Research and Educational Initiatives

Max Donath
Director
Roadway Safety Institute

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Pittsburgh
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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 Illinois
Western Michigan University
University of Akron
University of Minnesota
Southern Illinois University Edwardsville
Human Centered Solutions to Advance Roadway Safety

Research Overview

- Rail Grade Crossings
- Tribal Lands
- Connected Vehicles
- Intersections
- Vulnerable Users
- Impaired Drivers
- Safety Policy
- New work zone/driver distraction projects funded by state DOT partners starting later this year
Real-time arrival prediction at grade crossings

Ren Wang and Dan Work
Department of Civil and Environmental Engineering
University of Illinois at Urbana Champaign
• **Motivation:** Improve safety at rail crossings
  – 239 deaths, 763 serious injuries (2014, FRA)

• **Our research:** developing data driven prediction algorithms to estimate arrivals at grade crossings
  – *Phase 1:* Historical predictors
  – *Phase 2:* Online, real-time predictors for improved performance

• **Application areas**
  – “In-vehicle” potential collision alerts broadcast to approaching vehicles
  – Improved staging of emergency response vehicles (Y. Ouyang, UIUC)

• **Progress**
  – Exploration of Amtrak data to understand delay patterns
  – Development of a *vector autoregressive process* (VAR) forecast algorithm
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 involving hazardous material pose significant threats
– Safety, public health and the environment
– Major 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**
– Catastrophic consequences directly impact 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
  – 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)
  – Optimizing coordination of emergency responders from multiple jurisdictions (e.g., those from different states and private sector)

• 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
Accident Prediction Models at Grade Rail Crossings using Macro and Micro Scale Analysis

Rahim F. Benekohal and Juan C. Medina
Department of Civil and Environmental Engineering
University of Illinois at Urbana-Champaign

Micro Analysis at a crossings
- Create pattern trees (now static, later dynamic)
- Identify contributing factors
- Find crash occurrence and risk

Macro Analysis (at regional/national level):
- Statistical models being developed
- Incorporate new variables from micro analysis
- Comparisons with current prediction models
Microscopic Analysis of Crashes at Chestnut/Lehigh crossing in Glenview, IL

Findings:
- The **youngest** driver was 61 years old.
- In 4 of 5 crashes, the vehicle was stopped at the crossing.
- 3 of 4 crashes happen after dark.
Assessing Severe Injury Risks in Reservation Areas

Kathy Quick and Guillermo Narváez
Humphrey School of Public Affairs
University of Minnesota

Motor vehicle crashes is 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

Ongoing collaboration with American Indian community leaders

Translate findings into strategies for resources, management, and policy

Gather community stakeholders insights on crash risks

Characterize patterns (risks, information gaps, success stories, priority needs)
Preliminary Findings of Interest

• Elevated concern regarding pedestrian safety, which distinguishes reservation from other rural areas.

• Driver education and behavior concerns regarding non-residents as well as residents.

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

• Interaction of multiple factors relating to poverty and isolation.

• Inconsistent use of safety restraint systems. These findings are supported by previous research.
GIS and Tribal Traffic Safety

Thomas A. Horan and Brian N. Hilton
Claremont Graduate University

Traffic Crash Injury Hot Spots on MN Tribal Lands (Source: MNDOT and FARS, 2008-2012)

Safety Audit Findings on MN Tribal Lands (Source: MN DOT, 2014). Areas in dark red indicate increased risk.
GIS and Tribal Traffic Safety

• This study investigates the potential for new advances in Geographic Information Systems (GIS) to enhance the collection, availability, and use of information related to transportation safety.

• New advances include tools for quick hotspot analysis, mobile means for crash data collection and reporting, and online portals for sharing tools among tribes.

• Conducted in partnership with Esri, the study includes an assessment of Tribal geo-related traffic safety needs, uses and applications.

• Through collaborative analysis with tribal communities, the study will also develop prototypes for potential use that will be evaluated through a series of stakeholder assessments.
Acquisition of Vehicles’ Trajectories in Real Time

Imran Hayee

Connected Vehicles Research Lab (CVRL)
EE Department, University of Minnesota Duluth

Object: Acquisition of relative vehicle trajectories using connected vehicles technology to implement freeway merge assist system

Method: Differential GPS technique using simple GPS receivers to obtain lane level resolution.

