SPARKING INNOVATIVE TRANSPORTATION SOLUTIONS

Issue 16
Spring/Summer 2010

HIGHWAY SYSTEMS
RELIABILITY
TRANSIT
TRANSPORTATION SAFETY

Ignition

News from TRB's IDEA Programs

INSIDE:

- Can an intelligent sign inventory system identify what's in shipping lanes? See **"Where's Your Sign?"**

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THE IDEA PROGRAMS

Innovations Deserving Exploratory Analysis

IDEA programs provide start-up funding for promising but unproven innovations in surface transportation systems. The programs' goal is to foster ingenious solutions that are unlikely to be funded through traditional programs.

Managed by the Transportation Research Board, IDEA programs are supported by the member state departments of transportation of the American Association of State Highway and Transportation Officials (AASHTO), the Federal Transit Administration (FTA), the Federal Railroad Administration (FRA), and the Federal Motor Carrier Safety Administration (FMCSA).

The Transit IDEA program, which receives funding from FTA as part of the Transit Cooperative Research Program, is guided by a panel chaired by Fred Gilliam, President/CEO, Capital Metropolitan Transportation Authority in Austin, Texas. Harvey Berlin is the TRB program officer.

The NCHRP Highway IDEA program is supported by the member state departments of transportation of AASHTO through the National Cooperative Highway Research Program (NCHRP). It is guided by a panel chaired by Sandra Q. Larson, Director of Research, Iowa State DOT. Inam Jawed is the TRB program officer.

Safety IDEA is jointly funded by FMCSA and FRA. The committee is chaired by Bob Gallamore, a consultant. The program focuses on innovations to improve railroad, inter city bus, and truck safety. Harvey Berlin is the TRB program officer.

Reliability IDEA is funded throught the second Strategic Highway Research Program (SHRP 2) to encourage innovation in techniques and tools to reduce congestion and delay caused by unexpected events. The program's goal is to improve travel time reliability. The committee is chaired by Leslie Spenser Fowler, ITS Program Manager for Kansas Department of Transportation. Inam Jawed is the TRB program officer.

Visit the IDEA Web site:
www.TRB.org/IDEA

On the Cover: While dolphins are known to come from miles away to surf in the pressure wave ahead of a ship's bow (as shown in the cover photo taken by Louis Vest, Houston Pilots Association), not everything that shows up in shipping lanes can be easily accommodated. Image processing technology holds promise for detecting and monitoring waterway activities and objects.

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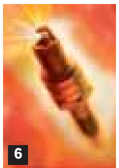


From the **Editor's** Desk

Recognizing What's Important

At the Cineplex, a movie opens with a busy street scene; we scan the images trying to catch what's important. Is it the woman in a sidewalk crowd looking back over her shoulder? The red-and-black cab screeching around a corner? The pre-school playground suddenly a-squeal with kids at recess? Our brains process all this imagery trying to recognize and capture what might be relevant to the story.

A similar challenge, presumably with a lower entertainment value, confronts transportation agencies trying to build road sign inventories from thousands of hours of video log images. Screeners, human or automated, must determine if an image contains a sign (about 5 percent do), what kind of sign it is, and what are its condition and location. Accurate inventories become increasingly important as asset management and performance monitoring goals are emphasized, so it's no surprise that the advances James Tsai of Georgia Tech has made in image processing technology have created national interest, even beyond the highway community. His story is featured in our Insight section.

In the New Ideas section, we look at two innovations in rail safety, which turns out to be good timing considering the investments planned for America's railway systems. One of the projects funded through the Safety IDEA program continuously monitors the condition of three wheel elements, allowing the components to be repaired or replaced before failure, and its sometime catastrophic results. The second innovation applies a pulse laser to pinpoint longitudinal stress that can buckle continuous rail members. Traditional methods require cutting and rewelding the rail. Another innovation improves safety for bus passengers with a retractable system for securing wheelchairs. The Lane Transit District in Eugene, Oregon, participated in the successful field tests.

In the Business section, we celebrate John Hillman's 2010 Award of Excellence from the *Engineering News Record* for creating the hybrid composite bridge beam, an innovation that received support from two IDEA programs. Our congratulations to John and our thanks for his strong endorsement of the programs, which have a pretty good record of recognizing what's important to the transportation community.

