RUTGERS
WINLAB | Wireless Information Network Laboratory

Harnessing the Automotive Infoverse

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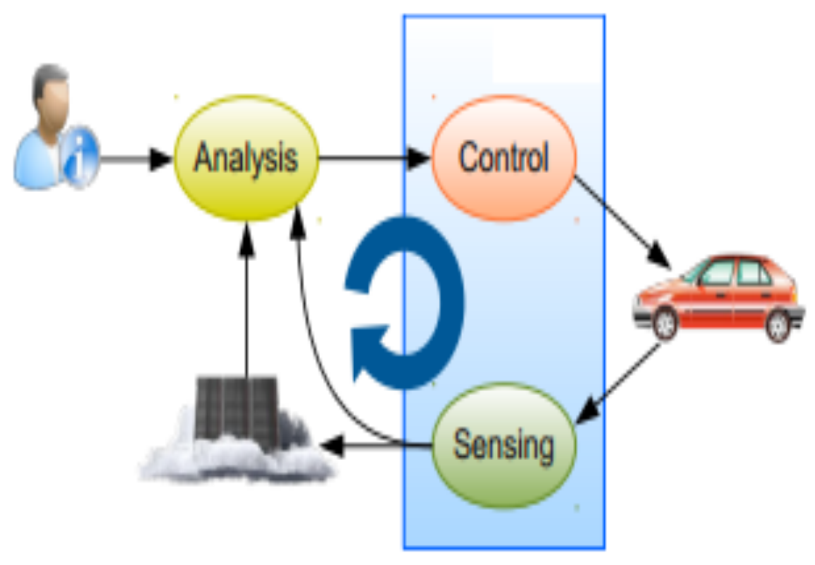
Abstract

Until now, the "cyber" component of automobiles has consisted of control algorithms and associated software for vehicular subsystems designed to achieve one or more performance, efficiency, reliability, comfort, or safety (PERCS) goals, primarily based on short-term intrinsic vehicle sensor data. However, there exist many extrinsic factors that can affect the degree to which these goals can be achieved. These factors can be determined from: longer-term traces of in-built sensor data that can be abstracted as triplines, socialized versions of these that are shared amongst vehicle users, and online databases. These three sources of information collectively constitute the automotive infoverse. This project harnesses this automotive infoverse to achieve these goals through high-confidence vehicle tuning and driver feedback decisions. It can have significant societal impact by reducing carbon emissions and improving vehicular safety, can spur innovation in tuning methods and encourage researchers to experiment with this class of cyber-physical systems.

Automotive Information Universe (Infoverse)

- Data from vehicle sensors are read and stored as *triplines.*
- Triplines are socialized – shared with own's social network or public.
- A collection of triplines create Infoverse that contain
  - The behavior of different drivers
  - The response of a given make or model to different driving habits under variety of weather and terrain conditions.



Main Goals

- Design software that permits the rapid development of apps using the infoverse.
- Processing the infoverse to explore how to derive important factors that affect PERCS goals.
- Exploring methods to generate feedback that characterize how these factors affect the specific PERCS goal.
- Develop methods for assuring the quality of data in the automotive infoverse