Progress: Initial Field Tests performed; the results are encouraging.
A field trial was conducted on W Arrowhead Rd with two vehicles having DSRC devices. Vehicles started on different lanes and switched lanes in the middle of the trial. The blue and red dotted lines show the relative positions of the two vehicles. The time line shows the relative position of the two vehicles at the same time.
RSI Connected Vehicle Testbed

John Hourdos and Stephen Zitzow
Minnesota Traffic Observatory (MTO)
University of Minnesota

• I-94 High Crash Area
  Minneapolis, MN
  – 150+ crashes every year
• Minnesota Traffic Observatory (MTO) past research has produced algorithms that successfully detect crash prone conditions.
  – Algorithms serve as a trigger mechanism for driver warning system
  – Requires advanced, minimal, but targeted traffic detection infrastructure.
• Phase II: V2I Queue Warning (Fall 2015)
  – New High-Resolution sensors capturing vehicle trajectories
  – Test vehicle with DSRC: warning from infrastructure to in-vehicle display
  – Test INFLO Q-WARN algorithm
• Phase III: V2I Speed Harmonization (Early 2016)
  – Test INFLO SPD-HARM algorithm
    • Utilize broadcast BSM when available.
    – Individual lane advisory speed 1+ mile upstream of high-crash area
• Exploratory phase:
  – Test the accuracy of the system in emulating the BSM for every vehicle in the instrumented area
Developing and Validating a Model of Left Turn Crashes to Support Safer Design and Operations

Gary Davis and Abhisek Mudgal
Department of Civil, Environmental and Geo-Engineering
University of Minnesota

Crash Scene Diagram

On-coming Vehicle

Left-turning Vehicle
OBJECTIVE: Validated causal model of left turn crash frequency to support safe design and operation

Model structure:
- Discrete choice model of gap acceptance
- Kinematic modeling of left turn/opposing vehicle interaction, given gap acceptance
- Monte Carlo sampling from distributions characterizing traffic conditions and driver actions

Phase 1: Modeling left turn behavior
- Literature review: gap acceptance a critical component of accurate crash simulation
- Gap acceptance data developed from video of left turn movements
- Logarithm of time gap significantly better as predictor of gap acceptance compared to traditionally-used untransformed gap
- Drivers who accepted long gaps also took longer to complete turn

Phase 2: Gap acceptance model incorporated in prototype causal model
- Prototype model produced crash probabilities of appropriate order of magnitude
- Prototype model showed variation in relative risk similar to that shown by statistical model being developed for MnDOT

Phase 3: ON-GOING RESEARCH
- Reconstruction of left-turn crashes from NHTSA National Automotive Sampling System
- Comparing reconstructed left-turn crashes to crashes as described by causal model
Positioning and Mapping Methodology Using Bluetooth and Smartphone Technologies to Support Situation Awareness and Wayfinding for the Visually Impaired

Chen-Fu Liao

Minnesota Traffic Observatory (MTO), University of Minnesota

Illustration of Bluetooth Low Energy (BLE) Beacons Placed at an Intersection

A BLE device (1.63” Dia. x 0.75”)

Illustration of Bluetooth Low Energy (BLE) Beacons Placed at an Intersection
• Provide traffic information such as signal timing or work zone info to the visually impaired thru a smartphone

• Develop Bluetooth Low Energy (BLE) system prototype that is “self-aware” and
  – Can handle situations when GPS signals not reliable or accessible
  – Can detect when batteries are low or when BLE tags have been vandalized, and
  – Monitors infrastructure and makes sure information is up-to-date

• Develop smartphone app to integrate
  – GPS & motion sensors on the smartphone
  – BLE tags placed in the environment

• Provide audible messages (signal, work zone, etc.) to pedestrians through Text-to-Speech (TTS) interface