Linda Mason
Communications Officer
Transportation Research
Board of the
National Academies

Your comments are welcome and may be sent to the editor at **lmason@nas.edu**

Insight

Where's Your Sign?

Creating a Roadway Sign Inventory

The Georgia State Department of Transportation estimates that a little more than 2.5 million road signs are located on the 18,000 centerline miles of its state-maintained roads. Add the signs on locally maintained roads and the number would be much higher. To meet asset management goals, Georgia and all state DOTs need complete records of their road signs, including type, location, and condition. Additionally, road signs must comply with the Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD). When revisions to the MUTCD are made, DOTs are given time to change their signs. According to the 2009 edition of the MUTCD, the next round of changes—including changes to 'yield' and 'crossing' signs—must be made by January 17, 2011, and other changes will be required in 2012, 2013, 2014, 2016, and 2018. Road signs are also part of highway performance monitoring system data, which are used by the Federal Highway Administration, DOTs, and Congress to support their decision-making processes, including budget allocation. Add to these reasons the need to budget for road sign maintenance and it becomes clear that state DOTs need accurate inventories of a very large number and variety of road signs.

The prevailing method of creating a sign inventory is to write, by hand, information about each sign and then input the information into a database—a time-consuming and error-prone system. Another method uses software to review each frame of a video and extract data about signs for the database. This technique sounds much faster, but repeating the action on millions of images—only about 5 percent of which actually contain a sign—is still very time-consuming. Because this method is labor-intensive and takes so long, it limits the use of the video log images that are widely available. This second method is used in only a few states. DOTs are looking for a quicker method of detecting and recording all types of signs.

