ANALYSIS OF RURAL CURVE NEGOTIATION USING NATURALISTIC DRIVING DATA

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OUTLINE

• Background
• Objective
• Data Sources
• Site Selection
• Data Reduction
• Future work
• Benefits
Horizontal curves have a crash rate 3x that of tangent sections (Glennon et al., 1985)

27% of all fatalities in 2007 occurred on horizontal curves (Cheung, 2010)

76% of curve related fatal crashes are single vehicles leaving the roadway and striking a fixed object or overturning.

11% of curve related crashes are head-on collisions (AASHTO, 2008)

Many studies on roadway factors which are relevant
  - Radius and Degree of curve
  - Presence of spirals
  - Shoulder width

Little research has been done to identify which driver behaviors contribute to curve crashes
OBJECTIVE

- Assess the relationship between driver behavior and characteristics, roadway factors, environmental factors, and likelihood of lane departures using SHRP 2 Naturalistic Driving Study data and roadway data from the SHRP 2 Roadway Information Database
- Develop models to quantify the relationship between driver behavior and the roadway environment
- Focus on curves on rural 2-lane paved roadways
Drivers have their car instrumented with equipment to capture data as they drive
- Approximately 3,100 drivers of all genders and ages
- Approximately 4,000 data years including 5 million trip files and 30 million data miles
- 6 states (FL, IN, NY, NC, PA and WA)
SHRP 2 NATURALISTIC DRIVING STUDY (NDS)

- Captures a variety of data
  - Vehicle network data (i.e. speed, acceleration, pedal position)
  - Accelerometer data (3 axis)
  - GPS coordinates
  - Forward and rear radar
  - Cameras

image source: VTTI
SHRP 2 ROADWAY INFORMATION DATABASE (RID)

- Data from mobile data collection and other existing roadway data along with supplemental data.

- Data collected includes
  - Mobile data collection (~25,000 collection miles)
    - Roadway alignment, shoulder width and type, signing, lighting, intersection locations, rumble strips, etc.
  - Existing roadway data
    - Asset management data, ADT, type of pavement, rest areas, etc.
  - Supplemental data
    - Crash data, changes to laws, etc.

Image source: CTRE
SAMPLING PLAN

- Balanced:
  - Need for statistically representative sample based on potential number of covariates
  - Cost to procure data
  - Time to reduce and analyze data
  - Time constraints for Phase II

- 200 initial traces
- 800 final traces
CURVE IDENTIFICATION

- NDS and RID not yet merged
- Queried RID for rural 2-lane curves of interest
  - radius, presence of RS, etc.
- Reviewed other RID data, Google Earth
- Number of trips and drivers
BUFFERS

- Created buffer shapefiles in ArcGIS
- Created a line over section of interest
  - Single curve if more than 1.0 mile
    separate subsequent curves of interest
  - Multiple curves if less than 1.0 miles
    separated

image source: ESRI
EVALUATION CRITERIA

- No turning or passing lanes in curve
- At least 0.5 miles of tangent on both sides of curve if it was not within a series of curves within a buffer
- No stop controlled intersection on the major approach in curves and tangents
- No signal controlled intersections in curves or tangents
- No railroad crossings within curve or tangents
- No sites within 0.5 miles of town
- No construction
DATA REQUEST

- Identified 203 segments with 707 curves (NC, NY, IN, PA)
- 32 existing from FL – had from proof of concept phase, did not request additional data for current work
- Already had from FL – tended towards urban
- WA – large urban component

image source: ESRI
### SELECTED CURVE CHARACTERISTICS

**Location of Buffer Segments**

<table>
<thead>
<tr>
<th>State</th>
<th>Buffers</th>
<th>Curves</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indiana (IN)</td>
<td>80</td>
<td>375</td>
</tr>
<tr>
<td>New York (NY)</td>
<td>71</td>
<td>173</td>
</tr>
<tr>
<td>North Carolina (NC)</td>
<td>20</td>
<td>58</td>
</tr>
<tr>
<td>Pennsylvania (PA)</td>
<td>32</td>
<td>101</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>203</strong></td>
<td><strong>707</strong></td>
</tr>
</tbody>
</table>

**Curve Radius**

<table>
<thead>
<tr>
<th>Radius (feet)</th>
<th>Number of Curves</th>
<th>Radius (feet)</th>
<th>Number of Curves</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;=750</td>
<td>110</td>
<td>&gt; 1500 to &lt;=2250</td>
<td>138</td>
</tr>
<tr>
<td>&gt; 750 to &lt;=1500</td>
<td>149</td>
<td>&gt;=2250</td>
<td>310</td>
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</tbody>
</table>
REDUCTION OF ROADWAY FACTORS

- Gather roadway alignment and countermeasure data (used RID when available)

- Estimate of road furniture
  - rating system of 1–3 (ranges from little to no road furniture to significant roadway furniture)

<table>
<thead>
<tr>
<th>Table 2: Roadway Variables Extracted</th>
<th>ArcGIS</th>
<th>SHRP2 RID</th>
<th>Google Earth</th>
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<tbody>
<tr>
<td>curve radii</td>
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<td>compound curve</td>
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<tr>
<td>super elevation</td>
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<td></td>
<td>✔</td>
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<tr>
<td>presence of rumble strips</td>
<td>✔</td>
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<td>✔</td>
</tr>
<tr>
<td>presence of chevrons</td>
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<tr>
<td>presence of w1-6 signs</td>
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<td></td>
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<tr>
<td>presence of paved shoulders</td>
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<td>presence of RPM</td>
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<td>advisory sign speed limit</td>
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<tr>
<td>curve advisory sign</td>
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</tbody>
</table>
REDUCTION OF VEHICLE FACTORS

- Spatially correlated vehicle trace to curve
  - Location of vehicle upstream, within, downstream of curve
- Calculate lane position from lane tracking variables

image source: ESRI
REDUCTION OF VIDEO

- Forward video
  - When vehicle is not following, following, following closely
  - Whenever another vehicle is passed
- Sight distance
- Environmental conditions
  - Day, dawn, dusk, night
  - Clear, raining, snow
  - Visibility
- Pavement marking condition
- Pavement condition
- Locations and presence of curve warning signs

image source: VTTI
REDUCTION OF KINEMATIC DRIVER FACTORS

- Driver distraction – forward and over shoulder video at secure data enclave
  - type
  - duration -- coded by video time

- Driver forward attention - forward video at secure data enclave
  - Head position
  - Scan (glance) location
RESEARCH QUESTIONS

- Use data to try to answer 3 research questions

1. Define normal curve driving based on curve geometry
   - Change in lateral position or speed from tangent to within curve
     - Schurr et al (2002); Krammes and Tyer (1991); Stodart and Donnell (2008)
   - Determine where driver begins to react to curve
     - Combination of a filter and potentially time series

2. What is the relationship between driver distraction, other driver, roadway, and environmental characteristics and risk of lane departure
   - Multivariate logistic regression with probability of a left or right side lane departure as response variable
     - Will give odds of a lane departure of a certain magnitude given driver, roadway and environmental variables

3. What roadway cues and countermeasures are the most effective in getting a driver’s attention and how do they affect driver response to horizontal curves
   - Time series model
BENEFITS

- Better understanding of relationship between roadway features, driver behavior, and curve negotiation
  - Ability to understand how and why countermeasures work/don’t work
  - Implications:
    - Road design
    - Signing
    - Selection and application of countermeasures
    - Policy
    - Advanced vehicle technologies
Questions?

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