Research on connected and automated vehicle (CAV) technology is an emerging field with a variety of applications. Researchers from the University of Minnesota are combining CAVs with another emerging technology—variable speed limits (VSLs)—to improve driving safety and efficiency at intersections.

In a project sponsored by the Roadway Safety Institute, the researchers aimed to model how CAVs behave at intersections if they are told to obey VSLs—which can be changed from minute to minute.

Technology developed by U researchers helps truck drivers in Kansas and Wisconsin find safe parking

Video detection technology developed by U of M researchers is being used in two states as part of the country’s first multi-state truck parking information management system.

Eight states—Kansas, Wisconsin, Minnesota, Indiana, Iowa, Kentucky, Michigan, and Ohio—are participating in the federally funded Truck Parking Information Management System (TPIMS). The technology developed by U researchers helps truck drivers in Kansas and Wisconsin find safe parking.

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Improving intersection safety through variable speed limits

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Speed continued on page 7
CTS has a new home: 2221 University Avenue S.E., Suite 440.

The move was prompted by a request from University administration. The U’s Department of Public Safety, which is housed on the first floor of the Transportation and Safety Building, will now expand into the second floor vacated by CTS.

“This is our third home on campus over our 30+ years in existence,” says Laurie McGinnis, CTS director. “The new office brings all of our staff together into a more welcoming and collaborative environment. Upgrades to technology provide more opportunities to engage partners and stakeholders remotely.”

The new space is across the street from the Green Line Stadium Village stop and just east of TCF Bank Stadium. “It was important to us that we remain accessible by all modes of transportation,” McGinnis says. “We are looking forward to continued growth and innovation in our new space.”

See our website—cts.umn.edu/about/contact—for details about parking and transit options. All CTS phone numbers remain the same.

U of M researchers, students share work at TRB

At this year’s Transportation Research Board (TRB) Annual Meeting, held January 13-17 in Washington, DC, University of Minnesota researchers shared their work in more than 40 sessions. Their papers and posters covered a range of topics, from accessibility to asphalt pavement to tribal transportation safety.

One paper, coauthored by Professor Greg Lindsey of the Humphrey School of Public Affairs, was honored by the Bicycle and Pedestrian Data Subcommittee. The paper, which focused on methods for producing valid estimates of annual average nonmotorized traffic, was one of two selected to receive the committee’s Outstanding Paper Award for 2019.

In addition, CTS funded travel awards for 10 graduate students to attend the meeting, where they presented research and networked with other attendees.
Many people deal with traffic congestion on a daily basis, usually during their morning and evening commutes, when it is often predictable and can be planned for. However, unexpected crashes, road construction, or weather conditions can worsen traffic and leave drivers frustrated and late. If this unreliability could be efficiently measured, however, traffic officials might be able to predict or even prevent congestion before it occurs.

Measuring the variability in travel times for any given route—called "travel-time reliability"—has been emerging as a major method by which researchers and traffic officials can quantify the effectiveness of a transportation network.

“Travel-time reliability is another way of looking at congestion and at strategies for making it more tolerable,” says Brian Kary, director of the Minnesota Department of Transportation (MnDOT) Regional Transportation Management Center.

Usually, calculating travel-time reliability involves manually gathering data on weather, traffic, crashes, work zones, and special events and calculating how much a driver’s commute time might fluctuate on a given day in given conditions. However, researchers in the Department of Civil Engineering at the University of Minnesota Duluth have figured out a way to streamline this process.

In a project funded by MnDOT, a research team led by Professor Eil Kwon designed a travel-time reliability measurement system (TTRMS) that automatically calculates travel-time reliability. The system gathers data by automatically accessing MnDOT’s traffic data archive and incident database as well as the National Oceanic and Atmospheric Administration’s weather database. Data for work zones, such as lane-closure periods and locations, can also be inputted.

“IT used to take hours, even days, to process travel-time reliability data,“ Kary says. “The TTRMS processes it in minutes.”

The system can automatically generate results in both table and graphical formats, thus saving traffic engineers significant time and effort. The TTRMS also includes map-based interfaces, which provide users with flexibility in defining corridors, specifying operating conditions, and selecting types of measures depending on the application.

To put the new system to the test, the research team used the TTRMS to evaluate traffic strategies deployed during the February 2018 Super Bowl in Minneapolis. During the week of the game, MnDOT and the Minnesota Department of Public Safety put extra effort into traffic management to ease tourist-induced congestion. Using the TTRMS, the research team confirmed that this extra effort proved extremely effective; travel-time reliability was actually higher than it had been two weeks before the game despite the increase in tourist traffic.

With insights like this, organizations such as MnDOT can better plan for traffic congestion and make effective changes.

“Since we can’t continually expand the roadways to accommodate traffic,” Kwon says, “the next best method for relieving congestion is to make the traffic system more efficient and reliable.”
An estimated 26.9 million American adults have some type of visual impairment, from “trouble seeing” to complete blindness, according to a 2017 National Health Interview Survey. With the aging Baby Boomer generation, this population is expected to grow.

