Video Based Machine Learning for Smart Traffic Analysis and Management

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Overview

This smart city project by University of Florida and the City of Gainesville is using *edge- based* video-stream processing (using multicore and GPU processors) to convert video data into space-time trajectories of individual vehicles/pedestrians that are transmitted to a cloud-based system. Key information is then synthesized at the cloud to create a real-time city-wide traffic palette. Real-time or offline processing both at the edge and the cloud is being leveraged to optimize intersection operations, manage network traffic, identify near-misses between various units of traffic, and a host of other traffic safety and optimization applications.

Community Problem

We broadly address the social dimensions consisting of community safety and mobility understanding and improvements at three levels: smart intersections, smart streets and smart system. The data collected from multiple sources afford real-time measurements and decisions which will then be used as part of an iterative approach to observe traffic and pedestrian mobility, allowing for the introduction of new design concepts (such as leading pedestrian intervals), new technologies (like reaction to autonomous and emergency vehicles) and impacts of environmental improvements at intersections.

We believe that our approach will have a tangible impact on the USDOT goal of the Vision Zero plan to minimize, and eventually eliminate motor vehicle related accidents.

Intellectual Merit

- Multi-target tracking: We have developed novel data association and track association for static cameras on intersections using novel machine learning algorithms.
- Integrated optimization and simulation for signal control: We are developing machine learning algorithms for modeling, simulating and optimizing traffic on a corridor. This includes cycle time, signal offset and barrier time optimization.
- Real-time Edge Processing: We have developed real-time GPU based algorithms for video and sensor data processing at edge servers. This architectural design is a good fit for video processing and reducing bandwidth requirements for communication with the cloud.
- Transportation Safety: We are developing proactive measures for assessing and enhancing transportation safety and mobility at intersections.

Activities and Outcomes

- We have developed a novel unsupervised method to detect near-misses in fisheye intersection video using an end-to-end deep learning model integrated with a combined camera calibration and spline-based mapping method. It maps road objects coordinates in fisheye images to a satellite based overhead map to correct fisheye lens distortion and camera perspective distortion. This allows for computing distance and speed more accurately.
- Our unified approach performs real-time object recognition, multiple object tracking, and near-miss detection in fisheye video. It is efficient and robust to handle geometry and uncertainty on object-level analysis in fisheye video, resulting in more accurate near-miss detection.
- The experimental results demonstrate the effectiveness of our approach and we show a promising pipeline broadly applicable to fisheye video understanding applications such as accident anticipation, anomaly detection, and trajectory prediction
- We have developed machine learning algorithms for detecting anomalous behavior e.g. cars crossing the intersection during a red light; or cars moving in the wrong direction.
- We have performed aggregation overs extended periods to visualize hour of the day and day of the week trends at an intersection
- We have developed tools to process, filter, analyze, display, and visualize trajectories of vehicles and pedestrians passing through a traffic intersection that can be used by transportation engineers. The visualization interface provides significant user interactivity with the underlying raw and processed data.
- We have developed novel machine learning methods to track vehicles across multiple intersections using image image signatures. This information is used for computing real-time travel time distributions on a corridor. Travel time distributions and other information will be used to develop signal retiming to minimize delays as well as improve pedestrian safety.
- We have published our work at major conferences and journals in Intelligent Transportation. We have also presented keynotes at several conferences on our work.

Broader Impact

- This study aims to improve the road safety for both motorists and pedestrians thereby directly impacting the Vision Zero goals of DOT. The reduction of traffic incidents will also lead to reductions in time wasted in traffic delays.
- Urban traffic control is one of the most important and challenging issues facing cities and requires practically effective and efficient solutions. The increasing volume of traffic in cities has a significant effect on road traffic congestion and consequently travel time of road users. We are addressing congestion that wastes time, hampers economic activities, harms the environment and deteriorates the quality of our lives.

Broader Impact (Sustainability)

- The algorithms and software are developed with input from Transportation Engineers at City of Gainesville and Seminole County to ensure it targets real end-user needs and has immediate as well as lasting impact.
- The software developed is currently being tested at five intersections in City of Gainesville for pedestrian and vehicle safety. We expect that City of Gainesville and other cities will adopt the software for future safety analysis and signal retiming.

Next Steps

- Develop machine learning based simulators that can encapsulate video data, ground sensor data and intersection geometry to predict traffic movement and near-misses at an intersection.
- Develop machine learning algorithms and software for signal retiming and optimization that incorporate data from video as well as ground sensors to automatically derive cycle times and split times
- Develop machine learning algorithms and software that use optical flow to improve pedestrian detection.
- Develop game-theory based algorithms for signal retiming that use machine learning models for deriving rewards for different options.