Human-centered solutions to advance roadway safety

Research and Educational Initiatives

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Roadway Safety Institute

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The Roadway Safety Institute is the University Transportation Center for USDOT Region 5, which includes Minnesota, Illinois, Indiana, Michigan, Ohio, and Wisconsin.

CONSORTIUM MEMBERS

University of Minnesota
Driven to Discover

The University of Akron

Southern Illinois University Edwardsville
Human Centered Solutions to Advance Roadway Safety

Research Overview

• Rail Crossing Safety
• Driver Assist Systems (teenage and older drivers, snowplow operators)
• Tribal Lands
• Vulnerable Users (pedestrians, bicyclists, the visually impaired)
• Intersection Safety
• Safety Policies; Better data
• Impaired Drivers (DWI and obstructive sleep apnea)
• Connected Vehicles (V2V and V2X)
• Work zones: Worker safety/driver distraction
• Safety for design and operations
• Countermeasures for wrong way driving and run-off-road crashes
• See http://www.roadwaysafety.umn.edu/research/index.html
Reliable Planning and Coordination of Emergency Responses to Railroad Incidents

Yanfeng Ouyang, Department of Civil and Environmental Engineering
University of Illinois at Urbana-Champaign

- Railroad incidents (those involving hazardous material) pose significant threats
  - Safety, public health and the environment
  - Huge issue in Midwestern states such as Illinois, Wisconsin, and Minnesota
- Challenges for emergency response systems
  - Emergency response vulnerable to incidents and induced disruptions – **must be reliable, smart, and informed**
  - Catastrophic impact on multiple entities and/or jurisdictions – **must be coordinated**
• Developing tools & guidelines for strategically positioning, allocating, and operating emergency resources in anticipation of rail incidents
  – Capturing probability and correlation of incidents along spatially distributed railroad networks [Xie et al., 2015]
  – Emphasizing vulnerability of the emergency response system itself, such as the risk of disruptions to the transportation network for first-responders (e.g., blockage of railroad crossings) [Xie et al., 2016]
  – Optimizing coordination of emergency responders from multiple jurisdictions (e.g., those from different states and private sector) [An et al., 2016]

• Case studies with real-world context and data
  – Outreach to Illinois and Minnesota government agencies

• Packaging model and algorithm into practical decision-support tools for policy makers, and field implementation

Assessing Severe Injury Risks in Reservation Areas

Kathy Quick and Guillermo Narváez, University of Minnesota

Motor vehicle crashes - Leading cause of unintentional injury for native Americans/Alaskan natives ages 1 to 44

Adult motor vehicle related death rates for native Americans is: 2x that of whites and almost 2x that of blacks
Methodological innovations

• Collaborating with 4 tribal governments on extensive case studies
  → Developed and tested tools for gathering new kinds of data about roadway safety risks in reservations
  → Remedies some commonly found data quality limitations for reservations
  → Undertaking intensive effort to share these methods and tools with tribal governments for their use through meetings organized by tribal governments and Indian affairs organizations, TRB, Lifesavers, etc.

• Engaged in extensive on-site work:
  – 77 researcher days on-site on reservations
  – 101 in-depth interviews with key informants
  – Tabling and data gathering from 199 reservation residents at 9 community events
Findings to date

• The **safety of pedestrians in roadways** is a topic of very elevated concern on reservations, distinguishing them from rural roadway safety issues more generally.

• According to residents and law enforcement, driver and behavior issues (texting, speeding, impairment) on reservations apply to non-residents as much as to reservation residents.

• **Coordination problems among jurisdictions** may be impeding enforcement, road engineering and maintenance, and record-keeping to identify and address key safety concerns.

• Mixed feedback on **safety restraint system use**. In some reservations, education efforts improve use and in others it does not, suggesting a need for additional research on effective education methods.
Imminent Collision Warning System for Bicycles

W. Jeon and R. Rajamani, University of Minnesota

Schematics of sensors and electronics on instrumented bicycle
Bicycle Crash Statistics:

- Over 48,000 bicyclist-motorist crashes and 677 bicyclist fatalities in the U.S. (2011)

- Detailed 10-year study of crashes in the city of Minneapolis:
  - 41% of bicyclist-motorist crashes happen at intersections, another 40% occur within 50 feet of intersections
  - Motorist fails to see bicyclist in a large fraction of accidents
  - The most common pre-crash maneuvers for bicyclists are
    - Bicyclist riding ACROSS roadway (46%)
    - Bicyclist riding in the direction of traffic (29.8%)

Need for a black box recorder on bicycles:

- Most often, no data is available for police to analyze a motorist-bicycle crash

- Inadequate evidence to prosecute the motorist (“Is it OK to Kill Cyclists?” NY Times, Nov 10, 2013)
Objectives:

- Development of a sensor system and an associated imminent collision prediction system for a bicycle
- Sensors on bicycle will address the following three types of crashes:
  - Rear Collision
  - Side Collision with a Right Turning Vehicle
  - Side Collision While Bicycle is Riding ACROSS
Challenges/ Innovations

- Collision warning/ avoidance systems on cars are frontal collision prevention systems
  - A bicycle, however, needs rear and side collision prevention systems
  - Much more complex collision scenarios

- Cost, size and weight of electronics have significant constraints on a bicycle
  - Total allowed cost on a bicycle < $500
  - To use inexpensive sensors, need novel estimation and tracking algorithms
Rear Collision Prevention

Video – Tracking Rear Approaching Vehicle

- Video shows motion control of the rear laser sensor
- Rear vehicle turns towards bicycle and receives audible warning

