University of Minnesota
Center for Transportation Studies
Research E-News

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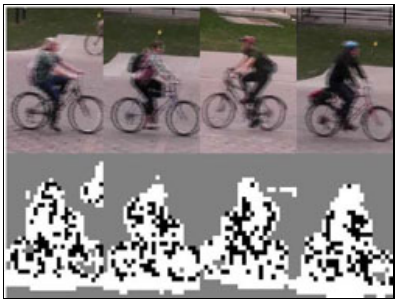
CTS Research E-News brings you the latest research project milestones, published reports, and seminar coverage.

In this issue:

Intelligent Transportation Systems

Using computer vision to count pedestrians and cyclists



The system converts video data into small image "patches" and classifies each patch as a bicycle (black) or pedestrian (white) before making an overall classification of the entire object.

Researchers in the Department of Computer Science and Engineering (CS&E) are continuing their work on a vision-based system for counting pedestrians and bicyclists. The system uses machine learning principles and complex algorithms to process video data and classify objects in the scene as either cyclists or pedestrians.

In this project, CS&E professor **Nikolaos Papanikolopoulos**, program director **Vassilios Morellas**, and graduate student **Guruprasad Somasundaram** refined the algorithms used by the system and tested the system's accuracy using data from four locations. The project was sponsored by the ITS Institute.

This vision-based system overcomes many of the shortcomings of existing detection and counting technologies—such as loop counters, buried pressure pads, and infrared counters—because it is capable of distinguishing between a cyclist and a pedestrian. This ability allows the system to obtain accurate traffic counts on bicycle trails, bridges, bicycle lanes, and other locations with heavy bicycle and pedestrian traffic.

The system works by first filtering out the background of available video data. It then takes the remaining foreground objects, called blobs, and converts them into small image patches. These patches are compared to object dictionaries for people and bicycles that the system has previously "learned" in a training mode. It uses these dictionaries to determine the classification for each image patch, and then to make an overall classification of the entire blob as a bicyclist or pedestrian.

Image quality is essential for accurate results, the researchers say. Higher-resolution images contain more pixels in each patch and help the system make a more accurate classification. Camera placement is also important for successful classification. Cameras should be placed in locations that are perpendicular to the area being studied whenever possible, allowing for optimal resolution and minimizing occlusions.

The research team tested the system by acquiring two hours of high-quality video data from three walkway sites at the University of Minnesota, as well as some high-velocity bicycle traffic data from the Gateway State Trail in Uptown Minneapolis. Results indicate that the system was able to correctly identify bicyclists 86 percent of the time and pedestrians 98 percent of the time. The overall accuracy of the system was 96 percent.

Obtaining these accurate counts of bicyclists and pedestrians can be essential for understanding nonmotorized traffic patterns and designing safer and more effective facilities, the researchers say. In future work, the team also plans to integrate a crowd-counting feature and work to improve the accuracy of traffic counts in mixed groups.

The project's final report, *Deployment of Practical Methods for Counting Bicycle and Pedestrian Use of a Transportation Facility* (CTS 12-01), is available on the ITS Institute website.

Seminar explores visual accessibility of indoor spaces

Visual accessibility—how effectively vision can be used to travel safely through or complete activities within a space—has an important impact on mobility for individuals with low vision. The ability of a visually impaired person to detect potential obstacles and hazards, plan and follow

routes, and keep track of his or her own location is essential for traveling safely.

At an ITS Institute seminar on January 31, **Gordon Legge** described his research on the visual accessibility of indoor spaces. Legge, a Distinguished McKnight University Professor in the University of Minnesota's psychology department, also outlined his team's development of a new form of adaptive technology designed to assist visually impaired individuals with indoor navigation.

Legge began by explaining that many factors can affect the visual accessibility of an indoor space, including variations in natural and artificial lighting as well as the color, texture, and gloss of various surfaces. To examine how these factors specifically affect the accessibility of indoor steps and ramps, Legge and his team conducted a series of experiments on an artificial walkway in a simple indoor space. Test subjects included people with normal vision wearing blur goggles as well as several low-vision individuals. All participants were asked to identify a target ahead of them on the walkway as either a step up, step down, ramp up, ramp down, or flat continuation.

One significant finding was that subjects correctly identified steps up 87 percent of the time but had a much lower success rate of 66 percent for steps down. This is because steps down are harder to see for those with severely blurred vision, Legge said. "Steps up can be identified by the horizontal shadow bands cast by natural or artificial light. The same stairs seen from above are basically invisible," he explained.

