ANALYSIS OF DRIVER BEHAVIORS DURING COMMON Tasks Using FRONTAL VIDEO Camera and CAN-Bus INFORMATION

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Problem Statement

- 100-car Naturalistic Study: Over 78% of crashes involved driver inattention

- It is estimated that drivers engage in potentially distracting secondary tasks about 30% of their time [Ranney, 2008]

- In-vehicle technologies, cell phones and navigation systems are estimated to increase exponentially [Broy, 2006]

- Detecting driver distraction early can have huge advantages and reduce damage to lives and property
Definition of Distraction

- Report by Australian Road Safety Board

- Highlights:
  - Voluntary or Involuntary diversion from primary driving task
  - Not related to impairment due to alcohol, fatigue and drugs
  - While performing secondary task focusing on a different object, event or person
  - Reduces situational awareness, decision making abilities
Multimodal Information

- Controller Area Network (CAN) Bus information
  - Steering wheel, Vehicle speed, Brake, Gas [Kutila et al. 2007], [Liang et al. 2007], [Ersal et al. 2010]

- Video camera
  - Head pose, eyelid movement, lane tracking [Su et al. 2006], [Azman et al. 2010]

- Audio information from microphones [Sathyanarayana et al. 2010]

- Invasive sensors to monitor physiological signals
  - EEG, ECG, pulse, respiration, head and leg movement [Putze et al. 2010], [Sathyanarayana et al. 2008]
Long-Term Goal: Monitoring Driver Behavior

Focus on this study is to identify relevant multimodal features
Our Goal

• Identify salient multimodal features to detect driver distraction
  • Monitor driving behaviors while performing various secondary tasks
  • Use real-world data
  • Use non-invasive sensors
UTDrive

- Highly sensorized driving research platform.
- Emphasis on understanding the driver behavior during secondary tasks
  - cell-phone use, dialog systems, radio tuning, navigation system.
- Developing driver behavior models to design human-centric active safety systems.
UTDrive

- Front facing camera
  - PBC-700
  - 320 x 240 at 30fps
- 4 - channel Microphone array
  - 25kHz
- CAN Bus for Steering wheel, Vehicle speed, Brake, Gas
- Road facing camera
  - 320 x 240 at 15fps
• Data Acquisition Unit - Dewetron
• Data Extraction Software - Dewesoft
Protocol

- 2 runs of driving per subject
- First run – with 7 tasks
  - Operating a Radio
  - Operating Navigation System (GPS)
  - Operating and following
  - Cell phone
  - Operating and talking
  - Describing Pictures
  - Conversation with a Passenger
- Second run – neutral driving (without tasks)

8 drivers (updated version has 20 subjects)
Good Day light, dry weather conditions to reduce environmental factors
Modalities

- **CAN-Bus Information**
  - Steering wheel angle (jitter), Vehicle Speed, Brake Value, Gas pedal pressures

- **Frontal Facing video Information:**
  - Head pose (yaw and pitch), eye closure
  - Extracted with AFECT
AFECT

Courtesy: Machine Perception Laboratory, University of California, San Diego
Analysis of Driver Behavior

- What features can be used to distinguish between normal and task driving conditions?

- Approach:
  - Contrasting features from task and normal conditions (for each route segment)

- Procedure:
  - Hypothesis testing (matched pairs)
  - Discriminant analysis (task versus normal conditions)
Hypothesis Testing

• Approach
  • Extract the mean and standard deviation of features over 5 sec windows
  • For each task and for each subject, evaluate the different between normal and task conditions
  • Matched pairs Hypothesis Testing across speakers
Hypothesis Testing

- Matched pairs Hypothesis Testing (p = 0.05)
Hypothesis Testing

- The mean of head - yaw is an important feature
Hypothesis Testing

- Error plot for the mean of head - yaw
Hypothesis Testing

- Histogram head yaw mean for Conversation
Hypothesis Testing

- Some tasks produce higher deviation in the features from normal conditions
Other tasks produce small or no deviation in the features from normal conditions.
Hypothesis Testing

- Percentage of eye closure in task and normal conditions
- Defined as percentage of frames in which the eyelids are lowered below a given threshold
Binary Classification (task vs. normal conditions)

- Binary classification per task: “Leave-one-out” cross validation
- Average classification Accuracy: k-NN classifier
- Forward feature selection - Increase in performance

<table>
<thead>
<tr>
<th></th>
<th>Video</th>
<th>CAN-Bus</th>
<th>Fusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radio</td>
<td>0.886</td>
<td>0.896</td>
<td>0.910</td>
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<tr>
<td>GPS - Operating</td>
<td>0.929</td>
<td>0.898</td>
<td>0.916</td>
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<tr>
<td>GPS - Following</td>
<td>0.628</td>
<td>0.629</td>
<td>0.635</td>
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<tr>
<td>Phone - Operating</td>
<td>0.740</td>
<td>0.740</td>
<td>0.813</td>
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<tr>
<td>Phone - Talking</td>
<td>0.636</td>
<td>0.570</td>
<td>0.591</td>
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<tr>
<td>Pictures</td>
<td>0.918</td>
<td>0.906</td>
<td>0.918</td>
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<tr>
<td>Conversation</td>
<td>0.632</td>
<td>0.719</td>
<td>0.742</td>
</tr>
<tr>
<td><strong>Mean across tasks</strong></td>
<td><strong>0.767</strong></td>
<td><strong>0.765</strong></td>
<td><strong>0.789</strong></td>
</tr>
</tbody>
</table>
Analysis of Driver Behavior

Number of time that features were selected for binary classification tasks (out of 7)
Multiclass Classification

- 8-class problem with k-NN
  - Normal and 7 tasks
- “Leave-one-out” cross validation
- Best accuracy = 40.7% at k = 10 compared to baseline = 12.5%
Conclusion and Discussion

- Real-driving data while performing common secondary tasks
- Multimodal features can discriminate between task and normal conditions
  - Frontal camera 76.7%
  - CAN-Bus 76.5%
  - Fusion 78.9%
- Highest accuracies
  - Radio, GPS Operating, Phone Operating and Pictures
- Lowest accuracies
  - GPS - Following, Phone - Talking and Conversation
Future Direction

- Regression models to predict driver distraction.
- We are collecting more data.
  - We now have 20 subjects.
- We are studying other modalities.
  - Microphones, other CAN-bus signals.
- Looking at the driver emotional state.
  - Study cognitive distractions.
THANK YOU!