U of M researchers receive NSF grant

Mechanical engineering professor Rajesh Rajamani and Roadway Safety Institute director Max Donath 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.

Project seeks to ease traffic congestion in a roundabout way

Freeways and highways aren’t the only urban roads with traffic congestion, even though traffic management strategies have been largely directed toward improving traffic flows there. So, U of M researchers have taken to city streets to reduce congestion in an innovative—albeit roundabout—way.

“There’s been a lot of research focused on controlling congestion on major highways and freeways, but there’s relatively less when it comes to looking at controlling traffic on urban arterials,” says Ted Morris, a research engineer with the Department of Computer Science. “It’s a very different
The Minnesota Department of Transportation (MnDOT) is exploring the development of freeway “lids” at key locations on I-94 in the Twin Cities. To analyze the potential for private-sector investment and determine what steps might be needed to make lid projects a reality, MnDOT invited the Urban Land Institute (ULI) MN to conduct a Technical Assistance Panel with real estate experts and other specialists. The U’s Metropolitan Design Center (MDC) provided background and research for the panel.

A lid, also known as a cap or land bridge, is a structure built over a freeway trench to connect areas on either side. Lids may also support green space and development above the roadway and along adjacent embankments. Although lidding is not a new concept, it is gaining national attention as a way to restore communities damaged when freeways were first built in the 1960s.

According to MnDOT, roughly half of the 145 bridges on I-94 between the east side of Saint Paul and the north side of Minneapolis need work within the next 15 years. A shorter window applies in the area around the capitol to as far west as MN-280. In anticipation of the effort to rebuild so much infrastructure, the department wanted a deeper understanding of how attractive freeway lids and their surrounding areas would be to private developers and whether the investment they would attract would generate sufficient revenue to pay for them.

The three-day panel session was designed to consider the I-94 corridor and study three specific areas: the I-35W/ Minneapolis Central Business District, historic Rondo Avenue in Saint Paul, and Fairview Park in North Minneapolis. It also included a “lightning round” for high-level observations of five other sites.

Mic Johnson, senior fellow with MDC, provided background about lidding and shared successful examples from around the country at the panel kick-off dinner. MDC has analyzed a wide range of freeway lid structures and identified seven basic lid typologies. “These typologies provide broad thematic guidance for thinking about what features best serve a location,” Johnson says.

The briefing book provided to panelists included detailed research by MDC about the economic opportunities of the area’s freeway lids. MDC also created four appendices (projects, case studies, prototypical lid diagrams, and health and economic value) for the panel final report.

MDC has been involved in lid-related activities for several years. Students participating in an Urban Design Studio

The U’s Metropolitan Design Center identified lid typologies for the project.

An estimated 600 HOMES AND 300 BUSINESSES were lost when I-94 was built through Saint Paul’s Rondo Community.
For millennials, car ownership and family life may not be obstacles to transit use

As the millennial generation comes of age, indications of a significant generational change in travel behavior have raised hopes of robust growth in transit use. As a whole, this generation owns fewer cars, drives fewer miles, and uses transit more than previous generations. However, one key question remains: will millennials continue their high rates of transit use as the economy improves and they increasingly settle down and start families?

“In older generations we have seen significant declines in transit use that coincide with the transition to family life and child rearing,” says Andrew Guthrie, a research fellow and Ph.D. candidate at the Humphrey School of Public Affairs. To gain insight into the question of whether the millennial generation will be different, Guthrie looked for changes in the extent that two factors—young children in a household and access to an automobile—affect transit use.

The study, conducted with Humphrey School associate professor Yingling Fan, looked for evidence of these bellwether changes in the Minneapolis–Saint Paul region between 2000 and 2010. This period saw the opening of the region’s first modern light-rail line as well as numerous bus system improvements, including a network of high-frequency local routes. In addition, the region has a strong, knowledge-based economy and has seen an in-migration of millennials.

The researchers used data from the detailed Travel Behavior Inventory conducted by the Twin Cities Metropolitan Council in 2000 and 2010 to compare travel behavior at both the trip and person levels.

Their analysis revealed that both young children in a household and access to an automobile have become “weakening obstacles” to transit use. “Specifically, research models show that participants with access to an automobile were more likely to use transit in 2010 than in 2000, and that participants with young children in their households were less likely than others to use transit in 2000 but not in 2010,” Guthrie says.

“Our models provide strong evidence that the basic relationship between transit use and the presence of young children in a household has changed, as has the relationship between transit use and access to an automobile,” Fan adds. “In fact, regardless of the specific modeling approach, these two traditional obstacles to transit use either weakened or disappeared entirely between 2000 and 2010 in the Twin Cities region.”

According to the researchers, the findings suggest that transit may now be better able to hold on to market share as its millennial users mature and start families, especially in urban areas where walk-and-ride trips are most common. In order to attract and accommodate these transit users, researchers believe ensuring an adequate supply of family housing and family-oriented community features such as high-quality schools and playgrounds in transit-served areas will be critical.

