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How Cooperation Between Connected Automated Vehicles and Smart Infrastructure Can Improve Traffic Safety Situational Awareness

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Issue

Escalating trends in pedestrian and cyclist fatalities points to a pressing need to improve traffic safety, especially for vulnerable road users such as pedestrians, cyclists, and scooters. A key challenge in enhancing intersection safety is the lack of accurate, detailed, and real-time data that captures the complexities of these dynamic and uncertain environment. If intersections themselves could "see" the diverse array of vehicles, pedestrians, cyclists, and scooters, each with unique movement patterns and safety needs, this could vastly improve safety. Making intersections "smart" by equipping them with Light Detection and Ranging (LiDAR) technology that can capture a detailed and real-time 3D environment could facilitate the accurate detection of vehicles and other road users, to better control signal timing and assist future connected vehicles (CVs) and/or connected automated vehicles (CAVs) in driving safely.

A recent UCLA Mobility Lab project deployed one of the first smart intersections on a university campus to serve as a living laboratory for intelligent transportation system research, enabling the collection of sensor data from infrastructure-based LiDAR, cameras, and radar, as well as data from onboard CAV sensors. The UCLA Smart Intersection project will help researchers answer:

- How can deployment of smart intersections improve safety for all road users, and inform travel movements for CVs and CAVs?
- How can combining sensor data from different sources help to achieve infrastructure-enabled "cooperative perception"?
- How can building resilience into smart intersections help to protect against cyber-attacks?

Key Research Findings

Smart intersections can detect and classify different road users and share this information with nearby CVs and CAVs. This is achieved by gathering data from the smart intersections and then the data can be leveraged to train and validate state-of-the-art cooperative object detection algorithms, which can be used to identify different road users like a car, truck, bicycle, scooter, or a pedestrian. This data can then be used to develop deep learning algorithms to estimate travel movements for different road users and identify potential conflicts.

The UCLA Smart Intersection improved awareness of all road users by combining views from high-mounted sensors with on-the-ground vehicles, and synthesizing this information. The UCLA Mobility Lab successfully built a comprehensive cooperative perception software platform,

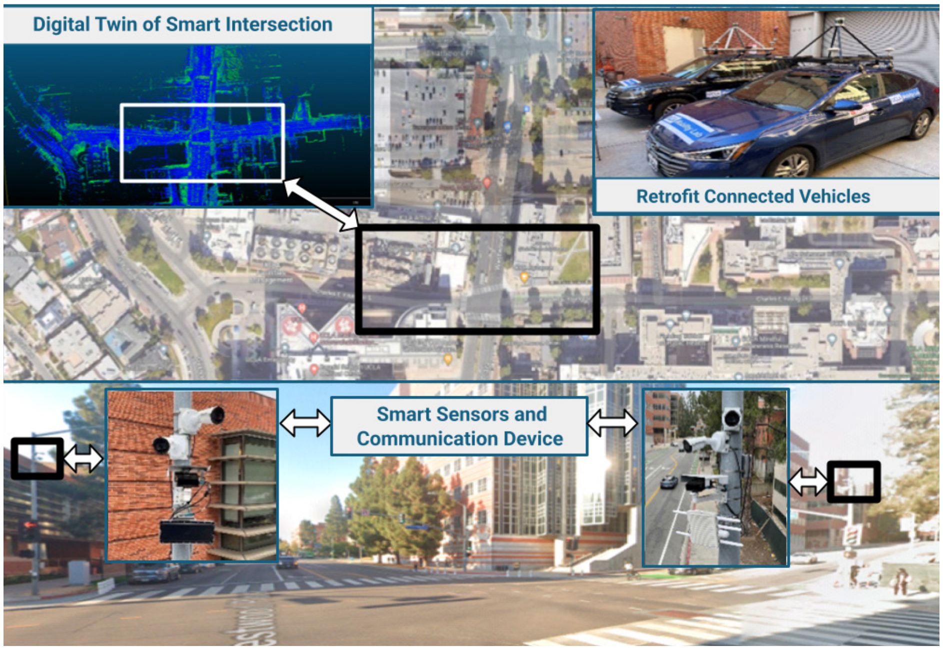

Figure 1. UCLA Smart Intersection. Multi-modal sensors equipped on both CAVs and smart infrastructure

capable of pinpointing road users. The platform used both off-the-shelf LiDAR-based object detection algorithms and a custom deep learning approach developed by the UCLA Mobility Lab. The efficacy of this cooperative perception system was demonstrated and validated in testing, proving that data from smart infrastructure can improve the performance of vehicle-mounted LiDAR, thereby boosting the safety of CAVs.

Building in system resilience from cyber-attacks is essential to improve the performance of cooperative perception platforms. The UC Irvine cybersecurity team and UCLA Mobility Lab stress-tested the resilience of the cooperative perception system against falsified data attacks, also called spoofing. Spoofing can include maliciously sending false or intentionally misleading information through the vehicle-to-everyone (V2X) communications channel that connects CAVs and smart roadside infrastructure. The joint research team designed and evaluated various attack scenarios, gaining valuable insights into the security risks posed by emerging V2X-based cooperative perception technologies. The attack models included metadata attacks, point removal attacks, and point manipulation attacks. They also explored the potential for object-hiding attacks under different attack models. These findings indicate that serious attention must be paid to potential cyber-attacks when designing cooperative perception algorithms or deploying cooperative perception techniques.

More Information

This policy brief is drawn from the report "Enhanced Perception with Cooperation Between Connected Automated Vehicles and Smart Infrastructure" available at www.ucits.org/research-project/rimi-5h. For more information about findings presented in this brief, please contact Jiaqi Ma at jiaqima@ucla.edu, Xin Xia at x35xia@g.ucla.edu, and Alfred Chen at alfchen@uci.edu.

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