

ANALYSIS OF DRIVER BEHAVIORS DURING COMMON TASKS USING FRONTAL VIDEO CAMERA AND CAN-BUS INFORMATION

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July 14th, 2011



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

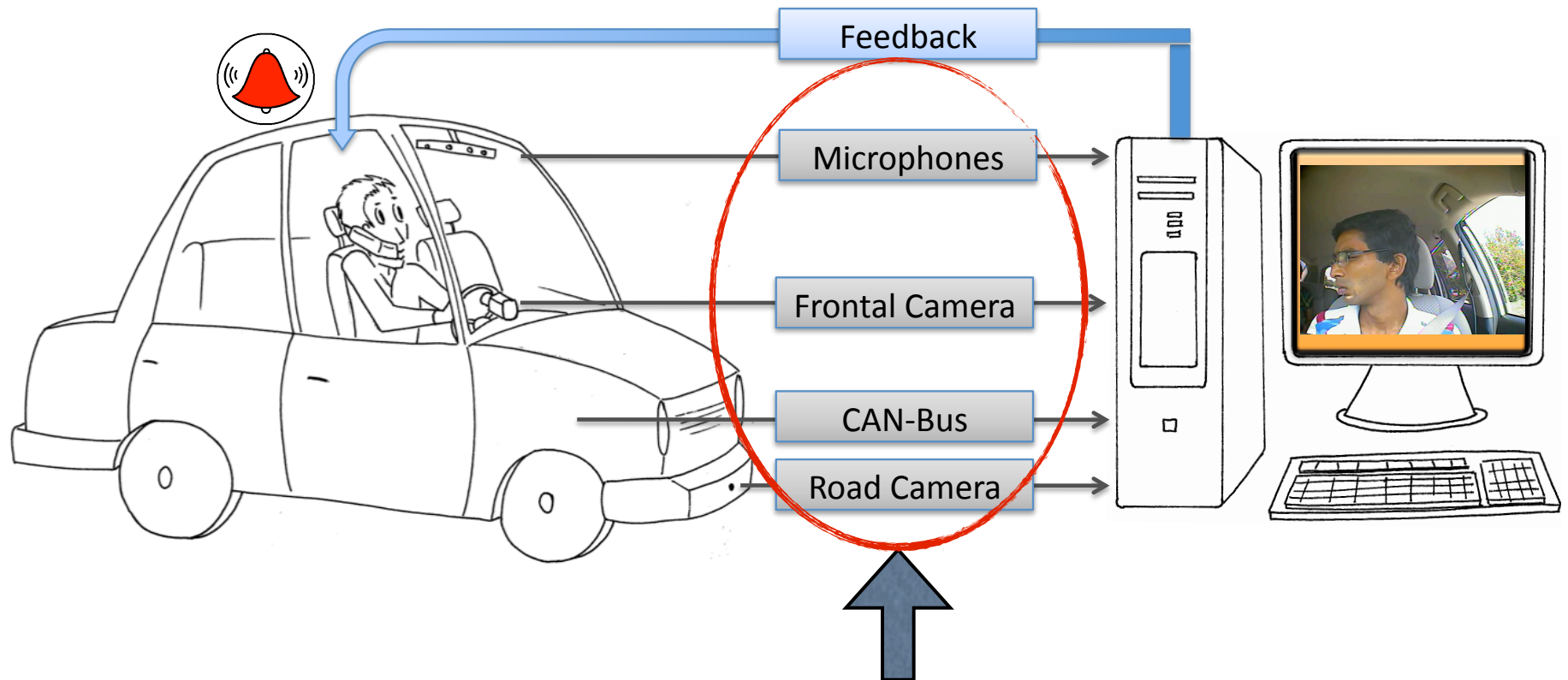
Definition of Distraction

- 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 [Kutilla 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



UTDrive



- 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)

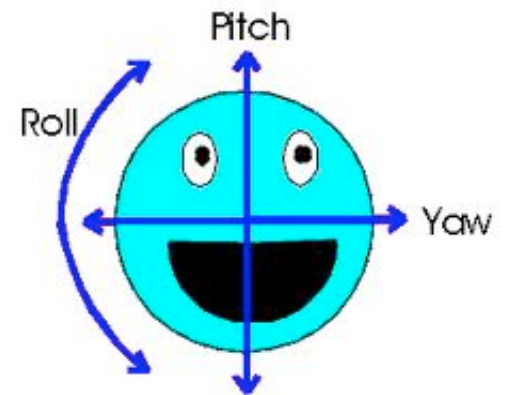


8 drivers (updated version has 20 subjects)