The research this paper was based on was part of a larger project funded by the Metropolitan Council and the Minnesota Department of Transportation. The paper was recently published in the Transportation Research Record.
Unmanned aerial vehicles (UAVs) are poised to play an important role in the world of transportation, with the capability to do everything from deliver small packages to inspect bridges, monitor traffic flows, and survey transportation systems after a disaster. However, one sticking point of UAV use has been the balance between flight time and maneuverability.

“Choosing a UAV for an application has typically required compromise between the flight time and long-range capabilities of a fixed-wing aircraft versus the maneuverability and stationary characteristics of a multi-rotor platform that can take off vertically and hover like a helicopter,” says Nikolaos Papanikolopoulos, professor in the Department of Computer Science.

Recently, new UAVs have been developed that use solar cell technology coupled with energy storage and new propulsion technologies to reach full-day or even multi-day flight—but those drones use a fixed-wing design in order to have enough surface area for the solar panels. Now, U of M researchers led by Papanikolopoulos are working on a technology that offers the best of both worlds: a UAV that can gather and store solar energy as a fixed-wing aircraft and then transform into a “multi-rotor” state in order to perform those helicopter-like takeoffs, landings, and maneuvers.

“The UAV we created removes the individual limitations and combines the strengths of both systems,” Papanikolopoulos says. “In its multi-rotor state, the aircraft cannot supply enough energy from solar power alone and will rely on stored energy. Once stored energy is close to being depleted, the aircraft will transition into a fixed-wing state where the on-board batteries can recharge and the process can repeat.”

Another advantage of the new UAV is its vertical takeoff and landing capabilities. “This allows our UAV to wait on the ground for suitable solar conditions and land in the absence of them, which makes the ability to achieve multi-day operation feasible,” he says.

A paper by the research team describes the design for the hybrid UAV, outlining and analyzing several important considerations in the design of the aircraft, including its stability and weight distribution and the mechanical transition between flight modes. In addition, the researchers created a prototype to demonstrate the aircraft operating in its multi-rotor configuration.

Currently, work is under way to improve the prototype and validate its operation in fixed-wing and transition states. The research team is also continuing to improve the aircraft’s propulsion system and expanding the energy model to include the transition between fixed-wing and multi-rotor configurations.

This research is supported by grants from the National Science Foundation. The paper—“SUAV:Q – A Hybrid Approach to Solar-Powered Flight”—was published in the proceedings of the Institute of Electrical and Electronics Engineers’ International Conference on Robotics and Automation (2016).

New exhibit teaches kids about reflectivity and safety

The Roadway Safety Institute celebrated the grand opening of its safety-themed museum exhibit at The Works Museum in Bloomington on December 9. The exhibit, a permanent installation at the museum, helps teach kids and their parents how to “be safe and be seen” while walking or biking in the dark.

At the grand opening event, advisory board members, Institute staff, and other stakeholders toured the exhibit along with kids visiting the museum. The exhibit includes a dark room where kids can try on reflective clothing to see how visible they would be to drivers at night, a microscope area for examining reflective materials up close, and a video produced by 3M about the importance of reflectivity.
Transportation agencies have long placed high importance on the thickness of their concrete roadways, making it a major focus of control and inspection during construction. While it is commonly believed thicker concrete pavements last longer, there is little data to support this claim.

“One big reason for the lack of data on the relationship between concrete pavement thickness and performance is the destructive nature of these measurements,” says Lev Khazanovich, a former professor in the Department of Civil, Environmental, and Geo-Engineering. “Concrete thickness is typically assessed by coring—a destructive, expensive, and time-consuming test that only offers widely spaced measurements of thickness.”

U of M researchers set out to fill this knowledge void by leveraging recent advances in the nondestructive testing of pavements that allow for large-scale, rapid collection of reliable measurements for pavement thickness and strength. They conducted four evaluations on three roadways in Minnesota using ultrasonic technology to collect more than 8,000 measurements in a dense survey pattern along with a continuous survey of observable distress.

“We found that both pavement thickness and stress measurements are highly variable, with a half-inch of variation in thickness about every 10 feet,” Khazanovich says. “Interestingly, three of the four surveys averaged less than design thickness, which is contrary to typical accounts of contractors building slightly thicker slabs in order to avoid compensation deductions.”

Data analysis showed that exceeding design thickness did not seem to increase or decrease pavement performance. However, a measurement of pavement strength and quality known as “shear wave velocity” did produce valuable findings. “A drop in the shear wave velocity strength measurement corresponded to an increase in observable pavement distresses such as cracking and crumbling,” Khazanovich explains. “This was especially apparent when we were able to easily identify locations of construction changes, where significant changes in shear wave velocity matched up with observable distress.”

The results of this study illustrate the importance of material quality control and uniformity during construction, since alterations in pavement strength and quality may significantly influence pavement performance. In addition, researchers say that despite inconclusive thickness results, it is still important that pavement has significant thickness to carry its intended traffic load over its service life. Finally, the study demonstrates that new methods of ultrasonic shear wave velocity testing are useful for identifying changes in construction and design that could lead to higher rates of pavement distress.

