Warning system aims to save lives in highway work zones

For highway workers, work zones can be dangerous or even deadly. Each year more than 20,000 workers are injured and more than 100 lose their lives in U.S. highway work zones; most of those injuries and almost all of those fatalities are caused by either construction vehicles or passing traffic.

"The main solution for making work zones safer has always been reducing the speed limit," says Imran Hayee, a professor of electrical engineering at the University of Minnesota Duluth. But while strict enforcement of lower speed limits is necessary to make road construction sites as safe as possible, Hayee says, "Lower speed limits alone cannot guarantee workers' safety because there are serious safety risks from sources other than passing vehicles." In an RSI-funded project, Hayee is investigating another way to help reduce the number of injuries and fatalities in work zones: by alerting the operators of heavy construction vehicles, as well as drivers in cars passing by work zones, that construction workers are present.
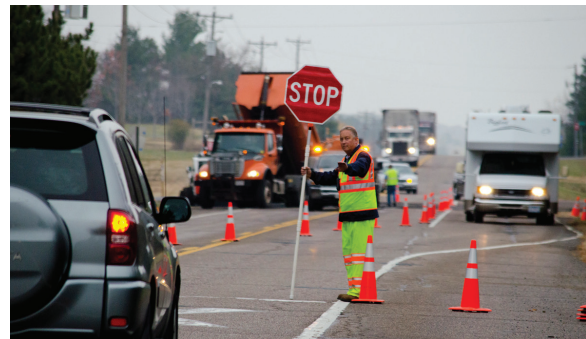
To accomplish this, Hayee and his research team designed and developed a system to improve worker safety by providing visual guidance to construction vehicle operators about a workers' presence in the vicinity. The system can also improve work-zone traffic mobility by dynamically posting suitable speed limits and other warning messages on variable message signs based on whether workers are present in a work zone.

The new warning system operates using dedicated short-range communication (DSRC) technology and consists of three main components: DSRC-based wearable safety devices, a construction vehicle with an onboard DSRC device and monitor, and DSRC-equipped variable message signs. Workers wear a miniature DSRC-equipped device embedded in their safety vests, which constantly broadcasts each worker's GPS location to the DSRC device installed on a nearby construction vehicle. The construction vehicle's DSRC unit is connected to a monitor that shows the vehicle operator the workers' real-time positions and warns them if a worker is dangerously close. Finally, DSRC-equipped variable message signs placed near the work zone

In this field test, a construction vehicle operator is looking at the tablet screen, which shows a worker's location (green dot) with respect to the location of the construction vehicle (blue dot).

automatically detect workers' presence and dynamically change the work-zone speed limit when workers are nearby.

"When lower speed limits are permanently in place regardless of workers' presence, traffic mobility decreases, causing congestion at work-zone sites and increasing the potential for rear-end crashes," Hayee says. "Our system provides an automated way to post the appropriate speed limits in work zones, which improves traffic mobility without compromising worker safety."

After developing the prototype system, researchers conducted field tests to demonstrate its functionality and evaluate its performance. Test results show the system works: it's able to display the workers' positions on a tablet with acceptable distance and directional accuracy for successful visual guidance. Future plans for the warning system's development include adding audio warnings, creating a prototype wearable safety device that includes "caution" and "panic" buttons and can be embedded into a worker's vest, and conducting real-world tests in an active work zone.

Creating rural road safety strategies that go beyond crash history

The transportation safety community has largely embraced a data-driven approach to highway safety, but this approach traditionally relies on "worst first" analysis based on crash history data. Unfortunately, the

traditional approach of using crash history alone does not always provide results, because serious crashes on the rural system are infrequent and appear to occur at random locations as a result of their low density. Now, however, transportation engineers are beginning to turn to a new "systemic" safety approach to reduce serious injury and fatal crashes on rural highway systems.

In a September 8 Roadway Safety Institute seminar, St. Louis County (Minnesota) traffic engineer Vic Lund described how Minnesota transportation engineers have recently begun applying this new systemic safety approach to rural highway safety on county and state highways.