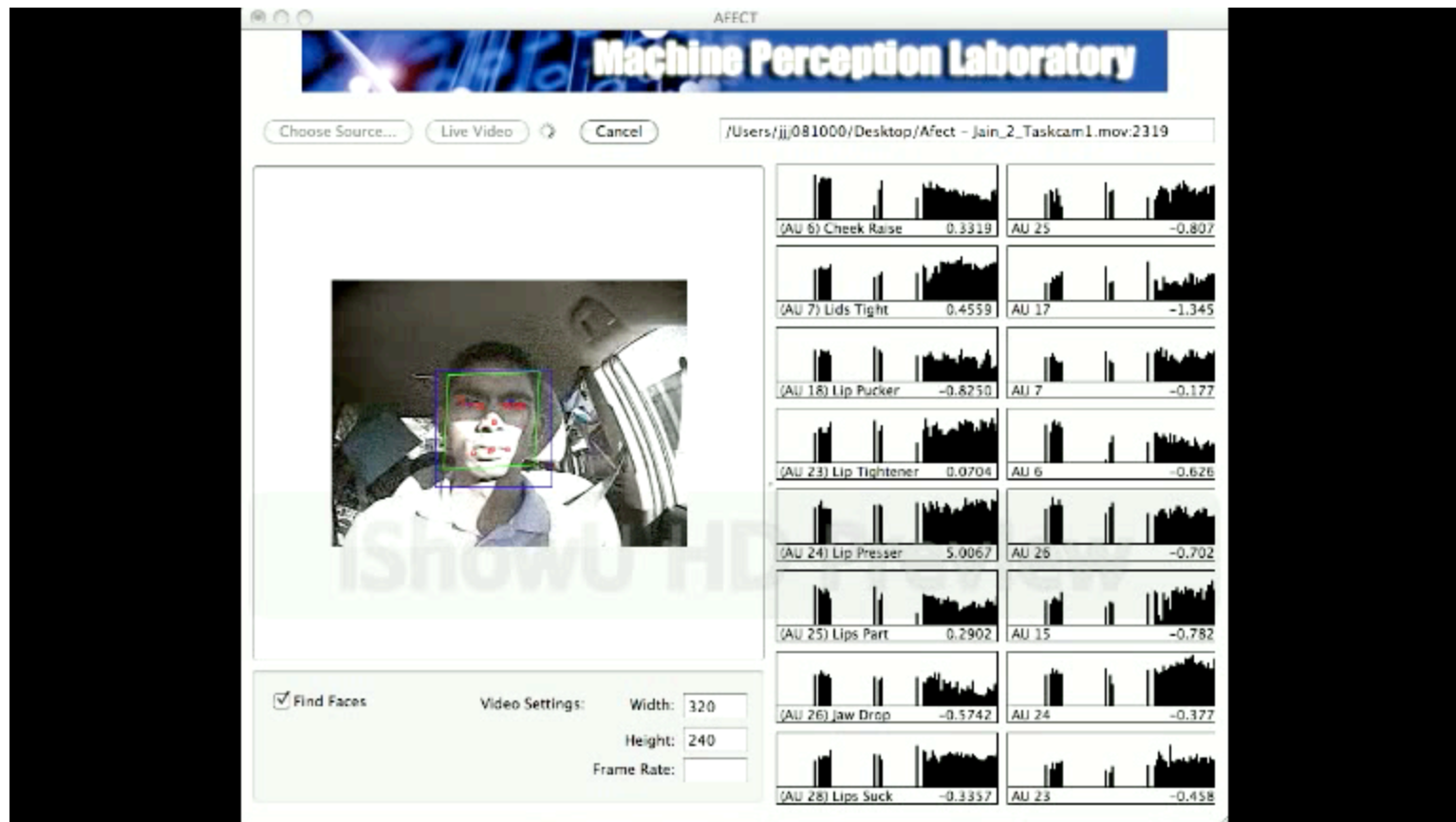
Good Day light, dry weather conditions to reduce environmental factors

