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Portable Multi-Sensor System for Intersection Safety Performance Assessment

tech transfer summary

Advances in deep learning offer the potential to use roadside cameras as a sensor system that could expand their capabilities to include traffic state estimation and automatic surveillance.

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RESEARCH PROJECT TITLE
Portable Multi-Sensor System for Intersection Safety Performance Assessment

SPONSORS
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The mission of the Center for Transportation Research and Education (CTRE) at Iowa State University is to develop and implement innovative methods, materials, and technologies for improving transportation efficiency, safety, reliability, and sustainability while improving the learning environment of students, faculty, and staff in transportation-related fields.

Objective

The main objective of this study was to investigate the use of roadside cameras as a sensor system for traffic state estimation and automatic surveillance.

Problem Statement

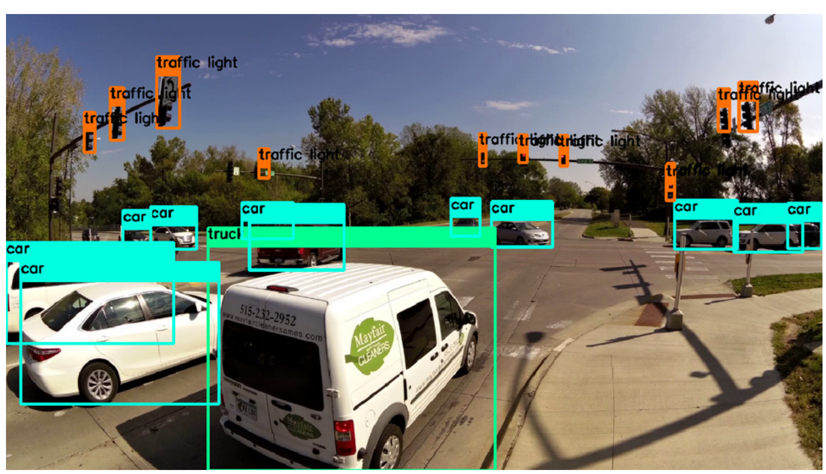
As the number of Internet-connected cameras continue to increase at a rapid pace, opportunities exist to use technological advances in deep learning computing processes to expand their monitoring capability beyond manual surveillance.

Research Methodology

The scope of the research project involved detecting vehicles, tracking them, and estimating their speeds.

The research team adopted a tracking-by-detection framework to perform object tracking and used the you only look once version 3 (YOLOv3) model for vehicle detection. The team used the simple online and realtime tracking (SORT) algorithm to track the objects that had been detected. Then, the team converted the displacement in pixels to actual displacement on the field by camera calibration and scaling.

The team collected video data at three locations in Ames, Iowa, and performed object detection and tracking tests on the resulting dataset.



Sample vehicle detection results obtained from videos recorded at 13th St. and Stange Rd. intersection in Ames, Iowa

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Sample vehicle detection results obtained from videos recorded at Stevens Creek and Winchester intersection in Santa Clara, California

They used a video dataset from four locations in Silicon Valley provided as part of the AI City Challenge 2018 to test the performance of the camera calibration and speed estimation methodology they had adopted.

Key Findings

- The YOLOv3 model successfully detected nearby objects but failed to detect some distant objects using the Iowa video dataset, but the Silicon Valley dataset showed that object detection works fairly well in test conditions. The model also performed at speeds that make it easy to implement online.
- The SORT tracking algorithm returned a high number of identity switches.
- The automatic vanishing point estimation as part of camera calibration yielded imperfect results, but manual calibration of vanishing points and scale factor determination can reduce errors in speed estimation. However, manual intervention would make it difficult to scale the algorithm across multiple cameras.

Recommendations for Future Research

- The detection task can be improved in the future by training the model on a larger dataset. Specifically, the University at Albany's detection and tracking (UA-DETRAC) dataset can be used in the future to improve detection results.
- Tracking performance result can be improved in the future by using Deep SORT or similar tracking algorithms that use appearance description for tracking purposes. This can help in reducing number of identity switches.
- Speed estimation can be improved in the future by extending automatic camera calibration to automatic scale estimation, which would also improve accuracy simultaneously.
- A detailed analysis in the future using speed data obtained from control vehicles in a test bed would help to determine the scope of improvement needed for the methodology adopted.

Implementation Readiness and Benefits

The results from this study demonstrated object detection, tracking, and camera calibration technologies can be fine-tuned to determine the speed of vehicles, and hence, the traffic volume within a camera field. The advances show great potential for using roadside cameras to make roadways safer and smarter in the future.