SHRP 2 Naturalistic Driving Study (NDS)

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In the next 40 minutes

- What’s a Naturalistic Driving Study?
- SHRP 2 NDS study – high-level overview
- NDS analyses – examples of research topics and goals
- How to use the data
- NDS website demonstration
- Questions, discussion, where to go for more information
Naturalistic Driving Studies

• Method: instrument volunteer drivers’ vehicles – continuously observe and record their driving for months or years
  – What do drivers really do? Speeding, tailgating, cell phone, alcohol …
  – What were they doing just before they crashed? Usual crash studies can only guess.
  – How do drivers react to cues from the vehicle and environment?
SHRP 2 Study Design

Two linked databases providing unprecedented detail on driver behavior and driver interaction with roadway features

• Naturalistic Driving Study (NDS) data – VTTI, Virginia Tech
  – record of every trip by volunteer drivers over 12-24 months
  – 3,147 drivers, male and female, all ages
  – 1,900 vehicles on the road at any time

• Roadway (RID) data – CTRE, Iowa State
  – from mobile van data collection in study areas
  – from roadway inventory
  – from other state data sources
NDS Study Design

- Largest Naturalistic Driving Study Ever Undertaken
  - 3,147 drivers, all age/gender groups.
  - 3,958 data years; 5 M trip files; 35 M vehicle miles
  - 2 years of data collection
    - Most participants 1 to 2 years
  - Vehicle Types: All light vehicles
    - Passenger Cars
    - Minivans
    - SUVs
    - Pickup Trucks
  - Six data collection sites
- Integrated with detailed roadway information
NDS Data Overview

- Driver demographics, assessments
- Vehicle descriptors

TRIP DATA
- Multiple Videos
- Machine Vision
  - Eyes Forward Monitor
  - Lane Tracker
- Accelerometer Data (3 axis)
- Rate Sensors (3 axis)
- GPS
  - Latitude, Longitude, Elevation, Time, Velocity
- Forward Radar
  - X and Y positions
  - X and Y Velocities
- Cell Phone Records
  - Beginning and end of all cell phone conversations on major carriers
- Passive Alcohol Sensor
- Illuminance sensor
- Infrared illumination
- Incident push button
  - Audio (only on incident push button)
- Turn signals
- Vehicle network data
  - Accelerator
  - Brake pedal activation
  - ABS
  - Gear position
  - Steering wheel angle
  - Speed
  - Horn
  - Seat Belt Information
  - Airbag deployment
  - Many more variables…
Data Acquisition System (DAS)
NDS Data Example
Roadway (RID) Data Overview

• New data: collected at highway speed from van, 12,538 centerline miles (both directions)
  – curvature location, length, radius; grade; cross-slope; lane number, width, type; shoulder type (width if paved); all MUTCD signs; medians; barriers; rumble strips; lighting; intersection location, number of approaches, and control type; videolog

• Existing data from ESRI and state inventories in 6 study states: any available roadway information – varies by state

• Supplemental data from 6 states: traffic, weather; work zones; crashes; roadway improvements; laws
Scope: 12,538 centerline miles in the 6 NDS sites

Method: Instrumented Van
## Videolog Images

<table>
<thead>
<tr>
<th>Route Name</th>
<th>Direction</th>
<th>Chainage</th>
<th>State</th>
<th>Collection Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>US 70</td>
<td>6</td>
<td>17.215</td>
<td>NC</td>
<td>11/03/2011</td>
</tr>
</tbody>
</table>
SHRP 2 Roadway Information Database (RID)
Geospatial database to manage and access disparate data sets

Mobile Van Data
- New data SHRP 2 collected
- Quality assured to meet project specs
- 25,000 driven/12,500 centerline miles across the six NDS sites

<table>
<thead>
<tr>
<th>Site</th>
<th>Total miles collected</th>
<th>% Rural/Urban</th>
</tr>
</thead>
<tbody>
<tr>
<td>FL</td>
<td>4,366</td>
<td>Rural: 45% Urban: 55%</td>
</tr>
<tr>
<td>IN</td>
<td>4,635</td>
<td>Rural: 64% Urban: 36%</td>
</tr>
<tr>
<td>NC</td>
<td>4,558</td>
<td>Rural: 59% Urban: 41%</td>
</tr>
<tr>
<td>NY</td>
<td>3,570</td>
<td>Rural: 68% Urban: 32%</td>
</tr>
<tr>
<td>PA</td>
<td>3,670</td>
<td>Rural: 83% Urban: 17%</td>
</tr>
<tr>
<td>WA</td>
<td>4,277</td>
<td>Rural: 31% Urban: 69%</td>
</tr>
<tr>
<td>Total</td>
<td>25,076</td>
<td></td>
</tr>
</tbody>
</table>