• Field evaluation and system validation
• Goal (long-term)
  – Decrease bicyclists and pedestrian accidents, injuries, and deaths
• Objectives (RSI project)
  – Develop practical methods to estimate bicycle and pedestrian traffic volumes and assess exposure to risk
  – Conduct case studies in large and small communities (Minneapolis, Duluth, Bemidji, Grand Marais)
  – Work with state and local officials to assess exposure to risk on roads, sidewalks, and trails
Assessing Exposure to Risk:
Case Study: Minneapolis Trail Crossings

- Measure exposure at 261 trail crossings (mid-block, intersection)
- Apply signal and beacon warrants
- Set priorities for new safety treatments based on risk
- Inform decisions that may save lives
Safety in Numbers? Accessibility, Traffic, and Safety of Non-motorized Travelers

Andrew Owen and David Levinson
Department of Civil, Environmental, and Geo-Engineering
University of Minnesota

Goals:
- Model non-motorized traveler risk based on multi-modal traffic volumes
- Maximize model coverage by imputing traffic levels based on accessibility and network structure
- Phase 1 focusing on pedestrian risk

Job accessibility by walking + transit
Minneapolis–Saint Paul, MN
• Collecting data for 18 North American metro areas:
  – Crash data involving non-motorized travel
  – Motorized & non-motorized traffic volume
  – Pedestrian & road network data

• Testing crash rate model formulations using:
  – Motorized & non-motorized traffic volume
  – Local accessibility
  – Local network link/node centrality

• Initial results in Minneapolis – Saint Paul, MN metro:
  – “Safety in numbers” effect exists for both motorized and non-motorized traffic
  – Correlation: locations with higher pedestrian accessibility tend to be safer
Imminent Collision Warning System for Bicycles

Rajesh Rajamani and Woongsun Jeon
Laboratory for Innovations in Sensing, Estimation and Control (LISEC)
University of Minnesota

Schematics of sensors and electronics on instrumented bicycle
• Development of novel sensor suite for a bicycle and an associated imminent collision prediction system
  – Emphasis on intersection crashes and rear-collisions
  – Detailed 10-year study of crashes in the city of Minneapolis illustrated that 41% of bicyclist-motorist crashes happen at intersections, another 40% occur within 50 feet of intersections
  – Over 48,000 bicyclist-motorist crashes and 677 bicyclist fatalities in the US (2011)
• Sonar sensor system can measure both radial distance and angle of a moving side target
• Experimental studies with an instrumented bicycle
• Implementation of a black box event recorder
Older Driver Support System

Nichole L. Morris

HumanFIRST Laboratory, Department of Mechanical Engineering
University of Minnesota

• The US population 65 years and older is expected to increase from 13.5% in 2012 to 20% in 2030

• Older drivers represent:
  – 2\textsuperscript{nd} highest injury and fatality rate per 10,000 licensed drivers (next to teenage drivers)
  – 1\textsuperscript{st} in fatalities per 100 million miles driven

• Older drivers (75+ years) are represented in a relatively low percent of total US crashes (~3%), but account for nearly 11% of driver deaths

National fatal passenger vehicle driver crash involvements per 100 million vehicle miles traveled by age group, 2007. Based on National Household Travel Survey VMT by Age and NHTSA FARS. [19]
Project Goals

• Determine the needs and wants of older drivers regarding the features and functionality of an in-vehicle support system
  – Usability and design investigation

• Modify an existing smartphone-based system built for teens to meet the needs and specifications of an older driver population into a functional prototype.

• Test in a controlled field study
  – Driver acceptance
  – Driver performance
Alcohol Related Hot Spot Analysis and Prediction

William H. Schneider, Center for Transportation Safety and Innovation (CTSI)  
University of Akron

Hot Spot Map of  
Fatal Stark County  
Alcohol Related Crashes

Identification of statistical crash clusters for safety campaign enforcement
• Develop geo-statistical based algorithms and applications that determine statistically clustered crash locations
  – Identify high risk crash areas.
  – Provide unbiased statistical justification of problem areas.

