Staying in Lane

Intelligent Fusion of Vehicle Sensor Data

Exploratory Advanced Research . . . Next Generation Transportation Solutions

More than 25,000 people die each year in the United States in crashes caused by a vehicle drifting or veering out of its lane. Preventing such crashes through a more accurate and reliable lane-keeping system is the challenge taken up in "Intelligent Multi-Sensor Measurements to Enhance Vehicle Navigation and Safety Systems." This Exploratory Advanced Research (EAR) Program project, launched by the Federal Highway Administration (FHWA) in 2008, is being conducted by Auburn University.

Driver-Assisted and Automated Lane-Keeping

Lane-keeping systems have been available since about 2000 and are becoming increasingly common on new vehicles. Recognizing the potential of positioning technologies to prevent many thousands of highway deaths, FHWA continues to support efforts to improve the reliability and accuracy of these systems.

The innovative approach of this EAR project is to integrate data from a variety of onboard sensing equipment that is already in use or will soon be available:

- Lane detection cameras, which inform lane-departure warning and prevention systems.
- Micro-electro-mechanical systems inertial sensors, such as accelerometers, wheel speed sensors, and rate gyroscopes, which supply navigation information—referred to as inertial navigation systems and used for electronic stability control.
- High-accuracy nationwide differential GPS, under development for positioning accuracy down to 10 cm (3.9 in.).
- Advanced light detection and ranging (LiDAR) systems, used for adaptive cruise control and collision avoidance.

While each of these technologies can contribute data to lane-keeping systems, each also has performance limitations and can be rendered unreliable under certain driving conditions. Cameras in lane-departure warning systems, for example, are prone to error where lane markings are missing or difficult to detect—in poor lighting, rain, or snow. GPS is subject to blockage by other vehicles, city buildings, and heavy foliage, as well as to delays and errors caused by satellite positioning and ionospheric and tropospheric conditions. Low-cost inertial sensors used for stability control accumulate position errors over time. Because of their differing modalities, however, there is potential for these systems to complement each other. The goal of this EAR project is to fuse the data from a range of sensors to compensate for the deficiencies of each—creating an accurate, robust, and reliable system for navigation and control.

Integrating Systems Data

Earlier studies have demonstrated the feasibility of integrating GPS and inertial sensors and of using lane-departure data to correct GPS and map database errors. Going a step further, this EAR project is developing algorithms for integrating data from GPS, on-board cameras, LiDAR, and inertial sensors, with particular attention to fusing high-accuracy nationwide differential GPS measurements with those of low-cost accelerometers and gyros that support electronic stability control systems.

"Although other work has focused on fusing sensor data," says Dave Gibson of FHWA's Office of Operations Research and Development, "this study attempts to fuse a wider range of sensors to provide overall accuracy—creating a bridge between navigation systems and safety systems. As a bonus, the project will yield information that engineers can use to improve safety products."

U.S. Department of Transportation
Federal Highway Administration

Staying in Lane

Intelligent Fusion of Vehicle Sensor Data

Key Challenge

The researchers have found that combining the measurements provided by the different sensors poses a critical challenge: each sensor's specific, individual error source must be corrected before the different but complementary measurements can be combined. The data are being gathered on a vehicle outfitted with differential GPS, various inertial measurement units, camera, Doppler radar, and the Ibeo LiDAR, with all necessary hardware and software for on-board data collection. Ibeo Automobile Sensor, a German company focused on the use of laser technology in driver-assistance systems, is providing support for the project.

Future Efforts

Following successful demonstration of enhanced lane-positioning capability, the project will produce a test methodology for use by industry, as well as a plan for using the study methodology and results in applied research programs supported by FHWA and the National Highway Traffic Safety Administration. A final goal is to refine and optimize the data integration algorithms for various driving conditions. Project completion is anticipated in 2011.

Learn More

For more information on this EAR Program project, contact David Gibson, FHWA Office of Operations Research and Development, at 202-493-3271 (email: david.gibson@dot.gov).

EXPLORATORY ADVANCED **RESEARCH**

What Is the Exploratory Advanced Research Program?

FHWA's Exploratory Advanced Research (EAR) Program focuses on long-term, high-risk research with a high payoff potential. The program addresses underlying gaps faced by applied highway research programs, anticipates emerging issues with national implications, and reflects broad transportation industry goals and objectives.

To learn more about the EAR Program, visit the Exploratory Advanced Research Web site at www.fhwa.dot.gov/advancedresearch. The site features information on research solicitations, updates on ongoing research, links to published materials, summaries of past EAR Program events, and details on upcoming events. For additional information, contact David Kuehn at FHWA, 202-493-3414 (email: david.kuehn@fhwa.dot.gov), or Terry Halkyard at FHWA, 202-493-3467 (email: terry.halkyard@fhwa.dot.gov).

Publication No.
FHWA-HRT-10-064
HRTM-04/07-10(1M)E