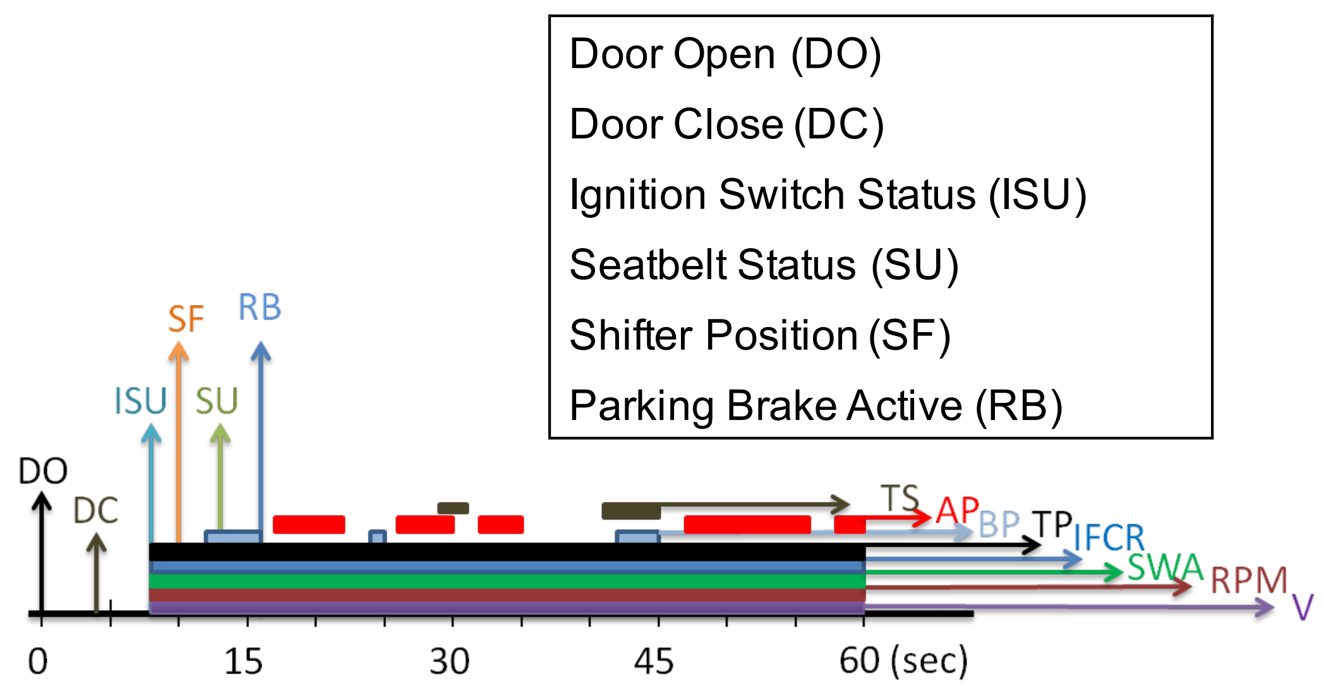
Privacy

- Sharing triplines and harnessing external information for vehicle tuning raises many security and privacy concerns.
- There is a tradeoff between privacy and data confidence.
- This project will consider anonymization and differential privacy techniques