After receiving orientation and mobility training, people with vision impairment can usually travel independently to known places along familiar routes by relying on a white cane or a guide dog to avoid obstacles. However, neither of these provides spatial awareness along their path (information to help them perceive the presence of a work zone, traffic intersection, bus stop, or subway entrance, for example) or guidance information to a destination.

Understandably, traveling alone in an unfamiliar environment is often a challenge. “Every day it’s a new experience,” says Ken Rodgers, president of the American Council of the Blind in Minnesota. “I never know what I’m going to encounter exactly.”

For Chen-Fu Liao, a senior research associate in the U of M’s Department of Mechanical Engineering, technology offers the potential to revolutionize the way people with vision impairment navigate city streets. In previous work, Liao developed the Mobile Accessible Pedestrian System (MAPS), which uses smartphone technology to provide location, signal timing, and work-zone information to visually impaired pedestrians. Developed in collaboration with Minnesota’s Vision Loss Resources, MAPS received positive feedback from testers. However, Liao discovered the technology was not acceptably reliable in GPS-unfriendly areas.

In his latest project, sponsored by the Roadway Safety Institute, Liao is aiming to improve the app’s accuracy and reliability by developing a “self-aware” infrastructure—one that can monitor itself and ensure the information it’s providing is up to date, even in urban canyons or indoor environments. To that end, Liao and his team have developed a standalone Bluetooth Low Energy (BLE) smart system integrating commercial off-the-shelf BLE beacons.

First, the researchers integrated the beacons with the necessary interface elements to sense other BLE devices within their range, Liao explains. The BLE beacons can be attached to traffic signal poles, work-zone barrels, or other objects and placed at decision points such as bus stops or building entrances. Then, using a positioning and mapping algorithm, the system can estimate a user’s location based on nearby Bluetooth signals, share information among devices, and inform the system administrator if any beacon location has changed. A database containing the location and message of each device is then integrated with the smartphone app to provide navigation information.

“This mapping methodology will ensure that correct audio information is provided to app users at the right location,” Liao says. “It could be used anywhere—at traffic intersections, skyways, or underground tunnels—to provide directions for travelers.”

Results of testing in a variety of environments indicate that the system can successfully detect if the location of one or multiple BLE beacons in a network has changed and detect when any of its beacons are not functioning—resulting from a loss of power or vandalism, for example.

Liao has received additional funding from the Minnesota Department of Transportation to deploy the system at six intersections in Stillwater, MN, in the summer of 2019. Researchers will integrate the Bluetooth system with the smartphone app and then conduct real-world tests of the new technology. The University of Minnesota has also filed a provisional patent on the technology.

“The benefit of our approach is that the visually impaired need nothing more than a smartphone with a text-to-speech capability to receive traffic and location information,” Liao says.

“The intent of our assistive system is not to undermine the skills and strategies that people with vision impairment have learned for navigation and wayfinding,” Liao adds. “Instead, the system aims to support their wayfinding capability, extend mobility and accessibility, and improve safety.”
Researchers from the University of Minnesota and the Mississippi Watershed Management Organization (MWMO) worked together on a unique study that aimed to measure the pollution washed into the Mississippi River when it rains in downtown Minneapolis.

“Stormwater runoff is a particularly challenging problem in large, urban settlements with many paved surfaces,” says Professor Bruce Wilson of the Department of Bioproducts and Biosystems Engineering.

When rain falls on roads, sidewalks, parking lots, and rooftops, it tends to pick up trace chemicals or particles and wash them into storm drains. These untreated pollutants ultimately end up in local rivers, streams, wetlands, ponds, and lakes—eventually harming the environment and our health.

“Because the Twin Cities sit within the Mississippi Watershed—the largest drainage basin in North America and one that reaches all the way to the Gulf of Mexico—it is especially important to understand how runoff works so that it can be better managed,” Wilson says.

Researchers from the U and MWMO worked together closely to study this process in a project funded by MWMO. First, they picked sites in downtown Minneapolis to set up rain collectors. Some of the water—collected off rooftops—came from natural rain events and snowmelt. Rain collected off ground surfaces such as roads, parking lots, and sidewalks was generated artificially so that the researchers could control how the water fell.

“Rain simulators allowed the study to focus on the role of surface types and seasonal differences by removing differences in rainfall characteristics,” explains Brittany Faust, MWMO environmental specialist.

The researchers collected samples from the sites at three different times of the year—fall, summer, and spring. They then sent the samples to a Metropolitan Council laboratory to test for contaminants including chloride, heavy metals, suspended solids, nitrogen, and phosphorous.

Some interesting findings emerged from the study. For example, runoff from ground surfaces showed the highest contaminant concentrations during the spring—particularly during snowmelt. In general, chloride concentrations from roofs were small for summer, fall, and spring, but contaminants from roofs exceeded Minnesota water quality standards for some events. And E. coli was detected in rooftop runoff.

The ground sites represented a range of automobile and pedestrian traffic, as well as impervious surfaces of different ages and materials. Roofs were selected based on the type of surface.