The researchers are also using computer graphics tools to further their study of visual accessibility. They have created a computer model of the test space and walkway, which allows them to investigate effects of lighting or architectural changes—such as adding a window—on the space's visual accessibility. Ultimately, Legge hopes this research can be used to develop computer-based tools to help architects and interior designers create indoor environments that individuals with low vision can navigate safely.

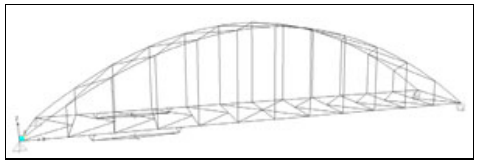
Legge's team has also developed a computer-based technology to assist low-vision individuals in indoor spaces—the Digital Sign System. The system uses digital signs at key locations to identify rooms, intersections, or special features inside a building. The user carries a handheld sign reader that uses an infrared camera to interpret the signs. The device then delivers auditory information to the user through a Bluetooth headset. If a digital map of the building is incorporated in the system, a user can obtain information about nearby rooms or objects and even receive precise directions to a particular location.

"Going to an unfamiliar space limits the mobility of a person with low vision. How do you find a particular office once you get to a building? With this technology, you don't have to memorize maps of buildings to find your way," Legge said.

Watch the webcast

Transportation Infrastructure

Extending bridge life with response modification strategies



Bridge model with response modification devices (bottom, left of center)

As part of an ongoing research effort, a team from the Department of Civil Engineering is continuing its work on a previously developed response modification framework designed to safely extend the life of bridges.

In an earlier study, Assistant Professor **Steve Wojtkiewicz**, Professor **Arturo Schultz**, and graduate student **Andrew Gastineau** demonstrated how a passive response modification device could help reduce the amount of stress placed on bridge components by changing how the bridge responds to loads. In this study, the team examined the use of multiple devices on a single bridge and investigated the optimal characteristics of the device. They also conducted a frequency analysis to determine whether using semi-active modification devices would be more beneficial than passive devices for reducing stress and increasing bridge life. The research was sponsored by CTS.

In their previous work, the researchers used a simple stiffness and damping device along with a scissor jack—a mechanical amplification device—to reduce stress on vulnerable bridge joints. The researchers performed a computer simulation using an existing model of the Cedar Avenue Bridge in Burnsville, Minnesota, to test the possible effects of this device. Results indicated that the device can successfully disperse stress on vulnerable bridge connections, reducing stress ranges by 39 percent and leading to a bridge life extension of as much as 60 years.

In this study, the researchers examined the use of multiple such modification devices to further minimize bridge vulnerabilities. Using a refined version of the same bridge model, the researchers placed a pair of response modification devices on each end of the bridge. Findings showed a 42.5 percent reduction of stress ranges at each of the two joints being studied and an overall bridge life extension of up to 426 percent, or 81 years.

The researchers also examined the optimal characteristics of the device components—including spring stiffness, member stiffness, and scissor-jack geometry—that would maximize the reduction in stress. After testing several configurations, the team found that the stiffness of the members and the length of the device had the greatest effect on performance, with longer and more rigid devices performing best.

The research team then conducted a frequency analysis to determine whether extending the modification framework to include semi-active damping devices would be beneficial. Their analysis of the passive device showed that, at certain loading frequencies, the bridge's response actually decreased by up to 100 percent over the original structure, while it increased significantly at other frequencies. A semi-active device, which can be modified to manipulate bridge response according to real-time loading conditions, could ensure that stress reductions are maintained over a larger range of loading scenarios.

In collaboration with mechanical engineering professor Rajesh Rajamani and his research team, the researchers are now focused on the development and control of semi-active modification devices to account for the variety of vehicle excitations imposed on the bridge.

Innovative Technologies for Lifetime Extension of an Aging Inventory of Vulnerable Bridges (CTS 11-27), a final report on the project, is available on the CTS website.

Performance specifications for asphalt pavements in cold climates

Good fracture properties are an essential requirement for asphalt pavements in the northern part of the United States, where low-temperature cracking is a common pavement distress. As temperature decreases, stresses accumulate in the pavement and eventually a crack or multiple cracks form.

In a February 7 CTS Research Seminar, **Mihai Marasteanu** summarized work performed under two phases of a national pooled-fund study investigating the low-temperature performance of asphalt pavements. Marasteanu, an associate professor in the Department of Civil Engineering, also explained how statistical analyses of lab and field data have been used to set the foundation for a performance-based specification for asphalt mixtures. The seminar was cosponsored by the Transportation Engineering and Road Research Alliance (TERRA).