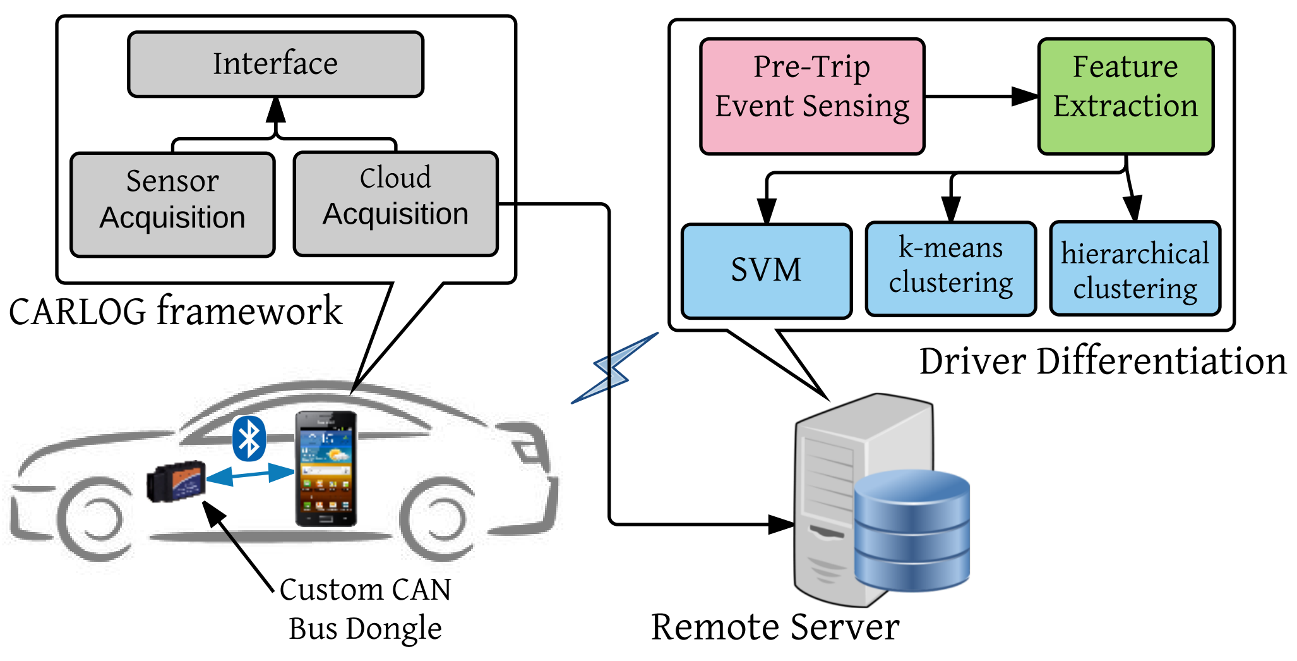
Driver Differentiation from In-Vehicle Data

Objectives

- Distinguish different drivers based on their behavior as observed through in-car sensors
- Identify a minimal set of in–vehicle data for driver distinction
- Understand the privacy implications of in-vehicle data

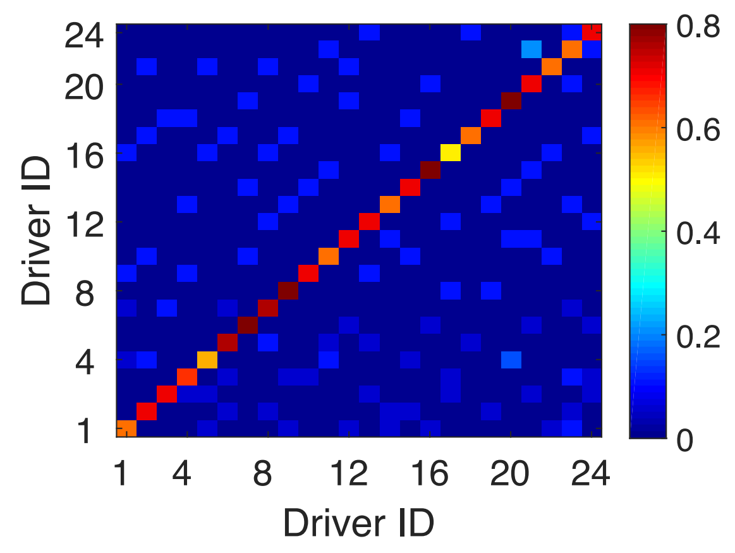

Door Open (DO)
Door Close (DC)
Ignition Switch Status (ISU)
Seatbelt Status (SU)
Shifter Position (SF)
Parking Brake Active (RB)