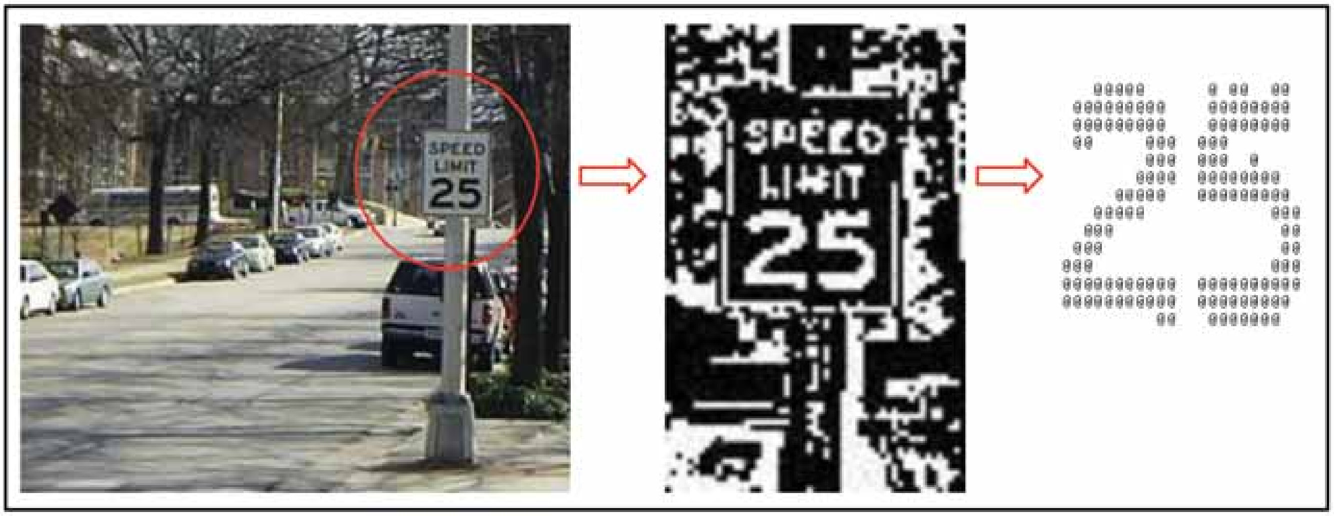
Sign Inventory

With funding provided through NCHRP IDEA Project 121, Dr. Yichang (James) Tsai, a professor of civil and environmental engineering at Georgia Institute of Technology, developed a new way to create a sign inventory. His idea applies two innovative algorithms for analyzing video: one that detects signs and another that recognizes them. These two algorithms form the basis of an intelligent sign inventory and management system. First, the generalized sign recognition algorithm detects a sign based on its shape, color, location in relationship to the road, and other features as specified by the MUTCD. This algorithm detects a sign's shape by using a polygon approximation approach, a statistical color model using an artificial neural network, and probabilistic distribution function (PDF) of sign locations based on training log images in which the sign locations were manually tagged. Next, the sign recognition algorithm uses multi-feature fusion to encode sign information, such as texture, color, sign shape, and PDF to identify the type of sign. Together, these algorithms can detect and recognize more than 670 types of traffic signs specified in the MUTCD much quicker than traditional methods. Preliminary tests were conducted on speed limit signs on an 80-mile stretch of I-75 from Atlanta to Macon, Georgia, and the results are very promising. Figure 1 shows sample results of a traffic sign inventory using these image processing algorithms.

National Interest

Results of the preliminary tests sparked the interest of the U.S. Department of Transportation, which decided to launch a two-year national demonstration of the technology that began in January of this year. The technology will be tested on rural and

Traffic signs can be automatically extracted from video images and labeled onto a Google map so transportation agencies know where their sign assets are.



Traffic sign data inventory using image processing algorithms (left to right: raw image, binary processing, extracted speed limit value).

urban roads in several states. Testing the algorithms in more settings will offer more opportunities to refine them. For example, the algorithms have not been tested on city streets, and it is possible that a window could be falsely recognized as a sign. The algorithms, however, can be tweaked to minimize false positives. Tests will be performed on existing video logs, as well as video obtained by vans throughout the demonstration. The researchers plan to use light detection and ranging (LIDAR) and GPS/GIS technology with the algorithms, so that each record in the inventory would include information on the sign type, condition (such as its retroreflectivity), and location. As part of the demonstration, Tsai also plans to package the algorithms into commercial software. The work and tests performed in this demonstration will prepare the technology for implementation.

In addition to the U.S. DOT demonstration project, the image processing technology has caught the attention of the Port of Savannah, the fourth largest port in the nation. Port officials plan to use the technology to develop a maritime awareness system for detecting and monitoring waterway activities and objects, including containers, vessels, and even dolphins. The hope is that by learning the patterns of logistics and biological activities in their waterways, they will be able to predict and prepare for future activities.

Motivation

Though fruition is near, James Tsai's journey began five or six years ago when he learned that the field of roadway data management needed to develop a sign inventory. He was warned that creating an automated sign inventory would be very challenging, but instead of discouraging Tsai, that motivated him. Tsai believed that if the industry were to move to a paperless, computerized format and automatically extract the necessary information, the process would become both easier and more reliable. That belief led Tsai to the creation of image detection and recognition algorithms.

Implementation

In NCHRP IDEA project 121, Tsai focused on creating software, not hardware. Many vendors already make hardware capable of recording pictures and video of signs from a moving vehicle. The problem comes from the time it takes to extract the necessary information from these systems. Because of this, Tsai created algorithms that could be integrated with multiple hardware systems. He hopes the final product will be able to streamline any organization's sign inventory process.

Principal investigator James Tsai can be contacted at james.tsai@ce.gatech.edu.

> "The prevailing method of creating a sign inventory is ...time-consuming and error-prone"

Strong ARMS to Protect Railroad Wheels

The failure of railroad car components can trigger a catastrophic event. A number of trackside monitoring systems can effectively warn of problems, but only when a train passes a detector. There are also monitoring systems that can be installed on a train for continuous monitoring, but they have invasive installation methods, can introduce other potential failure points, have operating restrictions, and can be expensive.

The research team in Safety IDEA Project 14, led by David Jacobs of L-3 Communications Coleman Aerospace, developed an economical continuous on-board wheel monitoring system for railroad applications known as the autonomous rolling stock system (ARMS). ARMS has the ability to improve railway safety because its continuous monitoring capabilities can warn train operators and railroad car owners before component failure occurs. The ARMS unit is a small electronics package that is attached to the outer hub of a train car wheel. The units on each of the wheels being monitored form a network that communicates data and trends to a central data collection unit on the train for transmission to a central database external to the train. Signal processing algorithms focus on three wheel elements—rollers, bearing cups, and bearing cones—to determine wheel bearing condition and longevity. The researchers expect that even well maintained trains will have some indication of bearing defect signals present, though not as severe as damaged units. Detecting minor bearing defects in real time will provide an opportunity to predict bearing failure.

