CENTER FOR TRANSPORTATION RESEARCH

PROJECT SUMMARY

Texas Department of Transportation

0-6877 (Phase 1): Communications and Radar-Supported Transportation Operations and Planning (CAR-STOP)

Background

A recent NHTSA report indicates that more than 80% of all annual car crashes could be prevented by vehicular communications. To that end, the focus of this project was to develop a framework (conceptualizations, processes, procedures, and algorithms) to harness and mature wireless technology to improve transportation safety, with an emphasis on collision warning/collision avoidance (CW/CA) systems.

What the Researchers Did

- Developed conceptual and functional frameworks for integrated CW/CA systems that incorporate information derived from both communication and radar platforms.
- Developed a new joint communication-radar paradigm for automotive applications using next-generation millimeter wave communication.
- Conducted preliminary tests with simulation data, and collected limited field data to develop a full Concept of Operations and requirements for full deployment.

What They Found

- Integrated CW/CA systems
  - Simulated driving scenarios were used to quantify the differences between radar and vehicle-to-vehicle (V2V) systems in terms of how many (and which kinds of) collisions can be avoided. As an example, for an automated warning before an unprotected right turn, our results indicate that radar and V2V wireless communication can detect and prevent 35% and 77% of crashes, respectively. A combination of the two achieves a crash reduction of 90%.
  - To effectively identify the presence of non-motorized road users such as bicyclists and pedestrians, deep learning for vision-based sensors was incorporated with a radar source for fast detection.
  - The software side of collision avoidance—predicting/interacting with other vehicles—was also studied; the research team demonstrated a distributed-intelligence-based system for CW/CA. This system showed that autonomous vehicles can learn to properly interact with human drivers—specifically, maneuvering an intersection (safely) without centralized control.

Research Performed by:
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Project Completed:
Phase 1 ended 8-31-2016

- Given the promise already shown, the ways in which software systems will adapt to new technologies should be investigated in further detail.

- Joint millimeter wave communication and radar systems
  - The research team showed that it is possible to combine both functions of communication and radar through a single waveform. The joint systems can achieve 0.1m range and 0.1m/s velocity estimation accuracies for radar in addition to achieving gigabits-per-second data rates for communication
  - This project established the main motivations for sharing raw sensor data among vehicles and infrastructure at gigabits per second: that transmission rate will further automated driving technologies, including advanced CW and more efficient coordination.
  - The researchers developed a joint radar and communication hardware prototype operating at the communication frequency already used by DSRC to demonstrate the feasibility of combining these two technologies.
  - Based on the proven feasibility of combining communication and radar for onboard use in vehicles, more effort is needed to quantify benefits at lower levels of automation, including CA, and to study the potential of moving the sensing from the vehicle to the infrastructure.

- The preliminary data collection reinforced the necessity of merging data from different sensors and using communication technologies to develop robust CW/CA systems.

- We have successfully shown, through concepts and simulations in the context of admittedly simple traffic scenarios, how V2V communications and radar systems can substantially reduce crashes. However, the algorithms and processes need to be fine-tuned and tested in a larger suite of scenarios, and the potential crash reduction benefits need to be quantified using more realistic field testing and data.

What This Means

- Our results in simulation settings appear to reinforce the notion that substantial traffic safety improvement is attainable though the use of automotive communication technologies, but also suggest this goal is likely achievable only through use of combination systems (e.g., of radar/camera sensing and V2V communications), an issue that has not received much attention. Our new frameworks for integrated CW/CA systems incorporating information from both radar and communication will help prevent collisions. Overall, CW/CA methods will be increasingly valuable as vehicles are further automated.

- Accidents involving non-motorized traffic participants (pedestrians and bicyclists) can be prevented by sharing raw sensor data (e.g., camera live images) among vehicles. Millimeter wave vehicular communication with high data rates will enable raw sensor data sharing. The developed joint millimeter communication and radar systems will seamlessly combine the communication and radar benefits to create a platform for sharing a multitude of sensor data.

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Keyword: Research