GPS-Based System Warns Drivers About Lane Departures, Approaching Curves

What Was the Need?
Lane departures and run-off-road crashes cause more fatalities and serious injuries in Minnesota than any other accident type. To achieve MnDOT’s Toward Zero Deaths goal, lane departure warning technologies must be developed and made available to all drivers.

Many current warning technologies rely on cameras that identify lane position based on pavement markings. In inclement weather, stripes and pavement markings can be difficult or impossible to identify; markings also wear off over time, reducing visibility even in clear conditions. Camera-based lane departure warning systems are also expensive and generally restricted to newer luxury vehicles, making them inaccessible to the general driving public.

Though in-vehicle technology for the public usually falls outside the research interests of the Local Road Research Board (LRRB) and MnDOT, the agencies have been funding development of lane departure warning technologies to improve driver safety. GPS technologies offer an intriguing path to consumer-level lane departure warning systems.

High-level GPS can be accurate to the centimeter level, but access is restricted and use is expensive. These systems also rely on accurate, lane-level roadway mapping, an elusive data set with high access costs.

What Was Our Goal?
LRRB and MnDOT sought research to develop a camera-free curve and lane departure warning system that uses consumer-level GPS capability without reliance on sophisticated, expensive digital maps.

What Did We Do?
Researchers began with a literature search of the uses of standard GPS receivers in lane departure and navigation. The research team then developed an algorithm for travel direction that uses standard GPS in a straight road lane departure system to determine driving trajectories at accuracy levels suited to safe driving needs.

Investigators adapted a publicly available digital mapping platform to the same algorithm to identify navigational points along curves and develop the curve lane departure warning system. The team enhanced standard safe distance methods to consider driver reaction time in determining when approach warnings should be issued.

Researchers then brought the two developmental stages of the system together with a warning system that identifies vehicle speed, curvature characteristics and safe speed limits, and calculates distance for driver response times to issue an audible warning to drivers on lane drift and a text warning of when and how much to reduce speed as the vehicle approaches a curve.

For project testing and demonstration, investigators programmed the algorithm into a device with a built-in GPS receiver, connected it to a laptop for messaging and conducted driving tests on Rice Lake Road and on Interstate 35 near Duluth.

An inventive approach used consumer-level GPS data to deliver a high-accuracy lane departure and curve warning system. With further development, the system can save lives by warning drivers about lane drift and approaching curves, preventing lane and road departure accidents.
What Did We Learn?

Finding no research on development of consumer-grade GPS for lane departure purposes, the research team adapted previous work on the relative accuracy of GPS readings from a MnDOT study on wearable GPS for work zone safety. Researchers adapted a consumer-level GPS device to acquire data at 10-hertz frequency, which yields a GPS position point of 2.7 meters if a vehicle is driven at 60 mph. The system calculates lane trajectory from cumulative readings and detects turns or drift. The curve warning system plots trajectories and compares these with open-source digital maps with road-level (rather than lane-level) accuracy to anticipate curves.

In road testing, the system issued audio warnings for every one of the approximately 200 lane changes, including curves. For curve warnings, the system scanned for curves at least half a mile ahead and calculated the vehicle’s speed and the distance to a curve to issue a timely text warning of the curve ahead and an advisory speed limit. Additional messages were issued when the vehicle was on the curve and when the curve had ended.

False alarms—warnings issued when the vehicle was not departing its lane—occurred in 10 percent of the tests, usually on sharp curves. Further adjustment of the algorithm and additional testing reduced false alarms significantly as the system accumulated data over multiple uses of the same roadway.

What’s Next?

Investigators filed a patent for the technology and will continue to develop the system. Further refinement of reference road direction information will improve accuracy and safety; the research team has developed a new project to employ vehicle-to-vehicle dedicated short-range communication technology to expand road direction reference data. The system will then need to be adapted for a consumer-level device or a smartphone app for use in any vehicle.