Photo: Shutterstock

"What we are doing with a systemic safety approach is similar to what doctors have been doing for a long time," Lund said. "They ask about your health history, diet, and behaviors to assess your risk for developing certain diseases, then help you find a way to proactively address those risks so you don't have to deal with more serious issues later in life."

The systemic safety approach considers the metric of risk versus the traditional metric of crash history. Determining the risk of a highway facility requires considering characteristics such as geometry, traffic volume, and presence of key features such as railroad crossings. Then, network screening allows for the identification of high-risk locations.

"For example, we know that one of the most likely places for a serious injury or fatal crash to occur on a rural road is a four-legged, two-way-stop intersection, and that some additional risk factors for these intersections include skew, curve, distance to previous stop signs, and nearby railroad crossings," Lund noted. "We can then rank all of our two-way-stop intersections based on risk and deploy proven, low-cost safety measures for every at-risk location within our system."

According to Lund, a systemic approach offers a number of important advantages. First, it identifies a "problem" based on a system-wide analysis of data and then looks for the roadway characteristics that are frequently present in serious crashes, which become the risk factors. Next, it focuses on one or more proven, low-cost countermeasures that can be deployed across the entire system. Finally, it identifies and prioritizes locations across the network for implementation.

"The traditional approach says that 'crashes equal risk' and 'no crashes equal no risk,' while the systemic approach recognizes this is not the case," Lund said. "When we use a systemic approach to focus safety strategies at high-risk locations—which are the minority of the system—we can start having an impact on the majority of crashes and make real progress towards our goal of toward zero deaths on Minnesota roadways."

New model targets train derailments

Though many train derailments are minor, others can have serious consequences that include extensive property damage, injuries or deaths, and environmental disasters. In an age when many hazardous materials are transported by rail, the danger of train derailments is especially acute.

"Track geometry defects such as uneven tracks are one of the two primary causes of freight train derailments on main tracks, so they have a critical role in railroad safety," said Hadi Meidani, an assistant professor in the Department of Civil and Environmental Engineering at the University of Illinois at Urbana-Champaign, during a recent Roadway Safety Institute seminar.

Because track geometry defects have been identified as a major cause of train derailments, the Federal Railroad Administration has set track safety standards requiring defects to be corrected or protected within a prescribed time limit. However, predicting when track defects are at risk of exceeding safety limits is a major challenge; although a large volume of track measurement data is currently being collected, track deterioration is a complex process.

In his presentation, Meidani outlined research focused on developing new models that account for the complex nature of track geometry deterioration. The new predictive model for track geometry defects will make reliable predictions on when a defect will exceed safety parameters. In addition to improving safety, this model could enable more efficient planning of track maintenance.

"Our idea was to see if we could use current information to predict when track defects would move beyond the cautionary 'yellow' level into the more severe 'red' level defect using a survival analysis probability model," Meidani said. "Essentially, this type of model calculates the probability of failure across time, telling us how much time we have before a defect enters 'red' levels and fails, and how long it could survive before failing."

To develop their model, researchers took data provided by rail companies, cleaned it, and determined which factors impact track geometry defects. In this case, they found only railroad class and defect amplitude had statistical significance, so those were the variables they included in their simplified model. Next, they tested their model to determine its accuracy and found that it could correctly predict failure more than 70 percent of the time.

"Our model had a higher percentage of correct predictions than the segment-based method currently being used by rail companies, as well as a lower percentage of wrong survival predictions, which is critical for safety," Meidani said.

Researchers are now working to optimize the model's resolution, determine whether there is an ideal track inspection policy that minimizes costs while improving safety, and quantify the relationship between better prediction models and improved safety.

RSI researchers receive NSF grant

Mechanical engineering professor Rajesh Rajamani and RSI director Max Donath, both with the University

The collision-warning system uses laser sensors mounted on the bike for rear collision avoidance.

of Minnesota, have been awarded a nearly $1 million grant from the National Science Foundation. This "Partnerships for Innovation: Building Innovation Capacity" grant awards funding to academe-industry partnerships whose proposals move research toward implementation of a human-centered smart service system. In this new project, Rajamani and Donath will partner with Quality Bicycle Products (QBP) to explore implementation and possible commercialization of the bicycle collision-warning system developed by Rajamani in his Institute-funded research.