Although further analysis is needed, the study provides a better understanding of where and when stormwater contamination comes from: which surfaces tend to contribute the most, which contaminants are most common, and what time of year is the biggest threat.

“By performing this study, we have the potential to use this data to figure out where to include best management practice projects in downtown Minneapolis to help reduce and remove pollutants from stormwater runoff,” Faust says.
system provides drivers, fleet managers, and owner-operators with up-to-the-minute parking availability along major freight corridors to help truck drivers find safe and legal parking.

Under TPIMS, vehicle detection systems measure available parking in lots in each state. The parking data are sent to the states and to third-party vendors. Information is then delivered to drivers and other users through dynamic messaging signs, navigation apps and in-cab navigation systems, and 5-1-1 travel information websites.

The technology used to monitor parking availability varies by state. Kansas and Wisconsin are using a computer-vision detection system developed in a series of projects by researchers in the U’s Department of Computer Science and Engineering (CSE).

“Our detection system uses a network of digital cameras suspended above a parking area to monitor space availability,” says Professor Nikos Papanikolopoulos, the principal investigator. “Image-processing software analyzes the video frames and determines the number of occupied spaces.” The technology was granted a patent in January 2018.

Key aspects of the system are that it is completely automated, operates 24/7 in all kinds of weather and lighting conditions, and is non-intrusive. “There is no need to intervene with manual resets or recalibration procedures, and pavements are not disturbed,” says Ted Morris, CSE research engineer.

The team installed and tested the video detection system at rest areas in Minnesota as part of a pilot study that began in 2013. The system continuously monitored parking availability for more than two years, demonstrating the system’s reliability. Research funders were the Minnesota Department of Transportation (MnDOT) and the Federal Highway Administration (FHWA); the American Transportation Research Institute was also a project partner.

In more recent work, the research team completed a pilot study and performance assessment of the final system deployment for the Kansas DOT, which includes 18 rest areas along 350 miles of the I-70 corridor. The technology was granted a patent in January 2018.

The Wisconsin DOT uses alternative detection technology (tripwire with “pucks” embedded in the pavement) at other truck parking facilities along I-94. MnDOT is also using different technology.

The eight partner states and the FHWA anticipate many benefits for truck drivers and businesses from TPIMS—cost savings, improved quality of life for drivers, fewer fatigue-related crashes, and better compliance. TPIMS is funded through a USDOT Transportation Investment Generating Economic Recovery grant and state funds, and it is coordinated by the Mid America Association of State Transportation Officials. Read more about TPIMS at trucksparkhere.com.
minute as traffic conditions fluctuate.

“There are a lot of vehicle interactions around intersections,” says Michael Levin, assistant professor in the U’s Department of Civil, Environmental, and Geo-Engineering and the project’s principal investigator. “Intersections force vehicles to come to a stop, [and] there are vehicles moving in conflicting paths that inherently cause safety issues,” Levin says.

With CAVs and VSLs, however, it might be possible to mitigate some of those safety issues. Levin, together with research assistant Rongsheng Chen and senior research associate Chen-Fu Liao from the Department of Mechanical Engineering, have been running computer simulations to determine if VSLs could be used to reduce the amount of deceleration or acceleration of cars approaching a stoplight. If a CAV knows that an upcoming light is about to turn green, for example, it might slow down slightly to ensure that it never has to come to a complete stop before the light turns. If there’s a crash on the road, CAVs could be warned to slow down more gradually, ahead of time, so that no vehicles have to brake suddenly. Not only is this safer, but it’s also more fuel-efficient.

CAVs, however, are not widespread and probably won’t be for a long time. VSLs also change so frequently (often every 200 to 500 feet) and by such small amounts that it’s unreasonable to expect human drivers to follow them exactly. To account for this, the computer models assumed that a small number of CAVs would be mixed in with a larger number of human-driven vehicles. What the models have shown so far is that even a small number of CAVs could have a large impact on traffic flow; a CAV that is following the speed limit creates a barrier for speeding human drivers. This forms a moving “bottleneck” and slows the overall flow of traffic. The idea is based on the standard kinematic wave model of traffic flow, which assumes that traffic moves like water—fast when the banks are wide, slower when it is constricted.

The research is currently preliminary; since there’s no roadside infrastructure in place to broadcast VSLs, the models cannot yet be implemented directly. However, they give an idea of how effective VSLs could be and how best to use them.

“Ultimately,” Levin says, “I hope that state, county, or city departments of transportation could implement this on their arterial roads.”

So far, the research team has finished creating the model of traffic behavior, and from that model they’ve determined what speed limits should be used to maximize fuel efficiency. Next, the team will analyze how VSLs affect safety on the road.
Researchers use VARIABLE SPEED LIMITS to improve INTERSECTION SAFETY.

CTS MOVES to new OFFICE SPACE.

Measuring travel-time reliability could help reduce TRAFFIC DELAYS.

Technology developed by U researchers helps truck drivers find safe parking.