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Driver-assist systems support snowplow operations

Snowplow operators have many tasks to do simultaneously while removing snow and spreading deicers. They often do this challenging work in low-visibility conditions, for long hours at a time. In an extensive line of studies, U of M researchers have developed technologies to help snowplow operators perform their jobs more safely and effectively.

The most recent research, a multiyear project funded by the Minnesota Department of Transportation (MnDOT), studied driver-assist systems for three applications: gang plowing, backup

Research provides guidance for improving youth transportation

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Currently, there is no measurement method that can be uniformly applied to allow a direct comparison between bridge and road conditions. In a new study, U of M researchers have developed a proposed Percent Remaining Service Interval (PRSI) measure that can uniformly assess the condition of bridges and pavements, enabling planners to make the most efficient use of preservation and improvement funding.

“The concept of a uniform rating system is simple, but getting to the payoff is challenging,” says Glenn Engstrom, director of the Minnesota Department of Transportation (MnDOT) Office of Materials and Road Research. “There are good systems for both pavements and bridges, but they are hard to compare.”

These inconsistencies between MnDOT’s bridge and pavement groups impede strategic funding decisions that might otherwise optimize the long-term good of the entire highway and bridge system. “Both the MnDOT Bridge Office and the Materials and Road Research Office have very good management systems in place,” says Mihai Marasteanu, a professor in the Department of Civil, Environmental, and Geo-Engineering (CEGE) and the study’s principal investigator. “There is a good potential to develop a new common metric that both offices could use.”

To begin developing this new measure, researchers conducted a literature review of current methods used in asset management and life-cycle cost analysis. The review of bridge research focused on performance measures and life expectancy assessment methods, while the study of pavement literature concentrated on performance measures as well as on the use of road service life measures.

Next, the research team, which included CEGE bridge professor Arturo Schultz, surveyed both bridge management staff and pavement management staff from state transportation agencies. Team members then analyzed the asset management practices of MnDOT’s Office of Bridges and Structures and Office of Materials and Road Research to identify methods for assessing service lives and rehabilitation needs and to highlight the similarities and differences in approaches.

Based on the findings from the survey and analysis, researchers suggested the new method of PRSI that would serve both pavement and bridge needs and offered guidelines for the next steps in developing and implementing a unified PRSI procedure.

“Ultimately, funds for guardrail repairs are drawn from the same purse that pays to fill a pothole or repair a deck joint,” Marasteanu says. “With PRSI, planners could target average values across systems to optimize life-cycle costs and pursue an even distribution of PRSI values to make planning consistent from year to year.”

In the next phase of the project, researchers will work with the pavement office to identify relevant data for calculating PRSI for pavements. “In addition, we plan to identify the time and costs required to reach the evenly distributed configuration of PRSIs necessary for planning consistency, assess how preservation activities impact funding efficiency, and calculate recommended metrics for asset sustainability,” Marasteanu says.
Students explore career possibilities in internship programs

This summer, university students put their skills to work on real-world transportation projects in internships at the Minnesota Department of Transportation (MnDOT) and Ramsey County.

Thirteen civil engineering undergrads participated in the eighth year of the Civil Engineering Internship Program, a partnership between CTS and MnDOT that gives students hands-on, professional experience to help them prepare for careers in transportation. Interns spent 10 weeks in a variety of MnDOT offices, where they worked on projects related to design, land management, bridges, water resources, traffic, construction, and more.

Many of the interns say that participating in field work, collaborating with transportation practitioners, and developing new skills were their favorite aspects of the program. Project highlights included helping with prescribed burns in wetland mitigation sites, conducting underwater 3D sonar scans of bridge piers and abutments, performing bridge inspections, and developing a document on temporary barrier guidance in work zones.

U of M student Inara Smith, who worked in MnDOT’s Environmental Stewardship Office, says she enjoyed seeing how MnDOT works to protect wetlands and wildlife. “It was definitely a great opportunity to learn how building roads and fixing bridges should be done without causing harm to our habitat—something that I am personally passionate about,” Smith says. “I’ll definitely apply the experience and knowledge that I gained during my internship in my future work.”

“I enjoyed seeing different kinds of bridges and comparing them, especially looking at modern versus older bridges and seeing how they have improved,” says Madeline Riddle, a U of M student who interned with the Metro Bridge Maintenance and Inspection Office. “This experience will help me relate what I’m learning in the classroom to what I’ve seen in the field.”

Building on the longstanding success of this program, CTS also launched a new summer internship with Ramsey County this year. The new program, focused on the county’s All-Abilities Transportation Network initiative, gave students the opportunity to work with several county departments, including public works, public health, and parks and recreation.

According to Josh Olson, redevelopment manager with Ramsey County, one of the program’s goals was for the interns to help facilitate collaboration across these departments. By creating a structured program that appealed to students in several disciplines, the county also hoped to encourage interest in Ramsey County as a future employer. “When they’re done with their college careers, students have a choice to make, and we’d love for Ramsey County to be top-of-mind,” Olson says.

