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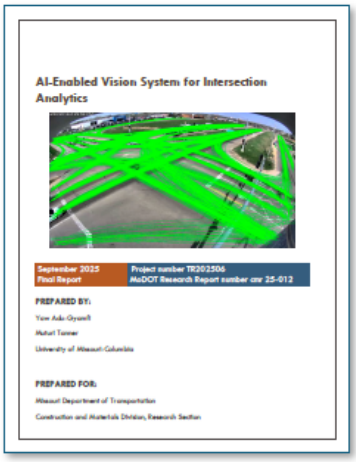
Research Summary

AI-Enabled Vision System for Intersection Analytics



As urban populations expand and vehicle usage rises, roadways experience increasing congestion, resulting in longer delays, higher fuel consumption, and elevated emissions. Traffic management systems, when properly implemented, allow transportation agencies to monitor roadway conditions and implement operational strategies to mitigate these impacts. Within these systems, vehicle counting plays a critical role.

Counting of vehicles at intersections is achieved through a Detection-Tracking-Counting (DTC) framework. Existing DTC systems rely on manually defined virtual zones to indicate movement; however, this is prone to error due to poorly placed detectors, camera shifts or change in field conditions. Furthermore, current approaches do not integrate vehicle count information with signal phase and timing (SPaT) data.

This project is designed to overcome the challenges faced by today's traffic management systems by:

1. Developing a fully automated vision system architecture to generate Turning Movement Counts (TMCs) eliminating the need for manual directional inputs.
2. Integrating TMCs with SPaT data to generate key intersection performance metrics including delayed movements, red-light violations, arrivals on red and green, low-volume movements, and the Purdue Phase Diagram.
3. Developing a platform that integrates and visualizes SPaT data alongside vehicle movement counts. The platform will enable the generation of intersection performance metrics and provide functionality for downloading a day's worth of SPaT data and corresponding video recording.

"This project delivers an automated, scalable system that combines video analytics and signal data for intersection traffic management."

Key outcomes of the project include:

1. Developed a fully automated framework for generating TMCs from MoDOT CCTV feeds, eliminating manual detection zones. Using YOLOv8, BoT-SORT, and a transformer-based trajectory classifier, the system achieved 96% classification accuracy across diverse movements and intersection types.
2. Integrated visual traffic data with SPaT to evaluate intersection performance and extract key operational metrics.
3. Revealed limitations in camera placement and coverage, where suboptimal angles and

restricted views reduced counting accuracy for certain movements.

The system should be scaled to a wider range of intersections, including rural, high-volume urban, and multimodal corridors. Additional sensors such as LiDAR, radar, and connected vehicle data will help overcome camera coverage gaps and improve accuracy under challenging conditions. The framework will also be extended to capture pedestrian, cyclist, and transit movements, enabling comprehensive multimodal performance monitoring.

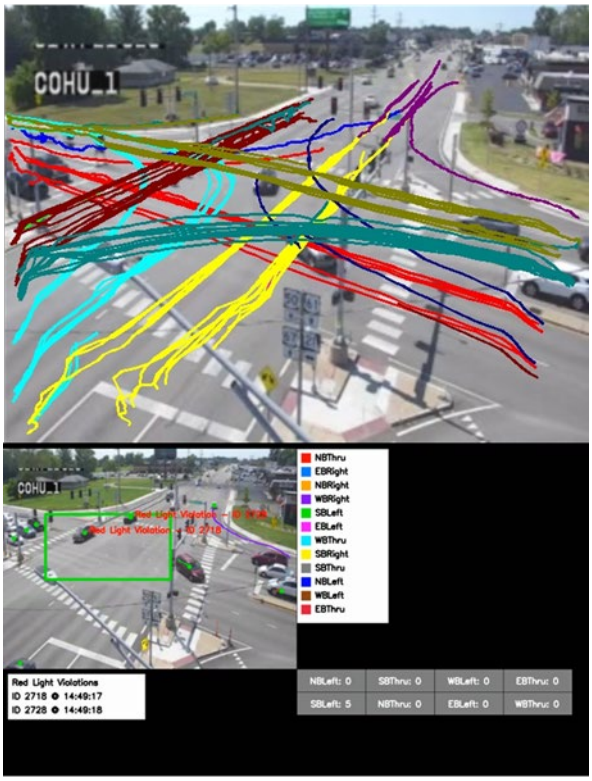


Figure 1: Snapshot of visualization when red light violations are flagged.

Project Information

PROJECT NAME: TR202506—AI-Enabled Vision System for Intersection Analytics

PROJECT START/END DATE: September 2024-September 2025

PROJECT COST: $88,865

LEAD CONTRACTOR: University of Missouri-Columbia

PRINCIPAL INVESTIGATOR: Yaw Adu-Gyamfi

REPORT NAME: AI-Enabled Vision System for Intersection Analytics

REPORT NUMBER: cmr 25-012

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Project Manager

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