This research was supported by the Minnesota Department of Transportation, the lead agency on the project; other participating states; and the Federal Highway Administration. The University of Wisconsin, University of Illinois, and Iowa State University have also contributed to the project.

For decades, it has been widely accepted that binder properties control the low-temperature performance of asphalt pavements, Marasteanu said. However, the increased use of polymers and other modifiers has made it difficult to correctly predict low-temperature pavement performance. "Because of these issues, binder testing alone is no longer sufficiently reliable for predicting the low-temperature cracking of asphalt mixtures," Marasteanu explained.

To address this problem, a national pooled-fund study that began in 2003 has focused on a comprehensive investigation of low-temperature cracking in asphalt pavements. In the first phase of the study, completed in 2007, researchers focused on identifying correlations between asphalt binder, mixture parameters, and field performance. Researchers extracted field samples of asphalt binders and mixtures and evaluated them with creep, strength, and fracture tests.

Results indicated that field performance correlated best with fracture parameters for both asphalt mixtures and binders. Existing performance grade specifications for binders are a good start, but other factors such as aggregate type and air voids also affect fracture resistance, Marasteanu said. Overall findings indicated a need for the development of mixture selection criteria similar to the performance gradient system. These criteria would limit values for fracture energy, stiffness, creep rate, and fracture toughness.

Phase two of the study, currently under way, has focused on exploring and developing such an asphalt mixture specification. According to Marasteanu, the biggest challenge for creating and implementing a specification has to do with how mixtures are prepared for testing to best represent real-world field and aging conditions. Marasteanu suggests coming up with an initial set of mixture preparations and aging conditions as a starting point and providing additional information about other preparation and aging combinations as more data become available.

Watch the webcast or learn more about Phase I and Phase II of the study

Transit, Bicycling, 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:

- Guidelines for Ferry Transportation Services (TCRP Report 152)
- Off-Board Fare Payment Using Proof-of-Payment Verification (TCRP Synthesis 96)
- Synthesis of Information Related to Transit Problems: 2012 (TCRP Research Results Digest 104)
- Competition Requirements of the Design/Build, Construction Manager at Risk, and Public-Private Partnership Contracts—Seven Case Studies (TCRP Legal Research Digest 39)
- Operation of Light Rail Transit through Ungated Crossings at Speeds over 35 MPH (TCRP Web-Only Document 53)

Upcoming Events

Research conference topics announced

Speakers and topics have been announced for the 23rd annual CTS Transportation Research Conference. The event takes place May 23 and 24 at the Saint Paul RiverCentre.

The opening session—"The Role of Transitways in Our Region's Economic Competitiveness"—will begin with a presentation of recent research findings from **Yingling Fan**, a CTS Faculty Scholar and assistant professor in the Humphrey School of Public Affairs.

By 2030, the Minneapolis–St. Paul region is expected to have a network of 14 transitways. Will these lines spur economic growth, and where? How well will they connect jobs to workers? What impacts will the lines have on neighborhoods and social change? Fan has been studying these issues for several years. In her most recent work, Fan led a team that analyzed the labor supply to "competitive clusters" of industries such as medical manufacturing and publishing. The team says that to improve job access by transit, it's more effective to centralize jobs than housing—and recommends integrated policies to encourage employers to locate near transit corridors. The study was funded by the McKnight Foundation, Surdna Foundation, and the Jay and Rose Phillips Foundation of Minnesota and builds on previous work Fan conducted under the Transitway Impacts Research Program.

Following Fan's presentation, a panel of state and national leaders will discuss the policy implications of the study and whether the findings can lead to greater economic competitiveness.

At the conference luncheon, author and journalist **Earl Swift** will chart the creation of the U.S. interstate system, which transformed America by turning dirt tracks into an organized framework of expressways in the space of a single lifetime. Swift will share highlights from his book: *The Big Roads: The Untold Story of the Engineers, Visionaries, and Trailblazers Who Created the American Superhighways*. The book brings to light the visionaries who created these essential highways as well as the critics and citizens who questioned their headlong expansion throughout the country.

Registration information is available on the research conference page. For more information, contact the College of Continuing Education at 612-624-3708, cceconf5@umn.edu.

More Upcoming Events

April 24-26
National Transportation Workforce Summit, Washington, D.C.

April 29-May 1
IBTTA Symposium on Mileage-Based User Fees and Transportation Finance Summit, Jersey City, New Jersey

May 23-24
23rd Annual CTS Transportation Research Conference, Saint Paul RiverCentre, St. Paul, MN