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LRRB
LOCAL ROAD RESEARCH BOARD

TECHNICAL SUMMARY

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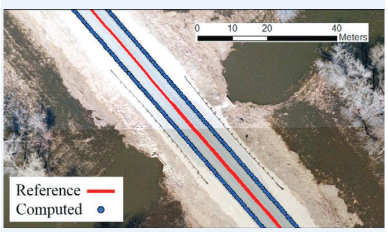
LRRB PROJECT COST:
$86,489



In many locations, fog lines were accurately computed to within 2 cm—so small that actual fog lines (marked in red) are not visible under computed lines (blue).

MINNESOTA DEPARTMENT OF TRANSPORTATION

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Mapping Roadways to Support Vehicle Safety Systems

What Was the Need?

In Minnesota, more than half of all fatal car crashes are caused by vehicles departing from their lanes, and many of these involve running off state and county rural roads.

While infrastructure-based safety countermeasures such as rumble strips are helpful, they have not significantly reduced run-off-road crashes as a fraction of roadway fatalities. Consequently, Minnesota is interested in improving safety with more advanced technologies such as lane departure warning systems, in which vehicles rely on global navigation satellite systems (GNSS). However, these systems require the creation of highly accurate maps of roadways and their boundaries so that they can reliably determine the precise location of the vehicle on the road.

By accurately mapping its roadways with low-cost systems such as the one tested in this project, MnDOT can support the implementation of lane departure warning and other in-vehicle safety systems, helping to reduce the frequency of the most serious accidents on rural roads.

Consequently, MnDOT is exploring the development of a low-cost, vehicle-mounted system capable of generating accurate maps with lane and roadway boundary information. Creating accurate statewide maps would not only assist in the implementation of lane departure warning systems, but also give rural counties better data for establishing speed limits based on the curvature of roads. Where the low volume of traffic does not justify the use of speed advisory signs on curves, this data could be used with smartphone apps that alert drivers when they ought to reduce speed because of an upcoming curve.

What Was Our Goal?

The goal of this project was to develop and test a low-cost, vehicle-mounted system for generating map data with lane and road boundary information accurate to within 10 cm (4 inches). This second phase of a two-phase project focused on evaluating how well the system could determine the location of fog lines—the white lines that mark the outer boundaries of roadways.

What Did We Do?

In a previous phase of this project, researchers developed a $40,000 system consisting of a low-cost LIDAR scanner, mounting hardware, computer and GNSS receiver capable of receiving real-time corrections from MnDOT systems. First phase results showed that the system could detect and locate curbs and guardrails with an accuracy of better than 10 cm. It could also determine road centerlines to within 6 cm without the use of LIDAR, relying only on GNSS-provided vehicle path information.

This second phase of the project expanded on these results by augmenting the system with a video camera for automated fog line detection and location. This camera is mounted so that it views an area of the ground adjacent to the passenger side of the vehicle. The video data collected by this camera is stored for later processing, during which fog lines are extracted by applying a computer algorithm that locates the fog line within the video frame under a variety of lighting conditions and calculates its distance from the vehicle. The line's distance from the vehicle is in turn used to determine the fog line's coordinates by using the vehicle's position as measured by the GNSS receiver.

continued

"Most fatal crashes occur on lightly traveled rural roads. The high-accuracy maps generated by systems like the one evaluated in this project can help make these roads safer."

—Max Donath,
Director, University of Minnesota Intelligent Transportation Systems Institute

"Beyond its utility for driver warning systems, high-accuracy map data will be useful to MnDOT and Minnesota local agencies for a variety of other reasons, including inventory tracking and pavement monitoring."

—Rick West,
County Engineer, Otter Tail County

The system tested in this project is installed with the camera facing downward so that its field of view contains the pavement adjacent to the vehicle to about 3 m away from the side of the vehicle.

Researchers tested this system on undivided highways with two lanes, a common configuration for rural roads where lane departure crashes are common. To evaluate the system's accuracy, they evaluated the difference between the known position of the fog line and the position as determined by the system.

What Did We Learn?

Researchers found that the camera and data collection system evaluated in this project were capable of detecting and locating fog lines on roadways in Minnesota. With the algorithms developed for this system and without manual intervention, it detected fog lines in the two test areas and accurately located them within 10 cm.

This system can perform its function at a price point that is cost-effective for wide-scale deployment and data collection. Researchers found LIDAR was unnecessary for determining fog line positions, reducing the cost of the system to $30,000. For agencies seeking to better characterize and digitize their roadway systems, this system is a modular solution for efficient and cost-effective data collection.

What's Next?

Since most in-vehicle lane departure warning systems are vision-based and require high-quality pavement markings, an added benefit of the system tested in this project is its ability to evaluate the quality of fog lines so that agencies can maintain them more effectively. If other roadway data is of interest, the system can be enhanced by adding cameras to acquire information about other roadway line types such as centerline striping. Adding a forward-facing camera would allow the system to detect road signs and roadside obstacles such as mailboxes and light poles.

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This Technical Summary pertains to LRRB-produced Report 2015-11, "Development of a Sensor Platform for Roadway Mapping: Part B—Mapping the Road Fog Lines," published April 2015. The full report can be accessed at mndot.gov/research/TS/2015/201511.pdf.