The study was funded by the Minnesota Department of Transportation.

Museum from page 4

of wearing reflective gear for safety.

In his opening remarks, Institute director Max Donath noted that besides getting the safety message to kids—and their parents—the exhibit aims to get them excited about technology and transportation topics and eventually, perhaps, transportation careers.

“It’s really important that we get kids to think about transportation safety and then interested in science and technology,” Donath said. “We’re trying to attract a diverse audience into [the transportation field].”

The exhibit was created for the Roadway Safety Institute in partnership with The Works Museum, HumanFIRST principal researcher Nichole Morris, KidZibits, and CTS.

READ CATALYST ONLINE for links to research reports and other resources.
picture when you get into urban arterials and the traffic behaviors going on there, because of the dynamics of route choice, pedestrian interactions, and other factors."

Morris is part of a research team that aims to create a framework for testing and evaluating new urban traffic sensing and control strategies for arterial networks. The goal is to balance safety and efficiency for all users—especially in places where new types of urban transportation facilities are planned in the next few years.

The team is using the 66th Street corridor in Richfield as a test bed for its research. The city, along with Hennepin County, is in the process of converting a series of signalized intersections along the route to roundabouts over the next few years. The roundabout designs also incorporate new facilities for pedestrians, bikes, and bus transit as part of a multimodal approach.

Initially, the researchers sought to create a larger network of interconnected sensors and a live test bed, Morris says. But funding limitations kept the project area to approximately 10 miles of arterial roads, a portion of which will be supported by a network of interconnected traffic sensors. The research team is instrumenting major intersections along 66th Street with a reliable, low-cost, high-resolution camera mounted on a center pole and supporting electronics as the intersections are being reconstructed.

“You can zoom in pretty closely to capture all the different movements and events that we need to use for measurement and detection,” Morris adds. “The key to this, to really make it reliable, is you need to very carefully quantify gap acceptance and how that varies in time and time of day. You also need to know how pedestrian activities interact with the traffic flow.”

The use of roundabouts has grown in the region because they cost less to build and maintain than signalized intersections, they meet the latest design standards, and they improve safety by reducing traffic conflicts. But predicting the capacity of roundabouts can be especially challenging when factoring in pedestrian traffic, uneven traffic origin-destination flow, heavy vehicle volumes, and approach vehicle gap-selection timing.

In addition to creating a sensor network to obtain real-time vehicle and pedestrian data to help control traffic and keep it flowing smoothly, the researchers also are developing a traffic simulation model that includes almost all of Richfield—more than 140 signalized intersections covering 21 square miles, including the arterials. The simulation model will be used to develop and test traffic control strategies under different scenarios. Minnesota Traffic Observatory director John Hourdos is leading that effort.

This research and the field deployment system are funded through a collaborative grant from the National Science Foundation Cyber Physical Systems program. SRF Consulting is the industrial partner to help design the sensor network and evaluate the system.

Minneapolis's Transportation Conference March 1–2, 2017 Saint Paul, MN

Registration is now open for the 2017 Minneapolis’s Transportation Conference, the largest transportation event in the state. This year's conference focus is going beyond the usual road, with presentations highlighting innovative and emerging topics and trends. The event, held at the Saint Paul RiverCentre, also provides attendees with the chance to network with other professionals.

Learn more at mntransportationconference.org.
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 more than 48,000 bicycle-vehicle collisions that occur in the U.S. each year.

The warning 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 audiovisual 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 U’s HumanFIRST Laboratory, will lead work on the human factors components of the research, which includes improving the warning system.

Additionally, Loren Terveen, professor in the Department of Computer Science and Engineering, will serve as a co-investigator.

A bicycle equipped with the prototype collision-warning system

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**Lid from page 2**

course in fall 2013 taught by Johnson conducted an extensive analysis of the I-35W/Minneapolis area and created an architectural model of a lid connecting the U of M’s West Bank to Downtown East. Their model was displayed at the IDS Center.

MnDOT Commissioner Charlie Zelle requested that ULI MN convene the panel as part of the larger “Rethinking I-94” project, which is developing a vision for the corridor through a comprehensive public involvement process. “Lid projects are one way being considered that could reconnect neighborhoods such as Rondo that were divided by freeways in the 1960s,” Zelle says. The Rondo neighborhood was also featured in the USDOT’s Every Place Counts Design Challenge in July.

As part of its report to MnDOT, the panel concluded that private-sector development would not pay for the lids directly, but lids would create development interest that could generate significant long-term revenue to pay for lid maintenance, programming, and other amenities.

To build momentum and create an identity for lid projects, the panel also recommended that the area’s lids be considered as a whole under a single banner, not as separate projects, as part of a rebranded vision called the Healthy Communities Initiative. The final report is available at minnesota.uli.org.

(Adapted from the ULI MN report: Healthy Communities Initiative, Nov. 2016.)

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