Design



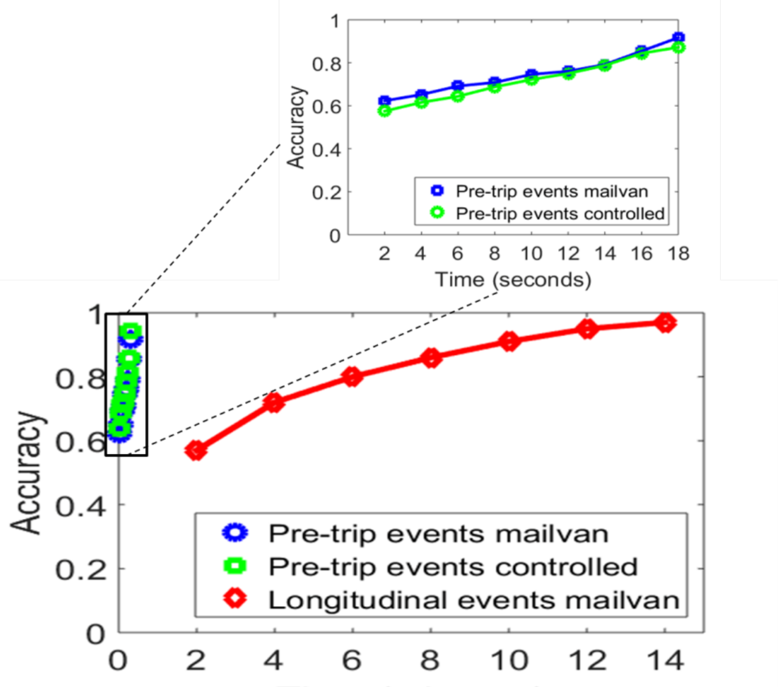
- CARLOG framework on the smartphone used to log data from the CAN bus
- A learning algorithm on the remote server extracts features
- The incoming sequence is matched to a driver in the database

Results



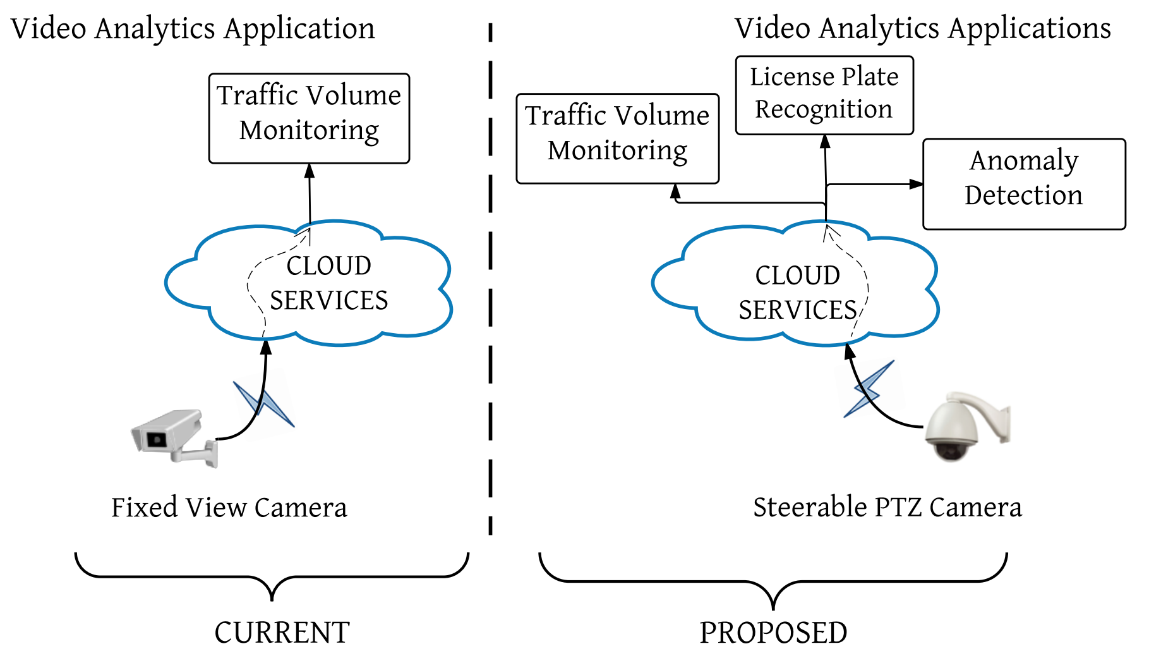
- Up to 16 drivers can be distinguished with 90% accuracy

- Driver differentiation accuracy 91% with 20s after entering the vehicle (in a dataset of 480 trips collected from 5 university mail vans).



