University of Minnesota
Center for Transportation Studies
Research E-News

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CTS Research E-News brings you the latest research project milestones, published reports, and seminar coverage.

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Announcement

University of Minnesota presenters at TRB Annual Meeting

The University of Minnesota will be well represented at the annual meeting of the Transportation Research Board in Washington, D.C. Engineering and public affairs researchers will present and discuss their recent research on a range of topics, including transportation planning, safety, congestion management, transportation finance and pricing, and pavement and bridge management.

For more information, download a complete list (128 KB PDF) of University of Minnesota and Mn/DOT presenters, or visit the TRB Annual Meeting website.

Intelligent Transportation Systems

Cell phones used to receive traffic safety messages

Delivering real-time information about roadway and traffic conditions to drivers could allow them to make smarter choices and avoid crashes, potentially saving lives. Professor **M. Imran Hayee** and graduate student **Beau Roodell** from the University of Minnesota Duluth's Department of Electrical and Computer Engineering have developed a system that transmits these messages to drivers through Bluetooth-enabled cell phones.

The research, funded by the ITS Institute, focused on designing a communication interface device (CID) that transmits messages to a driver's cell phone using a Bluetooth connection. The CID pairs automatically with the phone each time the driver enters the vehicle, and the cell phone displays new messages for the driver to view. Currently, the system is compatible with about 60% of cell phones, and more phones could be supported in the future.

The system relies on dedicated short-range communication (DSRC) technology, a medium-range wireless communication protocol designed for automotive environments, to get the information to the vehicle. DSRC technology wirelessly transmits messages from a roadside unit (RSU), which would receive traffic information from the state department of transportation, to an on-board unit (OBU) installed in the vehicle. The RSU transmits a message once every second, with the current message sent repeatedly until a new message is received. The OBU relays any new information to the CID, which sends it to the driver's phone.

Roodell and Hayee tested their prototype system in both urban and rural environments to determine communication range and evaluate system performance. RSUs were placed at different heights and distances in relation to the roadway, and vehicles equipped with OBUs drove past at different speeds and in varying traffic conditions. Vehicle-to-vehicle communication was also tested, with the OBUs in two vehicles sending messages to each other as they traveled. In all scenarios, communication between the sending and receiving units was diminished by line-of-sight obstructions such as trees, other vehicles, or changes in roadway elevation.

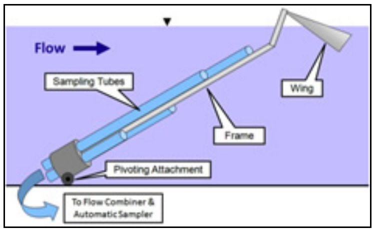
The maximum continuous communication range, in which the vehicle received all messages sent by the RSU, was 1000 feet. Intermittent communication, in which the vehicle received approximately one in every three messages, or one message every three seconds, occurred for an additional 500 feet. The researchers noted that intermittent communication would not hinder system operation in a real-world scenario, as new messages are unlikely to be sent that frequently.

The total range of the system was substantially less than the 1-kilometer goal, but the researchers suggest that changing the type of antennas on the RSUs and OBUs could increase range, as could placing the RSUs at higher elevations. Future improvements could also include text-to-voice capabilities, enabling messages to be read aloud to the driver.

A final report on the project, *Development of a Low-Cost Interface between Cell Phone and DSRC-Based Vehicle Unit for Efficient Use of IntelliDriveSM Infrastructure* (CTS 10-14), is available from the ITS Institute website.

Transportation & the Environment

Researchers improve water sampling accuracy



Improved sampling intake device

In an effort to provide better data on water pollution and increase water sampling accuracy, researchers from the University of Minnesota's St. Anthony Falls Laboratory recently completed work on a new device that improves the performance of automatic water samplers.

Civil engineering professor **John Gulliver** and graduate student **Greg DeGroot** developed and tested a device that gathers more accurate samples of suspended solids in stormwater runoff than existing samplers. The research, sponsored by the Minnesota Pollution Control Agency and the Local Road Research Board, targeted the sampling of larger suspended particles, which have historically been more difficult to measure correctly.