Watch the video
Computerized Crash Reports Usability and Design Investigation

Nichole Morris, HumanFIRST Lab, University of Minnesota

• Minnesota’s electronic crash report was outdated and too rigid for easy and accurate data entry
  – Initiative: Rebuild the entire crash records database
  – Opportunity to completely rebuild the crash report interface with the *user in mind*

• **Goal:** Design and create a crash report interface that improves accuracy, speed, reliability, and meaningfulness of crash report data
  – Utilize Human Factors analyses and principles
  – Capitalize on the experience and expertise of law enforcement
Phase 1: Human Factors Analysis

• Assess existing crash report using HF principles to address human and system performance issues
  – Hierarchical Task Analysis
    • 175 steps for reporting on a single unit crash
    • Breakdown of 151: 24 represented division of responsibilities between the user & system
  – Cognitive Walkthrough Analyses and Interviews
    • 12 officers from 7 agencies
  – Card Sorting Task and Survey
    • 167 officers from 68 agencies

• Main Findings:
  – Users preferred a one-to-many structure
  – Multiple reliability issues
  – Many components unclear regarding rules
Phase 2: Design & Usability Testing

- **Aim:** Build 2 mock interfaces based on findings of Phase 1
  - **Wizard:** Step-by-step queries; predetermined order
  - **Form:** Clearly divided interface; less restrictive workflow
  - Embed decision aids and intelligent reveal functions into both

- **Conducted 4 major rounds of usability testing**
  - 59 law enforcement officers from 32 agencies
  - Assessed error rate, usability and acceptance, and mental demand

- **Results:** Preference averaged to a 50/50 split
  - Both interfaces were recommended for use
  - No significant differences in usability, mental effort or duration between interfaces
    - Form slightly better under complex scenarios

- **Shift of Responsibilities** between user and system
  - Nearly 1:1 ratio!

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Final Results and Implementation

• Researchers worked with the state vendor, Appriss, to put both interfaces into practice
  – Assisted with Quality control, Beta Testing, User Acceptance Testing
  – Continued usability testing to guide final modifications
• Where are we now?
  – The system went live Jan 1st, 2016
  – ~40,000 crashes have been logged in the new reports (by early March, 2016)
  – Limited need for training and positive feedback!
• What’s next?
  – Measure accuracy and completeness of new crash data
  – Monitor use, reliability, and accuracy of crash reporting across the different interfaces
Exploring Relationships between Medical Conditions and Safety Performance in Commercial Drivers

Stephen Burks and Jon Anderson
University of Minnesota, Morris

In collaboration with Harvard Medical School, Virginia Tech Transportation Institute, and undergraduate research students at the University of Minnesota Morris
• **Focus**: Obstructive Sleep Apnea (OSA) in commercial drivers. Addressing potential differences in crash risks and medical insurance costs by OSA-status (diagnosis, and if positive, treatment success).

• **Importance**: Significant resistance among industry stakeholders to regulations requiring OSA screening and treatment for commercial drivers based on perceived benefits and costs. Medical insurance cost differences to the operator may provide a significant offsetting benefit.

• **Recent Publication**: Paper connecting the refusal to adhere to mandated sleep apnea treatment among drivers with OSA with increased risk of a preventable DOT-reportable heavy truck crash. Journal: *Sleep*, web release 3/21/16.

• **Current activity**: Using several different statistical approaches to quantify the differences in medical insurance costs by treatment adherence among tractor-trailer drivers, diagnosed positive for obstructive sleep apnea compared to appropriate controls.
• **What has been learned thus far?** Compared to controls who were screened unlikely to have the disease, drivers with OSA who are **NOT treatment-adherent** have a 5-fold increase in the risk of a preventable DOT-reportable crash, and drivers with OSA who **ARE treatment-adherent** are not statistically different from controls.

• **Interpretation:** If 1,000 drivers of each type worked for one year (100,000 miles) the controls and adherent drivers would have **about 14 preventable DOT-reportable heavy truck crashes.** Non-adherent drivers with OSA would have 70.

• **Public Policy Issue:** Because these drivers were diagnosed in a program internal to a specific motor carrier, non-adherent drivers with OSA can choose to quit (as did 60% of study subjects) and work at a carrier without such a program by keeping their diagnosis private.

• **Impact of research:** These results will be scrutinized in the Advance Notice of Proposed Rulemaking jointly announced by the Federal Motor Carrier Safety Administration and the Federal Railroad Administration on March 8, 2016.
Enhancing Worker Safety using DSRC-based V2X: Warning vehicle operators regarding worker presence

M. Imran Hayee, University of Minnesota Duluth

Ordinary vehicle
DSRC-equipped vehicle
Construction vehicle with DSRC-equipped monitor
Worker wearing DSRC unit
Work Zone Fatalities

- Work zone related accidents cause 20,000 injuries and 100 deaths among workers every year.

- 35% of total work zone accidents result from heavy machinery hitting a worker. Majority of deaths occur due to these accidents.

- The proposed project can help minimize these fatalities by providing improved situational awareness to heavy machine operators.
System Development

- Testing Feasibility of Wearable DSRC Device for Workers
- Developing DSRC-based Warning Interface for Construction Vehicle and Software for the DSRC-based Monitoring Subsystem
Tracking trajectory of worker walking around vehicle
Education and Workforce Development Activities

– Pedestrian safety exhibit in development with The Works Museum for K-12 audience, opening June 2016

– Summer camp introducing transportation safety to Native American students in grades 4-8

– 18 travel awards to students to attend regional and national conferences, including Student of the Year
Technology Transfer Activities

– Hosted 3 pedestrian safety workshops in Wisconsin, Indiana, and Ohio for nearly 100 transportation professionals across the region to discuss new innovations and identify common issues

– Developed and delivered an implementation-focused webinar series with Region 7 UTC at Iowa State University

– Published RSI Biennial Report
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