Laboratory and fields tests were successful. The algorithms were successfully tested and verified in the lab. Field tests demonstrated that the units could be mounted on wheel hubs, produce the expected data, and transfer data sets to the data collection unit. Future work on ARMS will include refining the data collection algorithms, system shock testing, and weather testing. Work will also be done to make ARMS able to withstand the harsh railroad environment, which includes extreme weather conditions and vandals. The researchers plan to team with a commercial partner for implementation.

Project program manager Michael McCurdy can be contacted at Mike.mccurdy@L-3com.com.

Pinpointing Rail Stress

Kinked rail near Fort Campbell, Colorado. Photo courtesy of D.R. Uzarski, Ph.D., P.E., University of Illinois at Urbana-Champaign, Railroad Engineering Program.

Continuous welded rails (CWR) are rail sections that have been welded together to become long continuous members that are fixed at both ends. When the ambient temperature significantly increases or decreases from the rail neutral temperature (RNT), the temperature at which the rails experience zero stress, the metal can expand and cause the rails to buckle or contract and cause the rails to fracture. These effects can, in a worst-case scenario, result in railroad train derailment. Even installing CWR at a median ambient temperature does not guarantee that a rail will not buckle or fracture in the future, and it is sometimes necessary to reinstall the entire rail. A means of preventing these faults is to measure RNT and longitudinal rail stress of CWR to determine if the reinstallation of the entire rail is warranted to increase safety.

Several methods for measuring RNT and longitudinal stress exist, but they each have various pitfalls. RNT is traditionally determined by cutting the rail, measuring the gap, performing calculations, and re-welding the rail; but this method is destructive and labor intensive. Nondestructive methods exist; but they can be costly, are not always accurate, and may require contact with the rail. The technique being created, in Safety IDEA Project 15 by principal investigator Dr. Stefan Hurlebaus of Texas Transportation Institute, is a nondestructive and noncontact method of measuring RNT and longitudinal stress. This technique uses a pulse laser to generate Rayleigh wave polarization, which can be used to determine the longitudinal stress on the rails, and the RNT can be calculated using the relationship between the longitudinal stress, ambient temperature, and material properties. Rayleigh wave polarization is more sensitive and more robust than Rayleigh wave speed; thus it results in more accurate and more precise measurements. Benefits of this technique include: the ability to take measurements while a train is running and the ability to determine longitudinal stress by measuring the polarization of a single point. This technique also reduces the time needed to perform inspections, which can reduce maintenance costs and increase safety.

The properties of Rayleigh wave polarization have been researched. The project investigators constructed a setup with which additional experiments and tests were conducted. Following a thorough evaluation, the concept was tested at the Transportation Technology Center in Pueblo, Colorado. The results show that the polarization of Rayleigh wave changes with longitudinal stress. Knowing the longitudinal stress will help to prevent future buckling of the rail, reducing the number of derailments and increasing safety.

Contact the investigator by email at shurlebaus@civil.tamu.edu.