Gulliver and DeGroot found that existing automatic samplers consistently overestimate the presence of larger particles, defined in the study as those greater than 88 micrometers in diameter. These types of particles, mostly coarse silts and sands, are often a substantial portion of suspended solids associated with urban and highway runoff. The researchers suggest the ability to determine the concentration of such particles has implications for effectively monitoring water pollution mitigation efforts as well as evaluating the performance of stormwater best management practices.

To enhance the accuracy of automatic samplers, Gulliver and DeGroot developed a device that takes samples from multiple heights in the water column of a stormwater pipe. The new device consists of a frame with one end hinged to the bottom of the stormwater pipe, and four individual sampling tubes that collect water from different heights. A wing attachment is mounted to the top of the frame, and the force of the water against the wing lifts the device to the proper position in the pipe depending on water flow. A short distance from the frame, the four tubes enter a flow combiner.

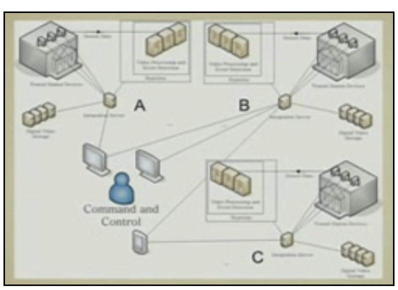
Multiple tests determined that the device sampled concentration accurately for particles up to 250 micrometers in diameter, and also performed well for particles even larger in size. Study findings suggest the improved accuracy can be explained by the varying concentrations of particle sizes at different water column heights. Larger particles, for instance, are more heavily concentrated at the bottom of the column, making the four combined samples a better representation of the overall concentration than a sample taken from a single point.

Researchers emphasize that the new device is easy to operate, inexpensive to build and maintain, and creates minimal flow obstruction. It can also be modified to fit in a variety of stormwater pipes, with frame height and wing size determined by pipe diameter and maximum water flow rates.

Improved Automatic Sampling for Suspended Solids (Mn/DOT 2010-38) is available from the CTS website.

Safety & Security

Camera networks for security and traffic applications



Camera network schematic

Security personnel traditionally monitor thousands of cameras at one time, often viewing only a single frame from each network camera every few minutes. Such a system provides a large amount of data that is difficult to manage and is often ineffective in identifying potential threats.

At the November 4 ITS Institute Advanced Transportation Technologies seminar, computer science and engineering professor **Nikolaos Papanikolopoulos** discussed the applications of a camera network system that has been under development by University of Minnesota researchers since 2004. The system, developed with seed funding from the ITS Institute, allows a single user to successfully monitor an entire camera network.

Work on the system began in 2004, when Papanikolopoulos and his research team completed a project using a camera system to detect drug deals at bus stops. Further advancement took place when the Department of Homeland Security asked the researchers to install a camera network at the 30th Street Station in Philadelphia, where all cameras and sensors throughout the transit facility were routed to a single individual for monitoring. A similar system will soon be installed at the light-rail station of the Minneapolis-St. Paul International Airport to observe human activities and perform threat evaluation, Papanikolopoulos said.

The camera network system is based on the Hyperion framework, which uses human and crowd activity monitoring, automatic camera placement, camera-to-camera tracking, semi-autonomous calibration, and video forensics analysis to evaluate all incoming video feeds and pass on critical information to a human operator, Papanikolopoulos explained.

For example, the system is capable of detecting a thrown or abandoned object anywhere in the network and informing the user of its presence. The user may then examine the data and choose to further investigate or ignore the incident. Additional system capabilities include trajectory identification, detection of camera tampering, and crowd monitoring. A search feature also allows the user to find all frames containing a particular individual, eliminating the need to examine footage from multiple cameras frame by frame.

By calculating the most efficient locations to place cameras, the system also allows a network to provide increased accuracy using fewer cameras, Papanikolopoulos said. This reduces the amount of duplicate or unnecessary footage and also keeps maintenance costs down.

The system's wide-ranging detection capabilities make it an effective tool for a variety of transportation applications, according to Papanikolopoulos. The system can be used at traffic intersections to evaluate the trajectories of pedestrians, count the number of bicycle crossings, or collect other data. Research is also under way on using the system to identify empty parking spots at truck stops and direct drivers to locations with space available.

