Naturalistic Studies of Driver Assistance System Use

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Topics

- Discuss UMTRI’s experience in naturalistic driving studies
- How naturalistic evaluation of systems differs from other naturalistic studies
- Discuss some tools and techniques UMTRI has developed and deployed
- Show some interesting findings
UMTRI’s Naturalistic Experience

- All, to date, have been associated with evaluating new technologies
  - ABS, adaptive cruise, crash warning systems
- Baseline periods or controls
  - Matched fleets or a within-subject design
  - Need to create a “before” and “after”
- Not strictly naturalistic driving
  - But baseline periods, in particular are close
# UMTRI’s Naturalistic Experience

<table>
<thead>
<tr>
<th>Year Range</th>
<th>Description</th>
<th>Type</th>
<th>Distance (mi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1993 – 1995</td>
<td>Long Combination Truck ABS and C-dollie</td>
<td>Naturalistic</td>
<td>870K</td>
</tr>
<tr>
<td>1996 – 1997</td>
<td>108 subjects, 2-5 weeks each, passenger cars, manual, CCC, ACC/ no braking</td>
<td>Naturalistic</td>
<td>114K</td>
</tr>
<tr>
<td>2000 – 2001</td>
<td>30 heavy truck drivers, 12 months, manual, roll stability advisory</td>
<td>Naturalistic</td>
<td>1.2M</td>
</tr>
<tr>
<td>2003 - 2004</td>
<td>96 subjects, 4 weeks each, passenger cars, manual, CCC, ACC/braking, FCW</td>
<td>Naturalistic</td>
<td>140K</td>
</tr>
<tr>
<td>2004 - 2005</td>
<td>78 subjects, 4 weeks each, passenger cars, manual, curve speed and lateral drift warning</td>
<td>Naturalistic</td>
<td>83K</td>
</tr>
</tbody>
</table>

* Most recent data sets contained in meta-data relational databases
Naturalistic Systems Evaluation

Very specific questions to be addressed

- Evaluate the performance and use of new technologies
  - “How does adaptive cruise control influence headway?”
- Instrumentation is specifically focused
  - Sensor selection often dictated by the system design
- Both with and without the users’ vehicles
  - Level of modification/instrumentation can prohibit using the consumer’s vehicle
Naturalistic Systems Evaluations

- Maintaining levels of control
  - How representative is the sample
    - There will always be the potential of sampling bias
    - Age, gender, roadway environment
  - Seasonal variations
    - Sensing lane position can be difficult in Winter
  - Vehicle variations
    - System performance, ability to install systems, and the possible affect on the driver (i.e., vehicle familiarity)
UMTRI Tools and Techniques

- Multi-generational data acquisition and database management systems
  - Progressively increase the performance capabilities of the data acquisition systems
  - Packaging gets smaller
  - Costs stay about the same
- The amount of data has increased 10x
- Database size and capability must keep up
  - 3 second rule
UMTRI Tools and Techniques

250K miles of naturalistic use
96% data success rate

Meta-data relational database
UMTRI Tools and Techniques

Data mining and maintenance issues

- Less data is better than unmanageable data
- Database development for mining is key
- Relational databases and “core” database structures
  - Ability to make comparisons across datasets, reuse analysis routines, minimize “relearning”
- Documentation and accessibility can be significant challenges
  - Your knowledge can’t graduate with the students
Customized analysis and visualization tools for meta data
UMTRI Tools and Techniques

- UMTRI has used a variety of data transfer techniques
  - Wireless remote
    - Cellular transfer of summary data
    - Remote system diagnostics
  - Wireless site based
    - WiFi-based data transfer to stations, and high-speed networking back to UMTRI
  - On-board storage
    - Cheapest and most reliable, but not always convenient
UMTRI Tools and Techniques

Making the data manageable

- Variety of image and data compression techniques
- Buffering video images and using triggering mechanisms to save video and higher than normal frame rates
- On-board data processing
  - You have one or two CPUs that can be processing data in parallel
Interesting Findings

- Benefits of Lateral Drift Warning (LDW)
  - Does an LDW system improve driver safety?
- Effects of secondary behaviors on driving performance
  - How does conducting secondary tasks affect driving performance
Findings: Lateral Drift Warning

- Enhanced Lane Departure Warning system
  - Prevent drivers from leaving their lane
  - Image processing and radar data
Findings: Lateral Drift Warning
Findings: Lateral Drift Warning

Rate of events in which vehicle edge comes within 0.1m of lane edge

<table>
<thead>
<tr>
<th></th>
<th>Wk 1</th>
<th>Wk 4</th>
<th>Left Side</th>
<th>Right Side</th>
<th>Either Side</th>
</tr>
</thead>
<tbody>
<tr>
<td>LDW disabled</td>
<td>0.05</td>
<td>0.10</td>
<td>0.15</td>
<td>0.20</td>
<td>0.30</td>
</tr>
<tr>
<td>LDW enabled</td>
<td>0.00</td>
<td>0.05</td>
<td>0.16</td>
<td>0.28</td>
<td>0.35</td>
</tr>
</tbody>
</table>

58% reduction, p = 0.002
43% reduction, p = 0.006
50% reduction, p < 0.001
Findings: Lateral Drift Warning

Percent of lane changes not signaled

Turn signal use per mile increases 18%:

- 25% of drivers with lowest initial signal use increase usage 96%.
- 50% of drivers with lowest initial signal use increase usage 55%.
Findings: Secondary Behaviors

Drivers engaged in secondary behaviors in approximately 34% of the video clips
- Conversation with passengers (15.3%)
- Grooming (6.5%)
- Cellular phone (5.3%)

Younger drivers, and women, were more likely to engage in secondary behaviors
- Y (42%), M (37%), O (20%)
- F (54%), M (46%)
Findings: Secondary Behaviors
Findings: Secondary Behaviors

Secondary tasks were associated with significantly higher variability in steering angle
Findings: Secondary Behaviors

- Secondary tasks had less affect on lane position
Findings: Secondary Behaviors

Percentage of clips with secondary behaviors over different weeks:

- Week 1: Baseline
- Week 2: Treatment
- Week 3: Treatment
- Week 4: Treatment

The graph shows a comparison between the baseline and treatment weeks, with a peak in the second week under the category 'Conversation'.
Summary

Naturalistic driving studies can provide valuable information
  - Baseline behavior and new systems use
  - Unique data for modeling driver behavior

Challenges include:
  - Sampling / representation
  - Data management and analysis techniques
  - Modeling new system use with naturalistic data