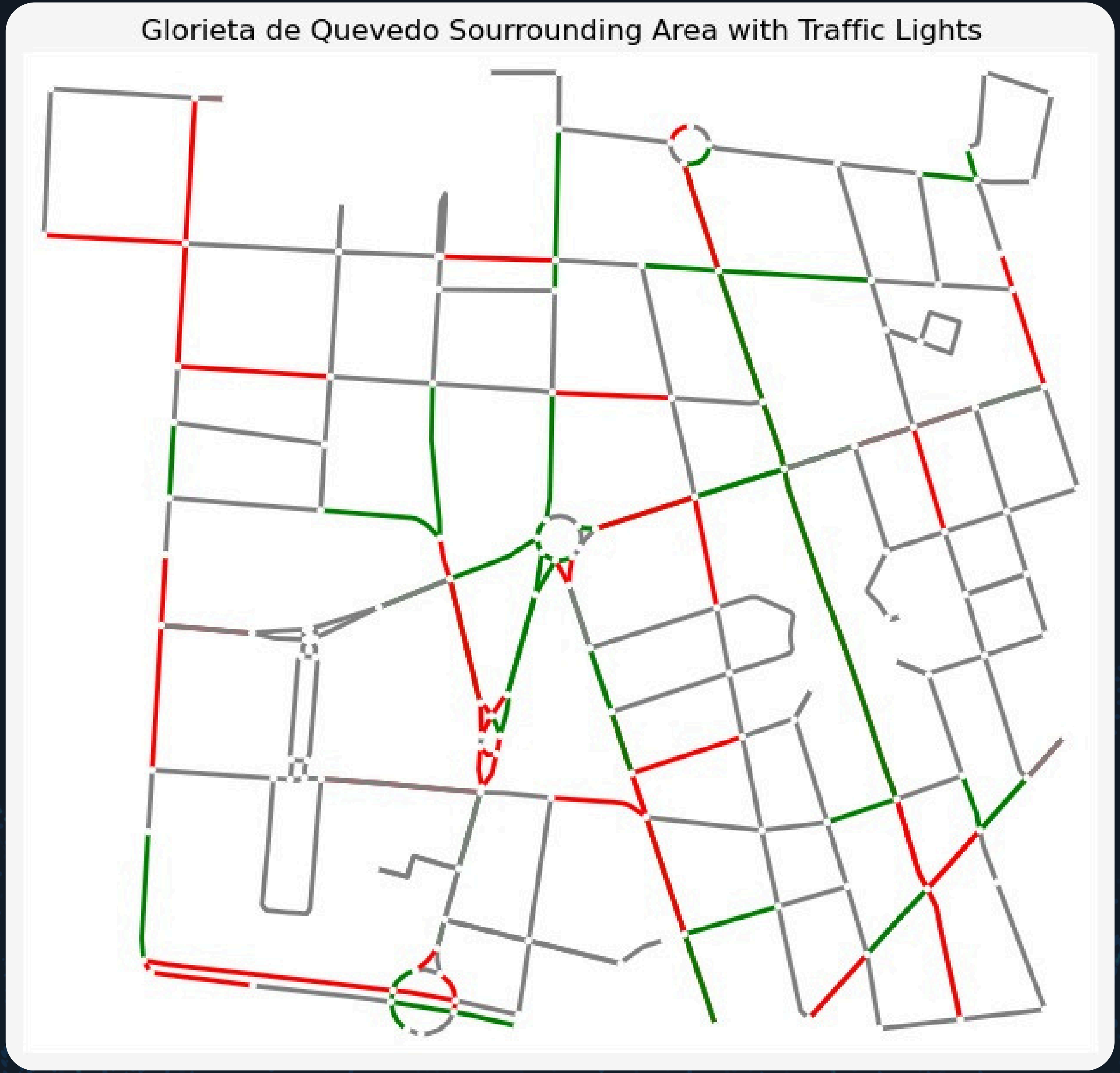


Vehicle Detection and Counting Module

Graph-based Road Network Modeling

A signal control system was developed that manages both vehicular and pedestrian traffic with real-time data at intersections around Glorieta de Quevedo, covering a 500 × 500 m section of Madrid.