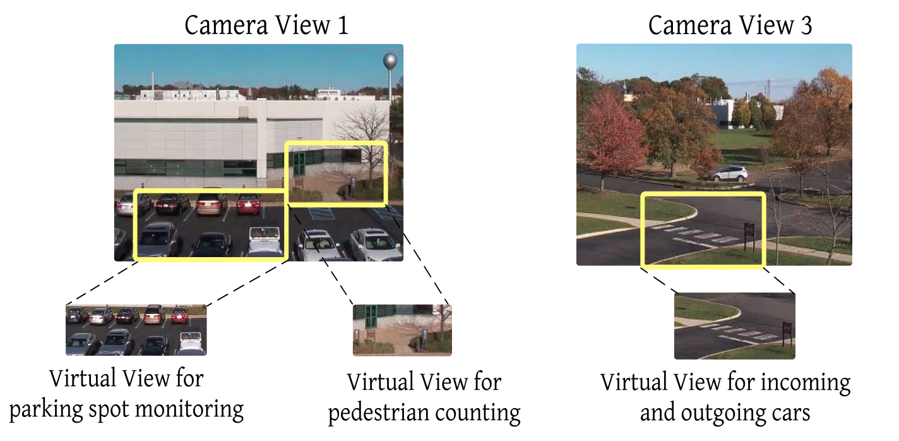
Application Support on Infrastructure Cameras

Objectives



- Support multiple vision-based applications on a single steerable camera
- Make steering changes transparent to applications through view virtualization
- Design a scheduling algorithm for application support

