On-board sensor technology (camera, radar, LiDAR) has several limitations as sole components of Advanced Driver Assistance Systems (ADAS): on-board sensor technology (camera, radar, LiDAR) has several limitations as sole components of Advanced Driver Assistance Systems (ADAS): •require nullifying the potential improvements in transportation efficiency (bicyclists) or save 1080 lives each year (emergency vehicles).\footnote{NHTSA (2014)}

Limited research into scenarios with non-communicating road users (pedestrians and bicyclists) or V2V equipped vehicles experiencing outage in exclusive V2V environments, drivers operate under a "paranoid strategy"—thus nullifying the potential improvements in transportation efficiency. Advanced applications like adaptive platooning and automated intersection control require highly accurate and reliable raw sensor data exchange. Failure in DSRC V2V alone can be catastrophic. High data exchange rates are not supported by DSRC.

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Motivation - Is V2V communication enough?

- NHTSA (2014)\footnote{NHTSA (2014)} estimates that basic V2V applications\footnote{Basic V2V applications include lane change warning, collision warning, and road departure warning.} can potentially reduce 600,000 crashes and save 1080 lives each year assuming 100% DSRC-enabled fleet.
- Limited research into scenarios with non-communicating road users (pedestrians and bicyclists) or V2V equipped vehicles experiencing outage in exclusive V2V environments, drivers operate under a "paranoid strategy"—thus nullifying the potential improvements in transportation efficiency. Advanced applications like adaptive platooning and automated intersection control require highly accurate and reliable raw sensor data exchange. Failure in DSRC V2V alone can be catastrophic. High data exchange rates are not supported by DSRC.

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Experience from Field Experiments

- Texas Highways & Harvard Pk. (Austin, TX): 11 types of maneuvers tested.
- DSRC V2G signal reception poor due to infrequent data exchange between vehicles.
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Redundancies in Cooperative Driving Ecosystem

- Real-time adaptive traffic management applications are limited by the data communication rates supported by DSRC.
- Towards an all-inclusive cooperative driving ecosystem.
- Bicyclists and pedestrians constitute one of the highest risk categories (6194 fatalities in 2015)\footnote{NHTSA (2015)}

- Solution - sensor (camera, radar) & mmWave technology-enabled infrastructure

mmWave V2I Challenge - Beam Training

- mmWave beam misalignments due to high mobility of vehicles
- Solution - Using sensors to narrow search space\footnote{Sensor fusion techniques can be used to narrow the search space for mmWave antennas.}

Ongoing and future efforts

- Incorporating road side DSRC and mmWave in equipment suite and collecting data at 8 intersections with different geometric characteristics and traffic characteristics.
- Analyzing accuracy and reliability of predictions using data fused from different sensing and communication equipment.
- Extending data collection and analysis to high speed passing maneuvers on rural roads, building on promising simulation results of Overtaking Assistant\footnote{Overtaking Assistant is an mmWave-based system designed to assist drivers in overtaking slow-moving vehicles.}, and areas with high density of pedestrians and bicyclists (university campus zone).
- Exploring the possibility to use LTE technology for system efficiency improvements, leveraging its high penetration rates and collecting data at 8 intersections with different geometric characteristics and traffic characteristics.
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