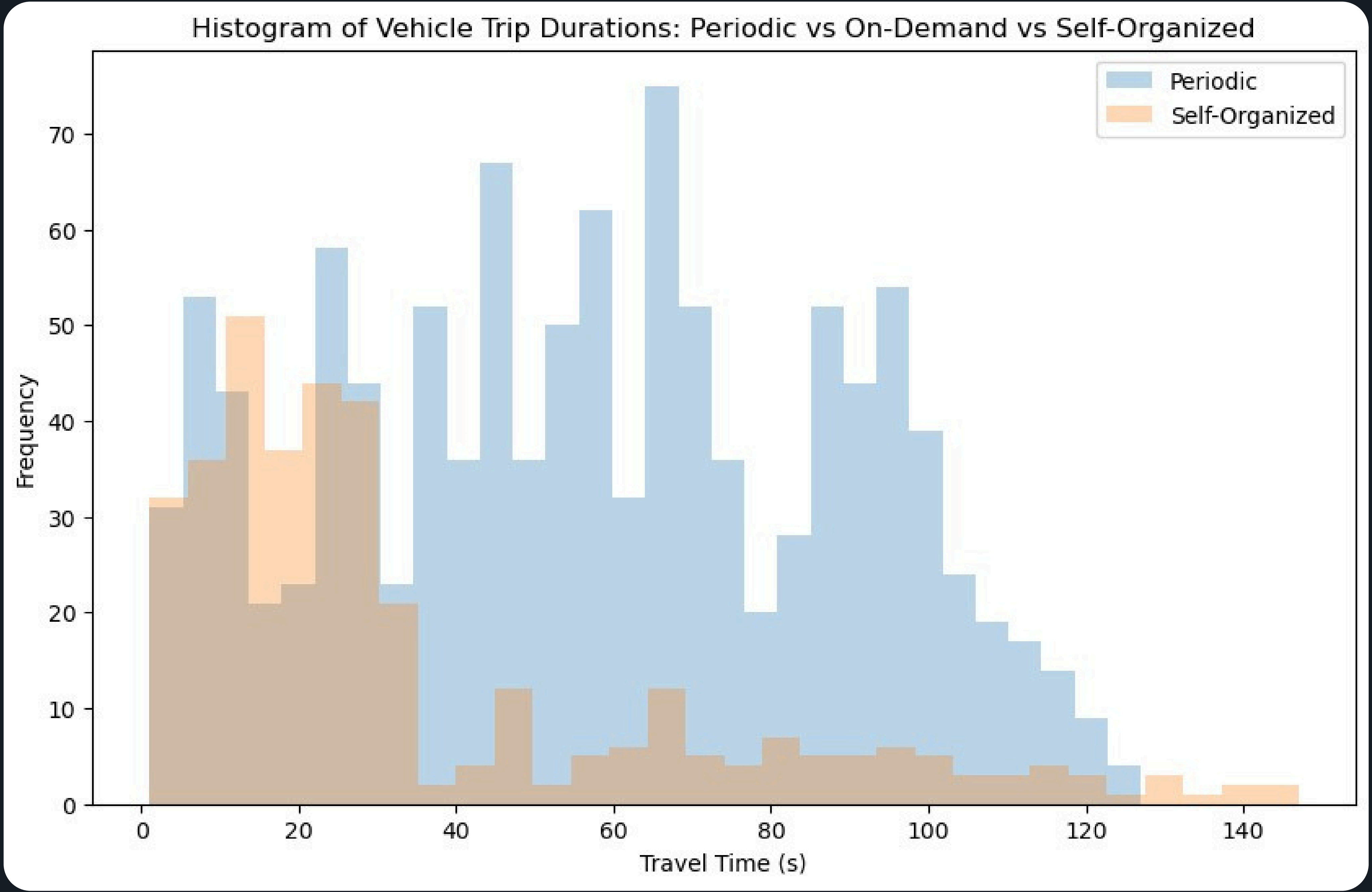
Using OpenStreetMap data, we modeled the road network as nodes (intersections) and edges (road segments) with a Python-based library. A dynamic traffic flow simulation was set up by chronologically processing "vehicle entry" and "light change" events in an event-driven loop.



Graph-based Road Network Modeling

Real-time detection results were transferred to a data line and a self-organized signal control mode with two different trigger rules was implemented. In contrast, a "periodic" mode based on a fixed 30 s green + 5 s red cycle was also set up to compare the two methods.

The results were visualized and evaluated with travel time histograms and road segment speed heatmaps. Periodic mode had an average travel time of 57.20 s (median 57.00 s), while demand-driven self-organized mode had an average travel time of 35.32 s (median 24.00 s). This difference shows that dynamic signal control significantly improves urban traffic flow.