Four undergrad and graduate students participated in the program’s inaugural year. Throughout the summer, they performed site assessments, updated websites and interactive maps to reflect the status of road projects, reviewed regional solicitation applications, mapped pedestrian ramps to assist with ADA compliance, mapped school walk zones, and participated in public meetings.

“I gained knowledge outside of the classroom that I’d never have the chance to learn inside the classroom,” says Ben Murphy, a U of M urban studies student who worked with the county’s public works and community and economic development departments. Murphy also says the internship experience confirmed his plans to pursue a master’s degree in urban and regional planning. “Now I know what I’m working toward is what I want to do.”

“I really believe that this program has been a win-win-win,” Olson says. “It’s been a great opportunity for the students to get some good exposure to how city and county government work, and also beneficial for the county at large. [It has also been] worthwhile for myself and the other supervisors who have been alongside the interns…The students come with a lot of energy and a lot of new ideas.”
Transportation researchers connected with attendees and collected data for their studies at the 2018 Minnesota State Fair.

Kathy Quick, associate professor in the Humphrey School of Public Affairs, asked fairgoers what they think about Minnesota’s transportation infrastructure as part of her study titled “Potholes and Politics! How to Patch Them Up?” Quick and her collaborator Guillermo Narváez were aided by seven graduate students and five volunteers from MnDOT. “We asked participants to take three to five minutes to share their opinions about what to do,” Quick says. “Raise the gas tax? Build more roads and/or more transit? Do nothing?”

Quick’s booth had more than 750 participants in just four half-day sessions. “The unique opportunity of the fair allowed us to gather high-quality data to inform policy decisions on an important issue,” Quick says. “Working side-by-side with MnDOT staff, we were able to scope a research project with high public value.”

Quick also notes that the graduate students, from four different degree programs, volunteered so they could interact with the public around these issues and get coaching and experience with social science research design and protocols. CTS sponsored the exhibit space.

In another study, a team led by Nichole Morris, director of the U’s HumanFIRST Lab, asked participants a series of questions about their sleep patterns and driving behaviors. Next, the researchers asked the participants—184 of them during four half-days—to look into a device with two lights that flickered at different speeds. “Similar to a hearing test, the volunteers responded when they saw the flickering light and again when it appeared steady state,” Morris says.

Preliminary analyses show that CFF scores had a statistically significant relationship to the frequency of how often people report having sleep problems during the week, how many hours of sleep they reported, and their age, she says.

Like Quick, Morris says the fair provided a “tremendous opportunity” to recruit and collect data from a very large sample in a short time. It also provided easy access to people from areas across the state in a wide range of ages, including an older population of research subjects (ages ranged from 18 to 80, with an average age of 41). “I am so grateful for the people who incorporated supporting University of Minnesota research while they were at the fair,” she says.

Catalyst will share results of the studies in future issues.
long as these young adults can get to work on time every day,” says Lawrence Eisenstadt, youth program coordinator with the Minnesota Department of Employment and Economic Development (DEED). “However, without appropriate transportation, these youth cannot guarantee meeting this important requirement. DEED asked MCOTA to systematically study this issue and provide policy recommendations.”

Frank Douma, director of the State and Local Policy Program at the Humphrey School of Public Affairs, and graduate student Charles Noble conducted the study. They began by surveying youth in various employment and training programs throughout Minnesota to collect data on employment status, age, gender, race, disability status, and type of transportation issues. Location and travel mode information was also collected. For age, respondents were asked which range they were in: 14–15, 16–17, 17–20, or 21–24.

The researchers found that transportation issues affect a large portion of the 181 respondents, but with variation among subgroups. “Urban youth generally were less likely to report transportation issues compared to their rural and suburban peers,” Douma says. “Even if youth in rural and suburban areas had cars and jobs, they still were likely to encounter transportation issues.”

In urban areas, walking and public transit are important for both employed and unemployed youth. Just under 48 percent of employed urban respondents and 75 percent of unemployed urban respondents used these modes of transportation. “Even though they still face challenges, urban youth have learned to use transit as an option that is not available to their suburban and rural counterparts,” Douma says.

The group with the most transportation issues were unemployed youth with disabilities, particularly in rural areas. “The combination of having a disability in a rural area significantly increases their likelihood of transportation issues, moving from 57.14 percent to 72.73 percent,” he says.

The final report offers recommendations for policymakers to address the issues identified in the analysis (see sidebar). Relevant case studies from around the country are included as working examples of the recommendations.

“DEED will use the findings to inform those who deliver its youth programs about the possibilities of coordinating communal transportation resources, ultimately allowing young adults to participate more fully in the labor market,” Eisenstadt says.

Don’t forget to register!