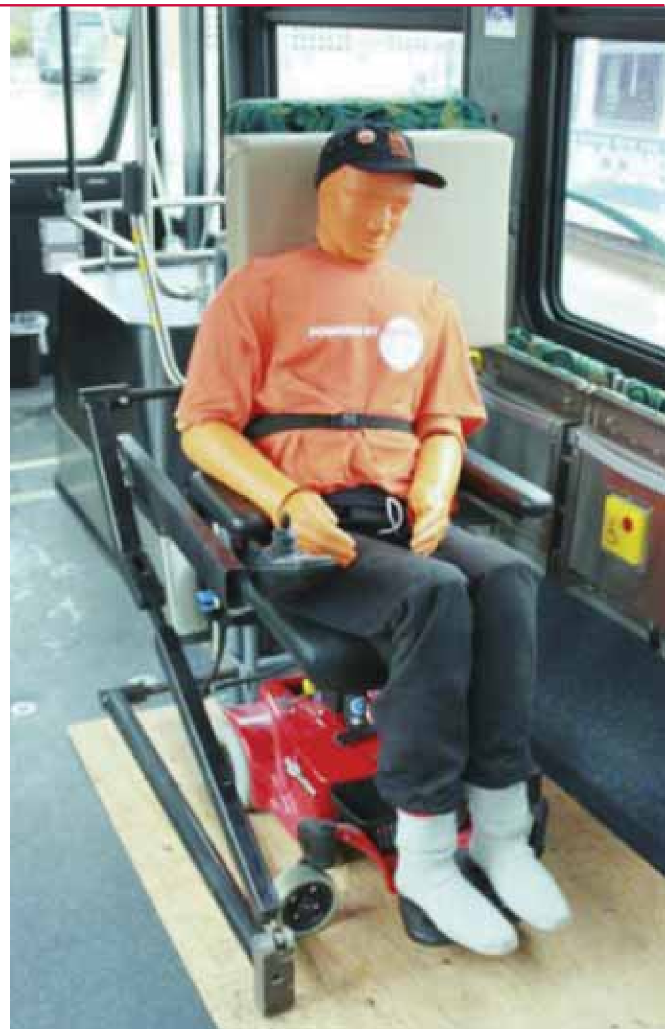
Improving Passenger Safety on Buses

Arrangements for securing wheelchairs on public transit can be difficult to use correctly in real-life situations. Incorrect use can result in unsafe riding conditions for all passengers. However, passengers in wheelchairs can board a large bus and ride it safely, without assistance from the operator, if an appropriate three-sided rear-facing wheelchair containment station is available. It is the third side of containment, the aisle-side of the wheelchair space, where problems arise. It has been challenging to create an aisle-side wheelchair containment that will not affect other passengers but will allow passengers in wheelchairs to ride a bus without assistance.

In Transit IDEA Project 57, Dr. Joseph R. Zaworski of Oregon State University developed and tested a new system for aisle-side containment in the wheelchair station on a bus. This system can be user-deployed and retracted when not in use. When retracted, the system is less than 4 inches wide and extends only 3 inches in front of the backrest. The motion is accomplished with a pair of pneumatic actuators that can be fully automated with push-button operation.

Field tests were conducted with a manual wheelchair and a scooter on an articulated BRT bus at Lane Transit District in Eugene, Oregon. In the tests, which included high-g turns, an anthropomorphic test dummy seated in a wheelchair contained by the system showed virtually no motion toward the aisle for either type of chair.

Principal investigator Joseph R. Zaworski can be contacted at Joe.Zaworski@oregonstate.edu.


Independent Wheelchair Securement

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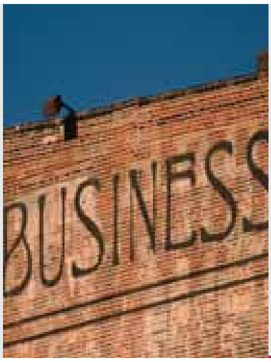

Business

Beam Me Up

The sky is the limit for John Hillman, who recently received the *Engineering News Record* 2010 Award of Excellence for creating the hybrid composite beam (HCB). HCBs have been used in the construction of three bridges and fabrication is under way for a fourth. The first bridge was a field test and evaluation at the Transportation Technology Center in Pueblo, Colorado, with assistance from a consortium of five Class 1 railroads to determine how well prototype beams would hold up under locomotives and fully-loaded freight cars over a prolonged period of time. These tests are still underway. In 2009, two permanent highway bridges were constructed: a 6-beam 58-foot bridge in Illinois and a 6-beam 31-foot bridge in New Jersey. The beams are also being used in the construction of the 8-beam 540-foot Knickerbocker Bridge in Maine, the longest HCB bridge yet, which is expected to open to highway traffic in fall 2011. HCBs could soon be used in Canada as well.

HCBs are corrosion resistant and bridge owners anticipate a service life of 100 years or more, but they are most popular for their light weight. A 30-foot HCB bridge weighs approximately one-seventh as much as a precast concrete bridge and one-third as much as a steel bridge of the same span. The light weight makes it easier and cheaper to ship and erect bridges with HCBs than with traditional materials.

Hillman's acceptance speech for the Award for Excellence acknowledges the role of the IDEA programs in his success: "I can unequivocally state that without the Transportation Research Board and the IDEA programs, I would not be standing before you tonight. I'm pretty sure that the investment of $330,000 to develop the world's first composite railroad bridge is a bargain when compared to other research investments. I encourage our profession to continue to support these programs."

Information about the IDEA project, which was funded jointly by the NCHRP IDEA and the Rail IDEA* programs, is available from Chuck Taylor, former Rail IDEA Program Manager, who can be contacted by e-mail at ctaylor@nas.edu, and from Hillman at HillmanJR@teng.com.

***Funding for this program ended in 2009.**