Optimizing Signalized Intersections under Presence of Automated and Conventional Vehicles

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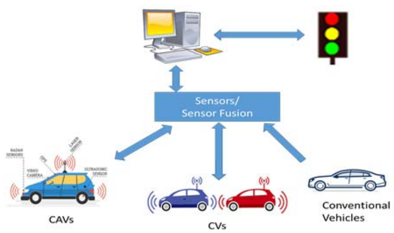
THE CHALLENGE

Traditional signal control allocates the green time at a signalized intersection based on the proportional demands of the competing approaching movements. Simpler, older systems use pre-timed control: signal timing intervals are pre-determined, and do not vary based on real-time demand.

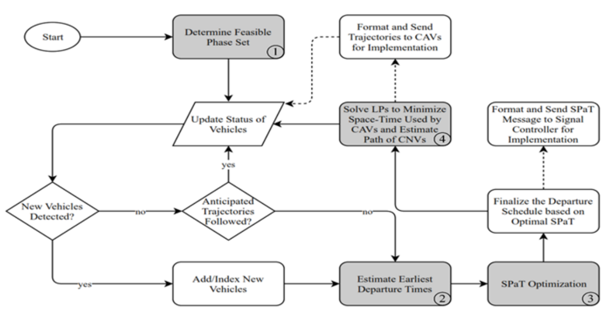
RESEARCH FRAMEWORK

The CAV CPS described here takes advantage of connected and autonomous vehicles' (CAV) ability to send information regarding their status and location, and to receive information regarding the network. A central controller receives all arrival information, and optimizes signal control jointly with vehicle trajectories. CAVs and connected vehicles (CV) are able to send and receive information, while conventional vehicles can be detected by sensors such as video or radar. All arrival information is received and synthesized using sensor fusion in order to obtain the most accurate information for each vehicle.



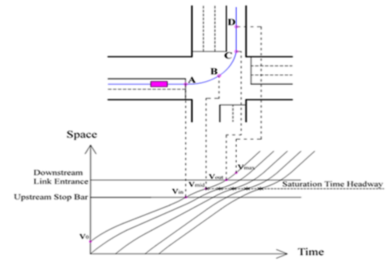
ALGORITHM

The algorithm is able to handle over-saturated traffic conditions by adding re-optimization steps to adjust vehicle trajectories and the signal control in order to account for changes in the anticipated vehicle movement. The algorithm is implemented in the Python 3.6 platform.



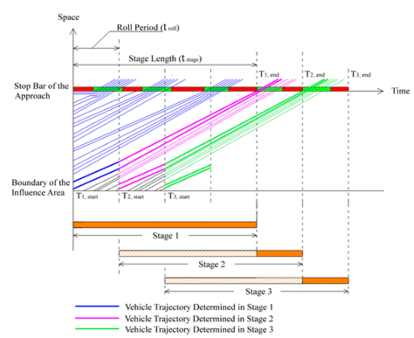
OPTIMAL TRAJECTORIES

Optimal trajectories are generated such that vehicle departures at the stop bar occur at the saturation flow rate (which corresponds to the minimum allow-able headway; its value is typically around 1.8 sec/vehicle). This parameter can be adjusted based on the vehicle characteristics and safety requirements. minimum headway and a predetermined maximum speed at the stop bar.



OPTIMIZATION PROCESS

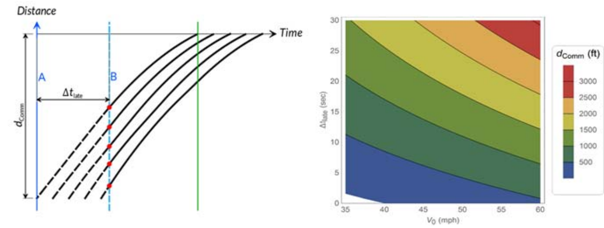
The optimization process and its frequency are important components of a CAV CPS, particularly during the deployment stage, as CAVs must be detected in real- time. In contrast to simulation, vehicles continue to move after being detected, while the algorithm must calculate and transmit optimal trajectories. During each time interval *Ti*, the algorithm considers the arrivals from each approach and estimates the optimal signal timings for a later time interval, considering the travel time required for vehicles to reach the stop bar.



Volume (*vphpl*)	CAV Percentage in Traffic 0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
250	248	249	248	248	248	248	248	248	247	248	248
450	447	447	447	447	444	444	444	445	446	445	446
650	566	569	573	577	581	586	593	600	608	617	626
850	568	572	576	580	584	589	594	603	613	622	635

FIELD DEPLOYMENT ISSUES

One of the key issues in the effective deployment of the CAV CPS described here is the communication range. The distance at which vehicles are detected must be long enough for the algorithm to be able to detect them and generate optimal trajectories. Given that the algorithm allocates green times to competing approaches, detection should occur over an interval (Δt) long enough to aggregate several arrivals from all approaches.



REAL-WORLD DEPLOYMENT

The results of this research will be implemented in the Spring 2020 at the intersection of Gale Lemerand and Stadium Road on the UF campus, as part of the Transition to Practice component. The research team has been coordinating the implementation of this work with the City of Gainesville and the UF Administration, and we have obtained the necessary permit from FDOT to test the algorithm. The permit application to use our software as a traffic control device for use in field testing has been approved by FDOT under Florida Statute 316.0745 (8).

NEXT STEPS

1. Continuous refinement of the algorithm for mixed traffic and preparation for field implementation
2. Installation of a multi-sensor suite at an intersection in Gainesville, FL to test the sensor fusion algorithms in the field
3. Continuous improvement of the simulation environment, and testing of the enhanced algorithm
4. Field deployment of the algorithm and sensor fusion jointly at the FDOT TERL and at an intersection in Gainesville, FL
5. Data collection and analysis

2019 NSF Cyber-Physical Systems Principal Investigators' Meeting
November 21-22, 2019 | Crystal City, Virginia

Award ID#:1446813