CTS Transportation Research Conference
November 1
Graduate Minneapolis Hotel, Minneapolis, MN

Join us for a day of discovery and innovation on the U of M campus! Full program information is available at cts.umn.edu/events/conference/2018.
Driver-assist systems

Driver-assist systems assist, and lane-boundary guidance. In gang-plowing operations (also called tandem plowing), one plow must follow another at a specified position offset. Led by Professor Max Donath, mechanical engineering (ME) researchers evaluated the performance and accuracy of onboard units commercially available in 2015–16 that enabled vehicle-to-vehicle (V2V) communication. “We found that using only V2V communication didn’t give the plow operators sufficiently accurate information to maintain spacing between two vehicles,” Donath says. “This will likely change in the future as higher-accuracy GPS modules become available.”

As the team was completing these tests, Donath learned from MnDOT’s Metro District maintenance staff that they were interested in a driver-assist system that would inform plow operators of the edge line of a road boundary, particularly when visibility is limited. In an additional request, the maintenance staff wanted the plow operator to be able to detect a vehicle behind the truck during backup. “As a result, the scope of our study was modified to address these needs,” he says.

The research team, which included co-investigators Chen-Fu Liao and Nichole Morris, developed a new lane-guidance system based on a high-accuracy differential Global Navigation Satellite System. It was installed on a snowplow operating on MN-25 running between Belle Plaine and Green Isle, a flat area that has the worst winter visibility in the Twin Cities metro.

The system is a less complex and more affordable version of the one developed in previous work and deployed in Minnesota and Alaska. “This new system omits the custom-made head-up display, which was a costly component,” says Liao, ME senior research associate. “The cost per plow of the old system was about $60,000, but the new system totals just over $15,000. We believe that the lower cost could lead to wide-scale deployment.”

Tony Johnson of the MnDOT Shakopee Truck Station adds that plow drivers really like the new system. “We’ve actually asked for more [systems] for other trucks,” he says.

To provide backup assistance, the research team developed a rear-facing radar-based system and deployed it on a snowplow that operates on Highway 169 in the southwest metro. When an object is detected, the system provides an audio warning to the operator to look at the display from a rear-view camera. “The plow operators say the system supports their work in crossovers, the areas where they cross divided highways,” Liao reports. “Crossover operations often require backing up, which can cause safety concerns.”

Morris, director of the U’s HumanFIRST Lab, led studies of human factors issues to better understand operator needs prior to designing the systems. “For example, we learned that drivers didn’t want an additional graphic display for lane guidance, so our team made a very simple adjustable LED display to show relative position in the lane,” she says.

Video shows how driver-assist systems help keep plows on the road

In a new video from CTS, snowplow operators share their firsthand experiences with driver-assist systems developed by the University of Minnesota. The systems are helping snowplow drivers stay on the road in low-visibility conditions—such as a storm in 2016 that left motorists stranded in southwest Minnesota. The video is one in a series by CTS that illustrates how transportation research is making a real-world impact.
Driver-assist systems: A long history in Minnesota

The U’s development of driver-assist technology began decades ago, spearheaded by Professor Max Donath of the Department of Mechanical Engineering (ME).

The technology is one of the first augmented-reality systems ever deployed. “The U is a leader in this technology, and we’re well-positioned to create the knowledge and data needed for vehicle automation on a larger scale,” Donath says.

The work began as an offshoot of pavement design research at the MnROAD research facility near Monticello. “MnROAD has a low-volume test track just off I-94,” Donath says. “In the mid-1990s a truck circled it constantly to study load impacts. MnDOT was concerned the driver would tire and leave the track, so they came to us for ideas. We developed a driver-assist system and installed it on the truck. It became our first GPS-guided test vehicle, in 1997. We demonstrated the technology to a national audience the next year.”

Following this deployment, Donath proposed using the technology on snowplows—triggering a succession of projects that continues to this day. Over the years, researchers developed high-accuracy GPS, digital mapping systems, vehicle-mounted sensors, and feedback systems for the driver. Numerous vehicles using the systems have been deployed in Minnesota and Alaska.

In addition to plows, the technology has been tested in other specialty vehicles such as patrol cars. It has also been used to support the operation of bus rapid transit routes on bus-only road shoulders or in dedicated bus lanes throughout the Twin Cities.

The technology was developed and refined under multiple research projects funded by MnDOT and the USDOT’s University Transportation Center program, along with other sponsors and partners. Many ME researchers and students contributed, Donath says, giving particular credit to Chen-Fu Liao, Nichole Morris, Ted Morris, Craig Shankwitz, Lee Alexander, Pi-Ming Cheng, Brian Davis, Vassilios Morellas, Alec Gorjestani, Heon-Min Lim, Sameer Pardhy, and Bryan Newstrom.

The SAFETRUCK circled the MnROAD low-volume loop in the late 1990s.

Freight and Logistics Symposium explores cybersecurity on Dec. 7

The annual Freight and Logistics Symposium will be held Friday, December 7, at the Delta Hotels Minneapolis Northeast in Minneapolis.

This annual symposium is designed to bring together members of the private sector and government to discuss current issues in the freight and logistics industry and to share public and private initiatives intended to strengthen the freight transportation system.

This year, the symposium will explore topics related to cybersecurity. Complete program information and registration will be available soon at cts.umn.edu/events/freight.

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