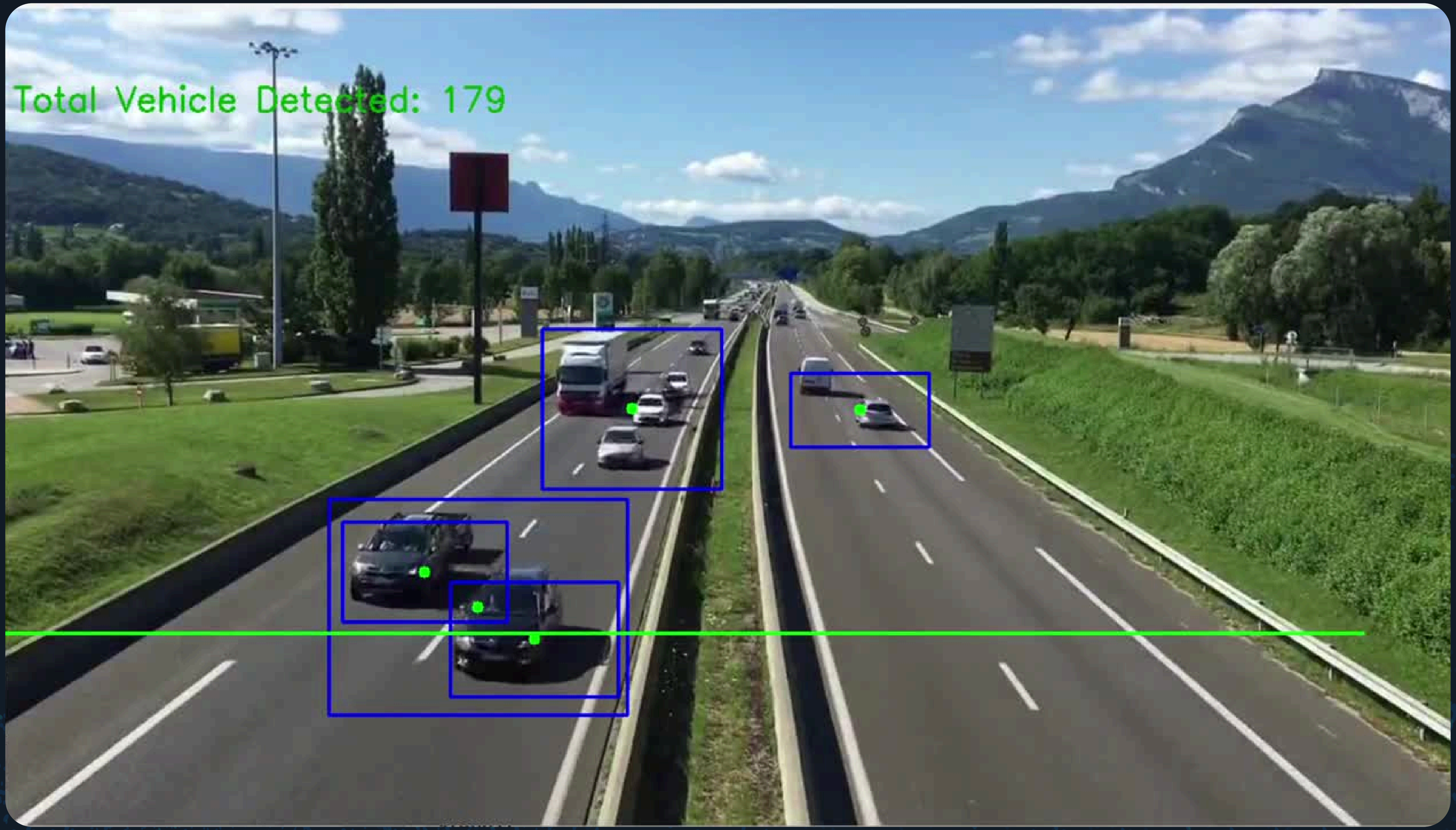
Pedestrian Detection Module

Using MediaPipe's Edge AI framework, a pedestrian detection system was implemented that identifies people in a defined crossing zone in traffic camera footage. The goal is to dynamically adjust traffic light phasing based on actual pedestrian presence.

