RESEARCH
PROJECT CAPSULE [24-4SS]

January 2024

TECHNOLOGY TRANSFER PROGRAM

Improved Signalized Intersection Performance using Computer Vision and Artificial Intelligence

JUST THE FACTS:

Start Date:
January 1, 2024

Duration:
24 months

End Date:
December 31, 2025

Funding:
TT-Fed/TT-Reg-5

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POINTS OF INTEREST:

Problem Addressed / Objective of Research / Methodology Used / Implementation Potential

PROBLEM

The efficient operation of signalized intersections is influenced by several factors. Some key factors that play a crucial role in signalized intersections include geometric characteristics and signalization systems [1]. The physical layout and design of an intersection, including lane widths, turning radii, and sight distances, can impact its efficiency. Well-designed geometric features can facilitate smooth traffic flow and minimize conflicts [2]. The design, timing, and coordination of traffic signals also play a crucial role in the efficient operation of signalized intersections. Factors such as signal phasing, cycle length, and detection can affect the overall performance. Evaluating the performance of signalized intersections is a crucial aspect of traffic management. A method used by the Louisiana Department of Transportation and Development (DOTD) for evaluating signalized intersections involves manual inspection of recorded videos. This process requires personnel to review the recorded videos to assess the performance and efficiency of signalized intersections. The evaluation typically focuses on factors such as traffic flow, congestion, and safety. It is important to note that evaluating the efficiency of current designs requires a more comprehensive and systematic approach. Therefore, automated traffic signal performance measures (ATSPMs), included in the Every Day Counts (EDC) 4 technology initiative, is defined as a suit of performance measures, data collection, and data analysis tools to support objectives and performance-based approaches to traffic signal operations, maintenance, management, and design to improve the safety, mobility, and efficiency of signalized intersections for all users [3]. EDC is an initiative of the Federal Highway Administration (FHWA) that aims to identify and deploy innovative technologies to reduce the time that it takes to deliver highway projects, enhance safety, and protect the environment [4]. This program identifies and deploys proven yet underutilized innovations that can save time, money, and resources that can be used to deliver more projects. Thus, this project is proposed to support performance-based approaches to traffic signal operations, maintenance, management, and design. It aims to provide tools for automating the evaluation of signalized intersection performance.

Figure 1. Vehicles at intersections and their trajectories [1]

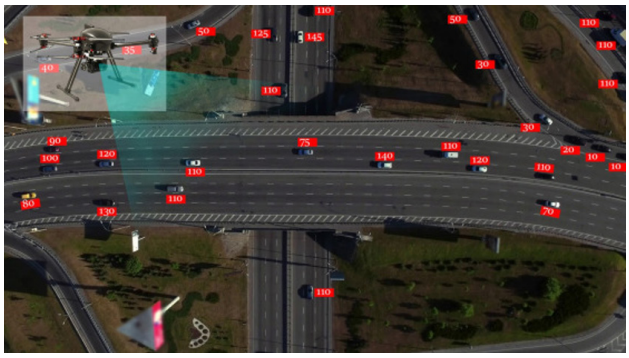

Figure 2. Traffic monitoring using drones [2]

OBJECTIVE

The primary objectives of this research are to:

- Assess the feasibility and accuracy of using computer vision technology for performance evaluation at signalized intersections.
- Provide intersection video footage data captured by drones.
- Use computer vision and artificial intelligence to automatically convert data from video recordings at selected intersections into trajectories of road users.
- Use computer vision and artificial intelligence to count road users, and detect queuing and demand for each approach at selected intersections using drone footage.
- Develop tools to facilitate DOTD traffic engineers in understanding road users' behaviors, evaluating intersection performance measures, and assisting in determining effective measures for improving safety and efficiency at intersections.

METHODOLOGY

To achieve the objectives of this research, the team will complete various tasks. The first task is a comprehensive literature review on vehicle and pedestrian detection, tracking, and counting to identify the most relevant and recent studies to the scope of the proposed research. The research team will then perform data collection that can be structured into datasets to be used to train models for object detection and more. Next, the team will conduct a feasibility assessment to evaluate the feasibility and accuracy of using computer vision technology for performance evaluation at signalized intersections.

The fourth task involves object detection, which plays an important role in signalized intersection applications. The team will focus on localization and classification for this task. This will be followed by trajectory extraction, a task that will involve the team developing computer vision and artificial intelligence algorithms to automatically convert data from video recordings into trajectories of road users.

A behavior analysis will then be conducted as the sixth task of this research. This analysis will seek to understand why road users exhibit certain behaviors at signalized intersections. Following this, task seven will involve intersection performance evaluation by developing an AI model that can detect queuing and demand at an intersection using drone footage. Lastly, a final report will be prepared detailing the team's research efforts.

IMPLEMENTATION POTENTIAL

Once the project is completed, the findings from this project can be implemented to benefit staff in the Louisiana Department of Transportation and Development (DOTD) and road users.
Here are some potential applications of the research findings:

- **Use developed algorithms to evaluate the performance of existing signalized intersections:** The findings can help identify areas for improvement, optimize signal timings, and enhance safety and efficiency at signalized intersections.
- **Improved traffic flow:** The data provided by the research team can be used for improving traffic flow and reduce congestion at signalized intersections by optimizing signal timings.
- **Enhanced safety:** By detecting pedestrians and adjusting signal timings to give them more time to cross the street, findings from this research could improve accessibility and reduce accidents.
- **Better policy decision:** By using the research findings to inform policy development within DOTD, this research can help shape policies related to signalized intersection design, traffic management, safety measures, and other relevant areas.
- **Improved infrastructure planning and design:** By incorporating the research findings into infrastructure planning and design processes, this research can help guide decision-making regarding signal timings, geometric design, traffic flow optimization, and other aspects of signalized intersection design.
- **More efficient data collection:** The use of drones to collect data is more efficient and accurate compared to other methods. The drones will be equipped with cameras and sensors to capture video footage and exact intersection data, such as vehicle counts, speed, and queue length. This data can be used to optimize signal timings and improve intersection performance.

The research findings from this project include the final report and data extraction tools. The tools will convert video footage into useful information, such as road user counts, trajectories, and traffic signal phase and timing. The research team will organize internal training sessions and workshops in the last three months of the project (PRC review period) to share the findings with DOTD staff. This will help raise awareness about the research outcomes and provide staff with insights into the potential benefits and applications of the developed algorithms. The research team will also provide hands-on training to help staff understand how to use the developed algorithms and tools. The time and location of these internal trainings will be determined with DOTD.

1. *Lee A. Rodegerdts, Signalized Intersections: Informational Guide, Federal Highway Administration, U.S. Department of Transportation, FHWA-HRT-04-091, 2004*
2. *Navid Ali Khan, N.Z. Jhanjhi, Sarfraz Nawaz Brohi, Raja Sher Afgun Usmani, Anand Nayyar, Smart traffic monitoring system using Unmanned Aerial Vehicles (UAVs), Computer Communications, Volume 157, Pages 434-443, 2020*
3. *FHWA, Automated Traffic Signal Performance Measures. Office of Operation, U.S. Department of Transportation. https://ops.fhwa.dot.gov/arterial_mgmt/performance_measures.htm, 2023*
4. *FHWA, Every Day Counts. U.S. Department of Transportation. https://highways.dot.gov/federal-lands/programs-tribal/partners-resources/2020*