Types of Mobile Van Data
- **Horizontal Curvature**: Radius, Length, PC, PT, Direction
- **Grade**
- **Cross Slope**
- **Lane** in terms of the number, width, and type (turn, passing, acceleration, car pool, etc.)
- **Shoulder** type/curb; paved width if exists
- **Intersection** location, number of approaches, and control (uncontrolled, all-way stop, two-way stop, yield, signalized, roundabout). Ramp termini are considered intersections
- **All MUTCD signs**
- **Barriers**
- **Median** presence (Y/N), type (depressed, raised, flush, barrier)
- **Rumble Strip** presence (Y/N) location (centerline, edgeline, shoulder)
- **Lighting** presence (Y/N)

Acquired Roadway Data
Existing roadway inventory data acquired from agencies such as the six State DOTs (Data items not consistent)
- ~200,000 centerline miles
- Includes HPMS files for the six states plus:
  - Functional Classification
  - Signals
  - Intersections
  - Access Control
  - Pavement Condition
  - Bridge Location
  - Vertical Alignment
  - Interchanges
  - Rest Areas
  - Terrain
  - Tunnels
  - FRA grade crossings

Acquired Supplemental Data
Existing data and information from State DOTs, Public Agencies, and Private Sources:
- ~200,000 centerline miles
- Crash history data
- Traffic information – AADT
- Traffic Data - continuous counts (ATR)
- Traffic Data - short duration counts
- Aerial imagery
- Speed limit data
- Speed limit laws
- Cell phone and text messaging laws
- Automated enforcement laws
- Alcohol-impaired and drugged drivers laws
- Graduated driver licensing (GDL) laws
- State motor cycle helmet use laws
- Seat belt use laws
- Local climatological data (LCD) NOAA
- Cooperative weather observer/other sources
- Winter road conditions (DOT)
- Work zone
- 511 information
- Changes to existing infrastructure condition
- Roadway capacity improvements

All data (mobile van data and acquired data) are referenced to a common basemap that covers the continental US
Data Summary

- 3,593 participants
- 3,958 vehicle-years
- 5 M trip files
- 35 M miles of driving
- 1,604 crashes, 2,778 near-crashes
- 12,538 centerline miles of roadway data collected by van
- 200,000 centerline miles of state roadway inventory data collected
SHRP 2 NDS Data Analyses

- 200 active or completed studies, 500 qualified researchers
- 68 published papers
NDS Study Topics

• Drivers
  – Distraction: secondary tasks, cell phones
  – Risk perception
  – Teens; older drivers; drivers with ADHD etc.
  – Belt use
  – Urban driving profiles

• Pedestrians
  – Signalized intersections
  – High visibility crosswalks

• Speeding
  – Speed limits
  – Speeding and road geometry
Analysis Topics

• Roadways
  – Rural 2-lane roads, horizontal and vertical curves, intersections
  – Lane departures
  – Freeway interchanges
  – Offset left-turn lanes
• Vehicles
  – Benefits of active safety and autonomous driving features
• Weather and lighting
  – Roadway lighting
  – Adverse weather conditions
• Work zones
• Modeling
  – Calibrate traffic simulation models
Safer glances, driver inattention, and crash risk in lead-vehicle following

Trent Victor,
Jonas Bärgman, Christian-Nils Boda, Marco Dozza, Johan Engström, Carol Flannagan, John D. Lee, Gustav Markkula

SHRP2 Phase 2 Final Report ETG Presentation 10 June, 2014
Research Topic

- Determine the relationship between driver inattention and crash risk in lead-vehicle pre-crash scenarios (rear-end crashes)

- **Show which glance behaviors are safer than others**
- Pinpoint the most dangerous glances away from the road
Glance locations in Random Baselines

- No Eyes Visible – Glance Location Unknown
- Forward
- Left&Right Windshields
- Left&Right Windows/mirrors
- Rearview mirror
- Instrument Cluster
- Center Stack
- Passenger
- Cell phone
- Other
- Interior object
- Eyes closed
- Over-the-Shoulder (left or right)
Glance locations in Matched Baselines

- No Eyes Visible – Glance Location Unknown
- Forward
- Left & Right Windshields
- Left & Right Windows/mirrors
- Instrument Cluster
- Center Stack
- Rearview mirror
- Other
- Passenger
- Interior object
- Cell phone
Glance locations before Near Crashes (minTTC)
Glance locations before Crash

- No Eyes Visible – Glance Location Unknown
- Not Annotated
- Forward
- Left & Right Windshields
- Left & Right Windows/mirrors
- Rearview mirror
- Over-the-Shoulder (left or right)
- Center Stack
- Instrument Cluster
- Cell phone
- Eyes closed
- Interior object
- Other
- Passenger

Percentage [%]

Time [s]
Rear-end crashes and near-crashes

- Most crashes result from a "perfect mismatch" – the interaction between last glance duration and the rate at which the situation changed.
- **Most crashes were associated with glances away from the road shorter than 2 seconds.**
- **Brake lights have little effect on following driver reaction.**

Implications

1. Distraction policy, regulation, guidelines: short glances can be risky.
2. Benefit of intelligent vehicle safety systems, e.g. Forward Collision Warning.
3. Safety benefit of good highway operations: reduce sudden stops.
4. Teach safe glance behaviors: glance away from roadway only with adequate headway.
How to Use the Data
Overview of the NDS Data