Design Principles

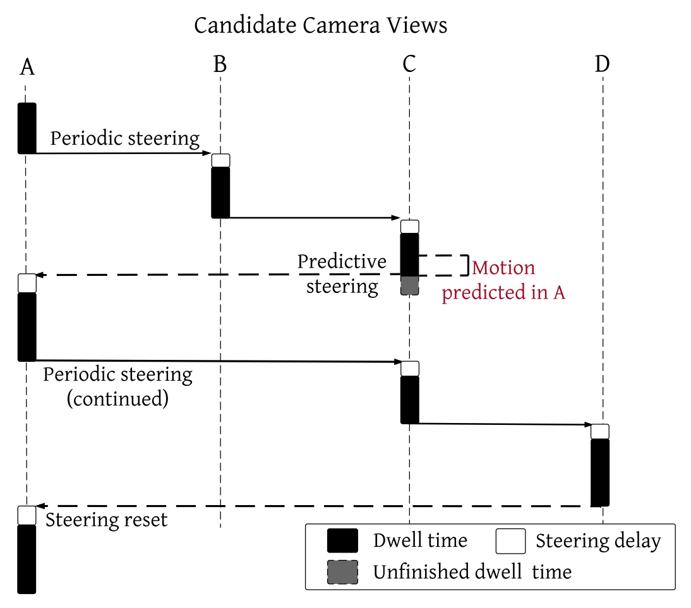


View virtualization

Provides application specific abstractions of the camera view

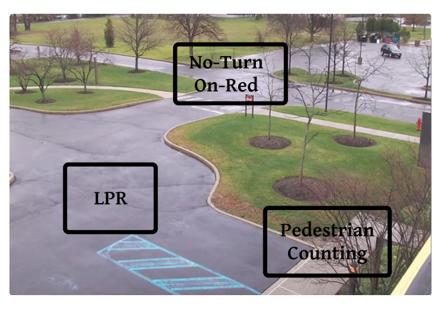
Mobility-aware scheduling

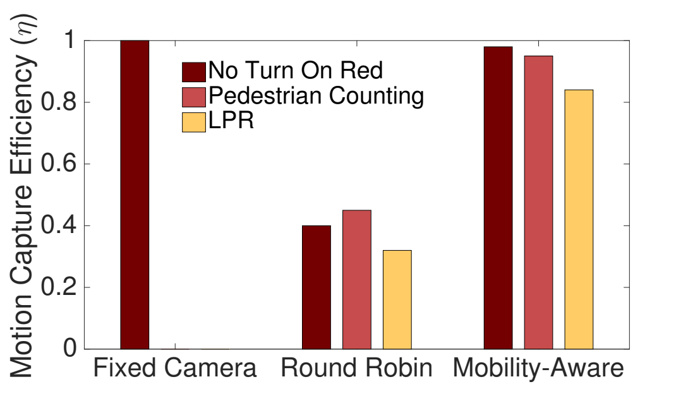
The system can accurately predict when a moving entity will enter a virtual view, and steer the camera just in time to capture this motion event.