The project, titled Smart Human-Centered Collision Warning System: Sensors, Intelligent Algorithms and Human-Computer Interfaces for Safe and Minimally Intrusive Car-Bicycle Interactions, aims to reduce the estimated 48,000 injuries and 700 fatalities that occurred last year in the U.S. as a result of bicycle-vehicle collisions. The system will help motorists keep a safe distance when passing bicyclists and alert only those drivers who are most likely to collide with a bicycle—while minimizing false alarms and unnecessary distractions to motorists. Bicyclists will get guidance cues from the system to ensure a safe and respectful response to vehicles. Human factors concepts will be used to design an alert system that gives motorists specific and effective audio-visual cues—and to help ensure cyclists don't respond to the improved security by riding more recklessly.

"Bicyclists face far greater consequences in a crash than a motorist," Rajamani says. "So it's in the best interest of the bicyclist to be proactive in preventing a collision."

Nichole Morris, principal researcher with the HumanFIRST Lab at the U of MN, will lead work on the human factors components of the research, which includes improving the warning system. Additionally, Loren Terveen, professor in the U of MN's Department of Computer Science and Engineering, will serve as a co-investigator.

Institute celebrates grand opening of museum exhibit

Join us Friday, December 9, 2016, as we celebrate the grand opening of the Roadway Safety Institute's safety-themed museum exhibit at The Works Museum in Bloomington, Minnesota.

The exhibit, a permanent installation at the museum, uses a variety of hands-on activities to teach preteens about reflectivity and safety. It features videos, interpretive signage, engineer and researcher profiles, a microscope area for examining reflective materials up close, and a dark room where kids can try out reflective clothing and see how visible they are in simulated headlights.

The grand opening, scheduled from 11:00 a.m. to 12:30 p.m., will include a light lunch, a short program, and tours of the exhibit.

In other education-related news, RSI staff presented a lesson on pedestrian safety at the Minneapolis Safety Camp on August 1. The program, offered by the Minneapolis Parks and Recreation Board, aims to teach children entering second through fifth grade about personal and social safety skills. During the RSI lesson, 200 kids participated in interactive activities emphasizing the importance of reflective apparel and nighttime visibility.

Researcher demos methods for safer crossings

This past August, RSI researcher Ron Van Houten, professor of psychology–human factors at Western Michigan University, took his research findings to the street—literally—by leading several pedestrian safety workshops and presentations in Minneapolis. On August 29, Van Houten accompanied approximately 15 City of St. Paul (Minnesota) staff on a bus

PWX conference attendees discussed an R1-6 sign gateway.

tour of some key pedestrian conflict sites in the city and provided insight about how to best address these sites. RSI director Max Donath and Minnesota Traffic Observatory director John Hourdos also attended. On August 30, Van Houten gave a follow-up presentation to 31 St. Paul city staff and citizen representatives and two Minnesota Department of Transportation staff, sharing research findings about effective and low-cost ways to improve pedestrian safety at street crossings.

On August 31, Van Houten presented a pedestrian safety workshop and walking tour for 15 attendees at the American Public Works Association (PWX) annual conference, held in Minneapolis. After giving a presentation about research-based pedestrian safety improvements, he led a walking tour to a nearby intersection, where, with assistance from the City of Minneapolis, he set up a demonstration of an R1-6 sign gateway. Participants observed driver behavior and pedestrian crossings before and after the temporary gateway installation. Prior research has shown that a gateway configuration of R1-6 in-street signs placed on each side of a road, on lane lines, and on the centerline produces a marked increase in the percentage of motorists yielding right-of-way to pedestrians on uncontrolled crosswalks on multilane roads.

Ron Van Houten crossed a street using the gateway installation.