• Examine how crash clusters are affected by:
  – Environmental surroundings (e.g. weather, terrain)
  – Social surroundings (i.e. vehicle registration). For example, the social environment may affect destinations and routes taken; drivers with alcohol problems may wish to avoid known locations where law enforcement personnel congregate.

• Reduce errors in the prediction of clustered crashes.

• Analyze the spatial movement of crash clusters.
Directional Rumble Strips (DRS) for Reducing Wrong-way Driving (WWD) Freeway Entries

Albert Luo (Co-PI) – Southern Illinois University of Edwardsville
Huaguo Zhou (Co-PI) – Auburn University
4 graduate research assistants

m = mass of vehicle

x(t) = velocity of vehicle

Suspension system

Neglected unsprung mass

Rumble Strips

Correct direction of travel

\[ t_1 \]

\[ t_2 \]
Wrong-way entry on freeways has been identified as a serious traffic safety problem. A recent study of the Fatality Analysis Reporting System (FARS) showed that traffic fatalities caused by WWD between 300 and 400 annually from 2004 to 2011 in the United States (ATSSA, 2014).

A comprehensive literature review has been conducted. A survey questionnaire has been designed to find out the best practices.

Test and measure vibrations and sound levels of passenger vehicles on current existing rumble strips on different roads.

A mechanical dynamics model and mathematical method have been formulated to predict vibrations of the vehicle.

Field test of initially-designed DRS was performed to verify the theoretical analysis.
Exploring the Relationships between Medical Conditions and Safety Performance in Commercial Drivers

Stephen Burks and Jon Anderson
The Truckers & Turnover Project
University of Minnesota, Morris

In collaboration with Harvard Medical School, Virginia Tech Transportation Institute, and undergraduate research students at the University of Minnesota Morris
• **Initial focus:** Extending work on Obstructive Sleep Apnea (OSA) in commercial drivers to address potential differences in 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 costs. Medical insurance cost differences may provide a significant offsetting benefit.

• **Current activity:** Constructing merged data sets for analysis from operational data for a participating motor carrier and medical insurance claims data from its medical insurance provider.

• **Challenge:** In this retrospective study of a driver population with high job turnover, having a preventable crash—the dependent variable of interest—affects who enters the study versus who is filtered out before being observed. The analysis must correctly account for these “selection effects” before moving to examine health insurance costs.
Reconciling Stakeholder Perspectives in Deploying Automated Speed Enforcement

Frank Douma, Nichole Morris, Spencer Peck
Humphrey School of Public Affairs
University of Minnesota
• Empirical Evidence Shows Safety Benefits of ASE
  – Reduced speeds and crash severity
• Still a Controversial Policy
  – Inconsistent Deployment Methods
  – Due Process Concerns
  – Anger that fines are being used for revenue generation
• Seeking to Crystalize and Understand Stakeholder Positions
  – Identify and Interview Key Influencers
  – Asking about perceptions of Colleagues, not personal or official positions
Roadway Safety Policy & Leadership Study

Lee Munnich
State and Local Policy Program, Humphrey School of Public Affairs
University of Minnesota

• Assess and compare current highway safety policies among six Midwest UTC states
• Using policies from national Toward Zero Deaths program, scoring criteria established to measure absolute and relative strength of state roadway safety policy
• Study also examines underlying issues contributing to adoption of TZD policies
  • Interviews with state legislators, legislative staff, traffic safety officials provide basis for additional analysis and scoring
  • Better understanding of underlying issues contributing to – or hindering – state policy adoption
## Implementation of Road Safety Measures

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Education and Workforce Development Activities

Attract and prepare future transportation professionals

– Traffic safety exhibit to be developed with The Works Museum for K-12 audience
– Summer camp introducing transportation safety to Native American students in grades 4-8
– Develop safety-related STEM curriculum for use in museum exhibit and summer camps noted above
– 10-week internship program with MnDOT Office of Traffic, Safety, and Technology to introduce undergraduate students to careers in transportation safety; expand to other DOTs in Region 5 in summer 2016
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Roadway Safety Showcase:
Safety Innovations for Today and Tomorrow
May 21, 2015
St. Paul, Minnesota