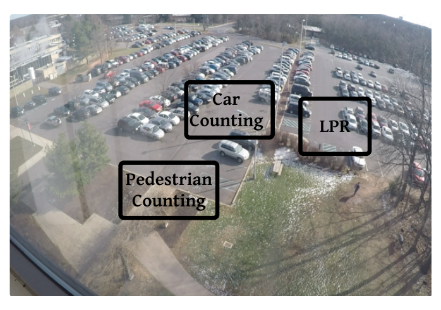
Results

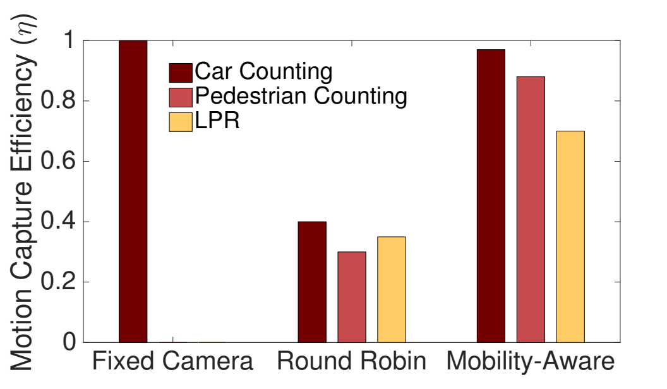
Sparse Traffic





Medium Traffic

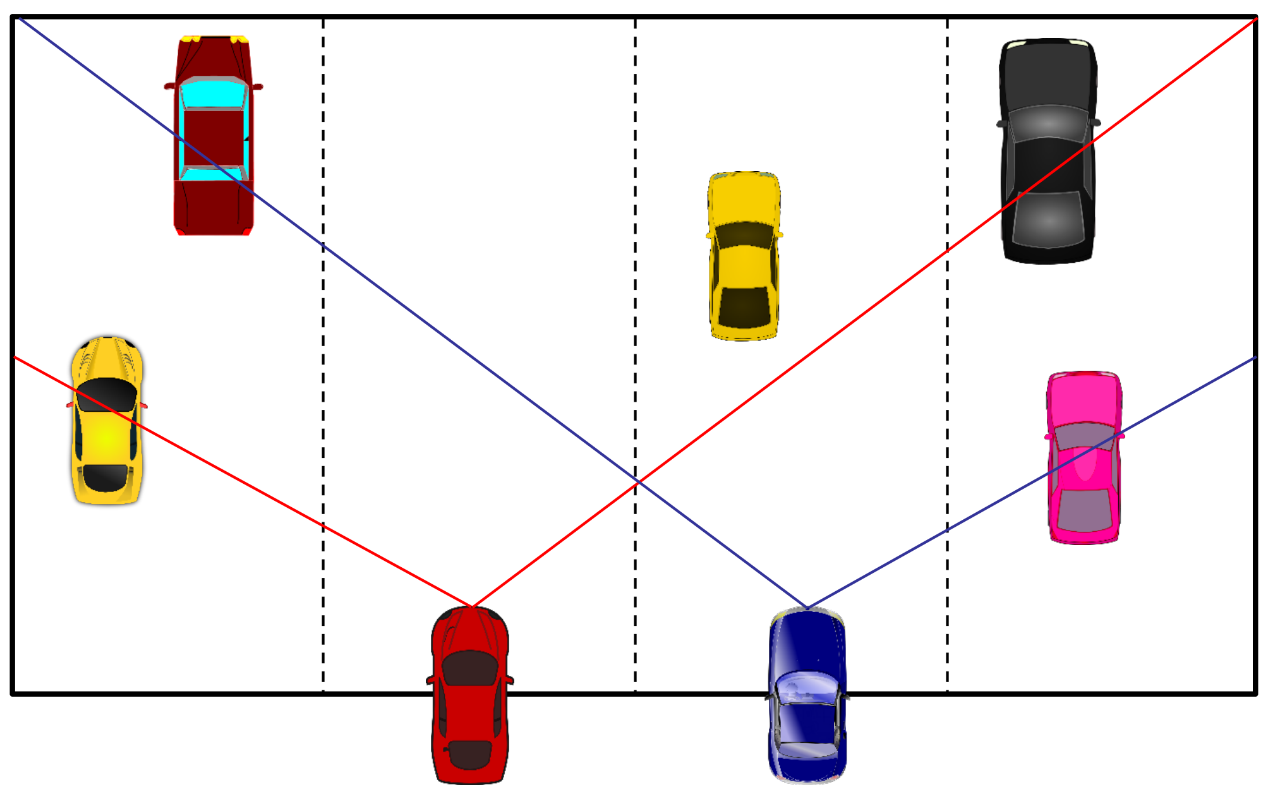




- The system can support multiple applications, capturing up to 80% more events of interest in a wide scene, compared to a fixed view camera.

Shared Traffic Perception Between Vehicles

Objectives



- Detect precepted vehicles and estimate distances for each camera equipped car.
- Combine the two individual views to create a shared 2D traffic perception topology.

Design

Experiment Settings:

- Two vehicles driving side by side
- Each vehicle is equipped with a mono camera on dash

Algorithm:

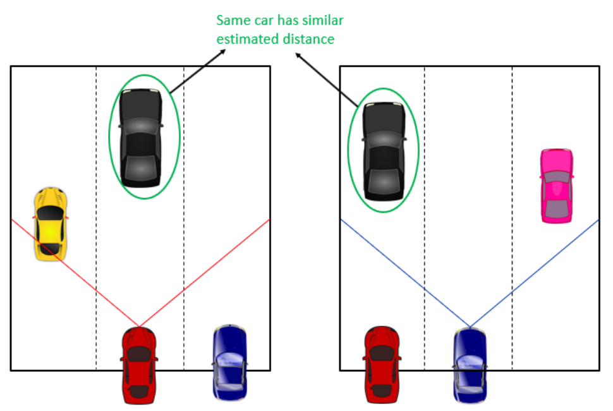
1. Hough Lane detection
2. YOLO Object Detection
3. Distance estimation for vehicles in the adjacent lanes
4. Coordination transformation
5. Clustering based on distance

$$\begin{bmatrix} x \\ y \\ w \end{bmatrix} = \begin{bmatrix} f_x & 0 & c_x \\ 0 & f_y & c_y \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \end{bmatrix}$$

Pixel coord. | Camera matrix | world coord.

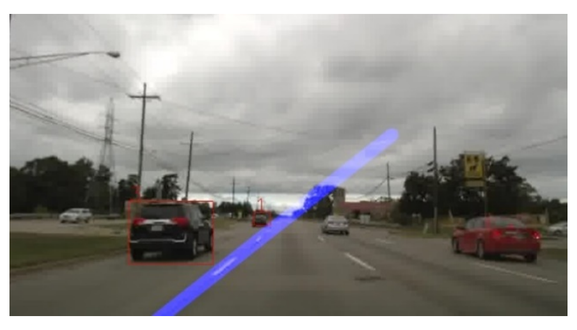
$$D = Z = f_x \cdot \frac{X}{|x_p - c_x|}$$

Distances of vehicles in the adjacent lane can be estimated when the lane width (X) is known.