Papanikolopoulos also explained that possible system applications extend far beyond security and transportation issues. For example, the system will be used in the future to monitor the mental health of children in daycare, with a focus on identifying precursors to various disorders. System technology could also be employed in radiation therapy, Papanikolopoulos said, where it could help machines identify patient movement to avoid damaging healthy tissues.

"This is an area of vast research and deployment opportunities," Papanikolopoulos said. "The implications are tremendous."

Transportation Infrastructure

Bridge health monitoring: Selecting systems for fracture-critical bridges

The Cedar Avenue Bridge in Burnsville, MN
(Photo: Wikimedia Commons)

The tragic collapse of the I-35W bridge over the Mississippi River in August 2007 thrust the issue of bridge health monitoring into the public eye. In the wake of the collapse, the Minnesota Department of Transportation redoubled its efforts to develop new, effective, and economical methods for monitoring "fracture critical" bridges—those bridges where the failure of a single critical component could compromise the entire structure. As part of this effort, Mn/DOT sponsored research by the University of Minnesota's Department of Civil Engineering to develop methods for selecting the most appropriate bridge health monitoring systems for a given bridge. A new research report by professor **Arturo Schultz** and graduate student **David J. Thompson** shows how these methods can be applied to a fracture-critical steel bridge in Burnsville, Minnesota.

In an earlier research project, Schultz led a research team that surveyed commercially available bridge health monitoring systems. Bridge engineers can choose from a wide variety of systems based on different technologies, including 3D laser scanning, acoustic emissions, digital image correlation, fiber optic sensors, and many others. The researchers gathered information from companies and evaluated systems based on several key issues: the nature of monitoring required, the type of bridge to be monitored, the specific features of the monitoring systems, and characteristics of the supplier. All this information was incorporated into a spreadsheet-based software application that can be used by bridge engineers when selecting a bridge health monitoring system.

In their new report, Schultz and Thompson demonstrate the selection system by evaluating the monitoring needs of the Cedar Avenue Bridge in Burnsville. The tied-arch construction of the bridge, with steel box girders serving as tension ties, makes the bridge fracture-critical. The researchers determined that acoustic emission (AE) monitoring would be the most appropriate commercially available technology for identifying the initiation and propagation of fatigue cracks in the bridge; although other technologies are capable of monitoring fatigue cracks, the researchers determined that systems based on acoustic emissions best fit the needs of engineers working with the Cedar Avenue Bridge.

After selecting AE monitoring as the most appropriate technology, the researchers designed a monitoring system for the bridge. The design includes the number and placement of sensors and data loggers as well as details of the power supply, data communications system, and methods of securing the equipment to the bridge. Because the Cedar Avenue Bridge is currently in good health with no evidence of fatigue cracking and little corrosion, the researchers developed finite element models of the bridge to identify locations where structural distress could be expected in the future and where acoustic emissions sensors should be installed to detect damage.

Acoustic emission technology offers two important capabilities for monitoring the Cedar Avenue Bridge, the authors note in their report. First, AE monitoring systems can determine where an acoustic signal event originates by correlating the data from multiple acoustic sensors; this is helpful in locating damage detected by the system, such as cracking. In their report, the researchers suggest a method for determining where to install acoustic sensors in order to accurately locate cracking. Second, AE systems can automatically characterize the acoustic signals they receive to determine whether a detected event is due to cracking, crack growth, or other causes.

Development of an Advanced Structural Monitoring System (Mn/DOT 2010-39) is available from the CTS website.

Transit, Bicyling, and Walking

TCRP research publications available online

The federal Transit Cooperative Research Program (TCRP), administered by the Transportation Research Board, provides practical transit research to address technical and operational issues. TCRP emphasizes putting research results into the hands of organizations and individuals that can use them to solve problems.

Recent TCRP publications include:

- *Guiding the Selection and Application of Wayside Energy Storage Technologies for Rail Transit and Electric Utilities* (TCRP Web-Only Document 5)

Upcoming Events

February 10

15th Annual TERRA Pavement Conference, St. Paul, MN

February 15

CTS Winter Luncheon: Driver alcohol-detection systems: The end to drunk driving?, U of M East Bank Campus, Minneapolis, MN

May 24-25
22nd Annual CTS Transportation Research Conference, Crowne Plaza, St. Paul, MN