Skysong Innovations
Advancing the Arizona State University Knowledge Enterprise

1475 N. Scottsdale Road, Suite 200
Scottsdale, AZ 85287-3538
Phone: 480 884 1996 Fax: 480 884 1984

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Inventors

Mohammad Khayatian
Aviral Shrivastava
Mohammadreza Mehrabian

Contact

Shen Yan
shen.yan@skysonginnovations.com

RIM: Robust Intersection Management for Connected Autonomous Vehicles

Background

The advent of Connected Autonomous Vehicles (CAV) promises to reduce traffic fatalities and improve throughputs of transportation infrastructures. Management of CAVs in traffic intersections have gravitated toward centralized approaches—where at least one task is globally decided for all vehicles by a single central controller—since decentralized frameworks pose added security risks and require higher network bandwidths.

Velocity-Assignment Intersection Management (VA-IM) is a popular centralized approach for coordinating CAV traffic at intersections: Each vehicle transmits its current position and velocity to the intersection manager (IM), which then allows the IM to assign each vehicle a target velocity. Because system efficiency is governed by the quality of these velocity assignments, errors from mismatched vehicle models used by the IM in addition to external disturbances (e.g., wind, road slope, bumps) can result in suboptimal performance. Therefore, a more robust and adaptive methodology is needed to advance CAV technology.

Invention Description

Researchers at Arizona State University have developed a novel centralized platform that improves efficiency of CAV traffic at intersections. In this method, called Robust Intersection Management (RIM), each vehicle sends a request to the IM containing its current position, velocity, acceleration, and the corresponding timestamp. Then, instead of assigning a velocity, the IM calculates and transmits an assigned Time of Arrival (TOA) and Velocity of Arrival (VOA) for the vehicle. Based on the assigned TOA and VOA, the vehicle determines its own optimal position trajectory. Tracking a reference position trajectory affords the vehicle more freedom to dynamically optimize its movement, thus reducing system sensitivity to model mismatches and external disturbances. RIM experiments conducted on a 1/10-scale intersection of autonomous vehicles resulted in 2.7x the intersection throughput, and an 18x reduction of position error at expected TOA compared to competing techniques.

Potential Applications

- Autonomous vehicles

Benefits and Advantages

- Robust – Allows dynamic compensation of external disturbances, vehicle modeling errors, and unexpected network delays
- Efficient and Safe – Compared to existing methods, experiments demonstrate significantly increased intersection throughputs and significantly reduced position error at expected TOA
- Innovative – Replaces restrictive centralized CAV management with a flexible platform that allows independent optimization of vehicle movement

Relevant Publication (PDF): M. Khayatian, M. Mehrabian and A. Shrivastava, "RIM: Robust Intersection Management for Connected Autonomous Vehicles," 2018 IEEE Real-Time Systems Symposium (RTSS), Nashville, TN, 2018, pp. 35-44.

Laboratory Homepage of Professor Aviral Shrivastava