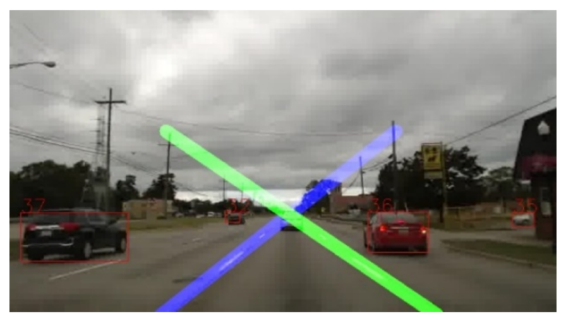


Results

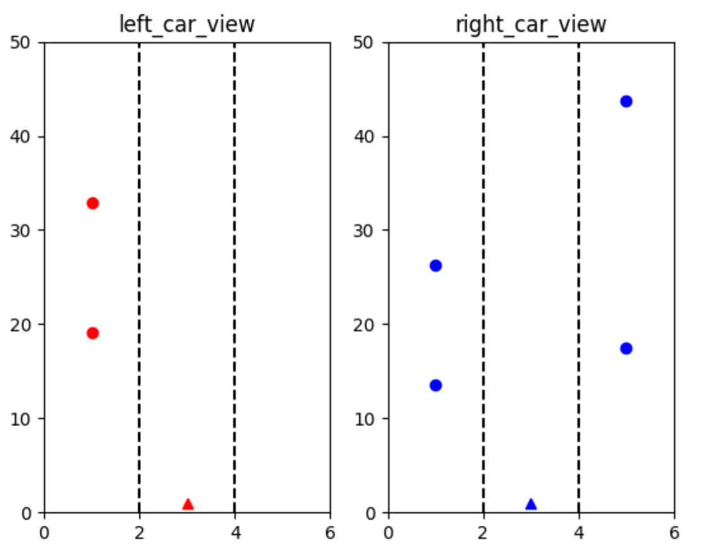
Left View



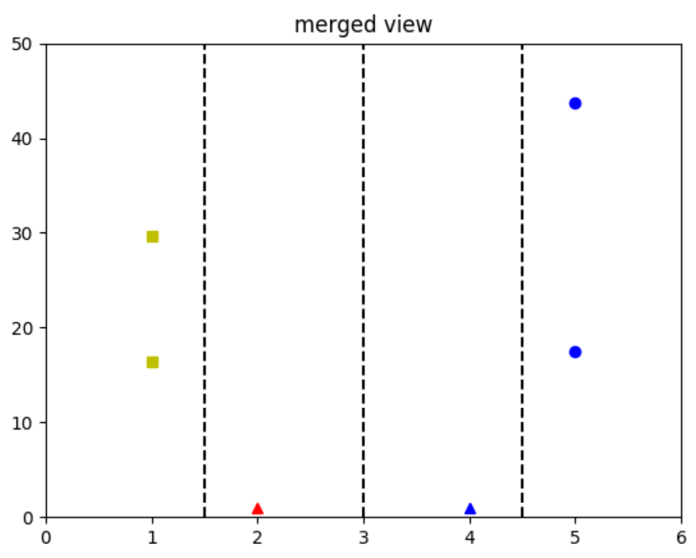
Right View



Individual Map



Merged Map



- The merging algorithm gives reasonable results when the lane and vehicles are well detected

Participants: Fan Bai, Jinzhu Chen, Ramesh Govindan, Donald Grimm, Marco Gruteser, Shubham Jain, Yurong Jiang, Gorkem Kar, Matthew McCartney, Hang Qiu