• Size: the file is huge
  – 2 petabytes = 2 million 1 gig flash drives
  – “Give me the whole raw data file” isn’t possible or sensible

• Complexity: different data types
  – Categorical data constant over a trip: driver age, vehicle type
  – Sampled data: collected at original resolution (once a trip up to 640 Hz during a crash): speed, acceleration, GPS position, radar, vehicle network information
  – Video data from 4 cameras; must be coded
    • Automated reduction: lane tracker
    • Manual reduction: all other items for specific analyses

• Privacy considerations: personally-identifying data (PII)
  – Video and other personal information access only with IRB approval for qualified researchers in secure location
Overview of the RID Data

- **Size**: the file is manageable
  - 50-60 GB without video, 6-8 TB with video
- **Complexity**: 4 different data sources
  - ESRI: baseline data for entire country, very few variables
  - State roadway inventory data: from 6 study states; data vary by state
  - Mobile van data: very detailed, about 12,500 centerline miles; includes forward video
  - Supplemental data: from 6 study states, data vary by state
- **Privacy considerations**: should be none
  - Video data may require IRB to determine exemption from IRB review
Bite-sized NDS Data - How to Eat the Elephant

- Trip summary file
- Crashes, near-crashes, baseline files
  - events and epochs
- Website data
- Other data enhancements
- Reduced data sets
Trip Summary File

• Trip summary file - categorical data on each trip
  (1 spreadsheet row per trip)
  – Identify trips of interest
  – Can be analyzed directly

• Variables
  – Driver data – demographics, driver assessments
  – Vehicle data – descriptive
  – Roadway data – roadway class, speed limit, rural-urban
  – Trip data – duration, speed, accelerations, headway, time to collision, etc.
  – Variables that change during a trip in bins, counts, or max/min:
    • speed bins 0-10 mph, 10-20 mph, etc. – time or % of trip in each
    • number of accelerations higher than threshold value
    • minimum time to collision
Crashes, Near-Crashes, Baseline Files

- Crashes: 1,604, varying severity
  - Most researchers want to examine crashes
- Near-crashes: “almost” crash but for sudden maneuver; 2,778
  - Crash surrogates; how did driver avoid a crash
- Baseline: 20,000 random, 12,589 additional matched
  - Denominator for risk calculations; measure overall prevalence
- Epoch files for each
  - 30-second data segments (20 before, 10 after; only 20 for baseline)
  - Includes most sensor data plus forward video
  - Manual eye-glance coding, other coded variables
- Event files for each
  - Categorical data coded from last 6 seconds of “before” data
  - Manual video reduction; data dictionary on website
  - Available on website
Website Data

- Data de-identified; no PII; fairly easy to access
- Descriptive data for whole data file
  - Drivers – age and gender distributions, etc.
  - Vehicles – type, age, etc.
  - Trips – number, mileage, etc.
- Categorical data on all trips – from trip summary
- Event data from crashes, near-crashes, baseline
- Viewer for forward video and time series data display for crashes and near-crashes – coming soon
  - Approximately 20 seconds before precipitating event (e.g. lead vehicle slamming on brakes) and 10 seconds after
Event ID: 2934487
Event Severity 1: Crash
Event Severity 2: Not Applicable
Event Nature 1: Conflict with a lead vehicle
Event Nature 2: None
Vehicle 1 Config: 20
Vehicle 2 Config: 20
Vehicle 3 Config: 21

Final Narrative: Subject vehicle is travelling on busy 4-lane highway in third lane from the left, with leftmost lane possibly serving as HOV lane. Subject, interacting with GPS unit mounted on windshield beneath rearview mirror by repeatedly looking at unit and pressing buttons, does not recognize activity of lead vehicle as it slows and stops unexpectedly too late to react appropriately and rear-ends lead vehicle.

Precipitating Event: Other vehicle ahead - slowed and stopped 2 seconds or less
Event Start: 1669177
Event End: 1675098
(Non)Motorist 2 Evasive Maneuver: No reaction
(Non)Motorist 2 Pre-Incident Maneuver: Decelerating in traffic lane
(Non)Motorist 3 Evasive Maneuver: Not applicable
(Non)Motorist 3 Pre-Incident Maneuver: Not applicable
Other Data Enhancements

- Radar data processing and coding
  - Headway, time to collision
- Identify trips with possible alcohol use
  - Passive alcohol sensor
- Cell phone records
  - From cell phone providers or study participants
- Link NDS and RID files
  - Identify all trips passing over a given roadway segment
  - Identify all roadway segments over which a given trip travels
  - Link matches trip IDs and roadway segment IDs
Reduced Data Sets

• Reduced data
  – Trips or trip segments for specific research questions: trips with teenage drivers; trip segments on rural 2-lane curves; …
  – Retain only variables needed for research questions
For More Information

- Jim Hedlund, Highway Safety North
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- David Plazak, TRB
  - DPlazak@nas.edu

- InSight website (direct data access, information):
  https://insight.shrp2nds.us/

- TRB SHRP 2 Safety publications:
  http://www.trb.org/Publications/PubsSHRP2ResearchReportsSafety.aspx
Questions and Discussion

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