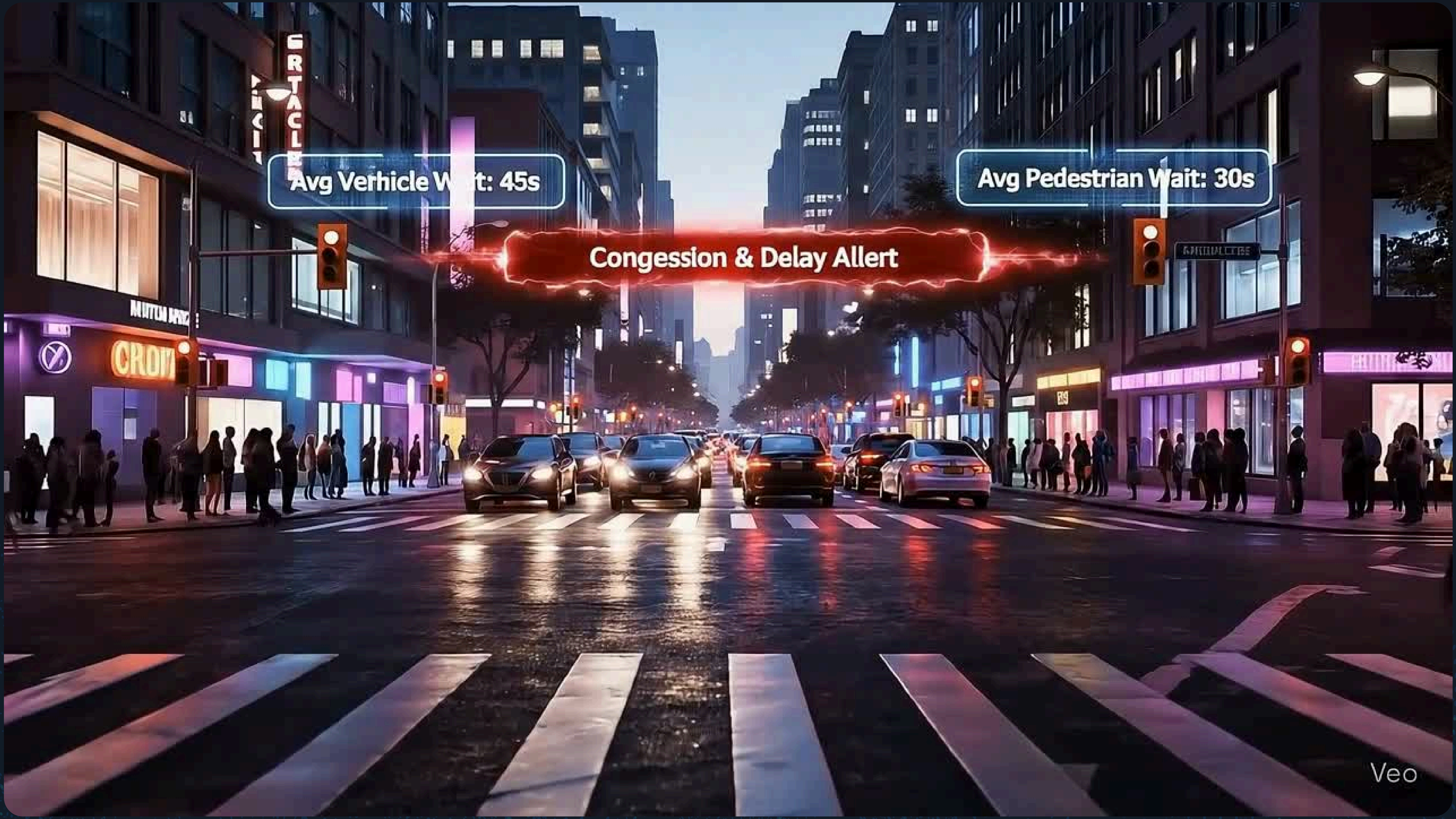
A region-based detection approach was chosen to avoid false positives and to use a single camera for multiple sidewalks. This also improves processing speed and reliability. The detection module is designed to output live head counts to a shared data pipeline so that it can trigger a pedestrian signal extension or early green for safety and traffic flow optimization.

Vehicle Detection and Counting Module

In order to perform real-time vehicle counting from fixed intersection camera images, we used OpenCV to read the frame-by-frame video stream and identify moving pixels by taking consecutive frame difference.



After grayscale and Gaussian blurring, the object mask was created with binary thresholding and morphological operations. Real vehicles were selected from the contours detected by FindContours with a magnitude filter, and the number of vehicles passing the virtual counting line was increased by calculating the geometric center of each contour. This counter output, visualized with green counting line, blue box and green center points, is directed to the demand-driven signal control system to dynamically adjust the traffic lights.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Avg Pedestrian Wait: 30s
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Bibliography

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THANKS