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



AFFECT



Courtesy: Machine Perception Laboratory, University of California, San Diego

Analysis of Driver Behavior

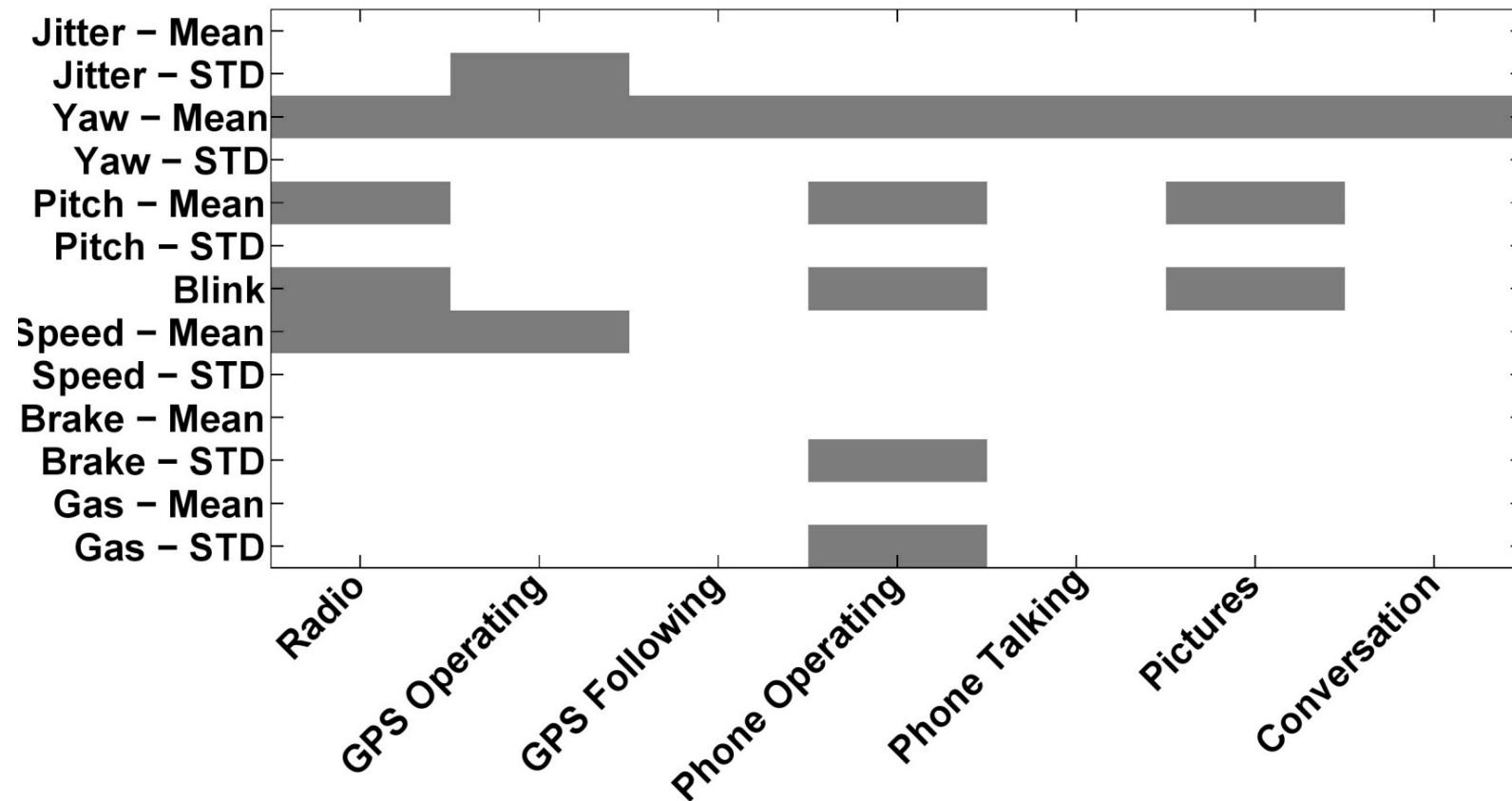
- What features can be used to distinguish between normal and task driving conditions?
- Approach:
 - Contrasting features from task and normal conditions (for each route segment)
- Procedure:
 - Hypothesis testing (matched pairs)
 - Discriminant analysis (task versus normal conditions)



Hypothesis Testing

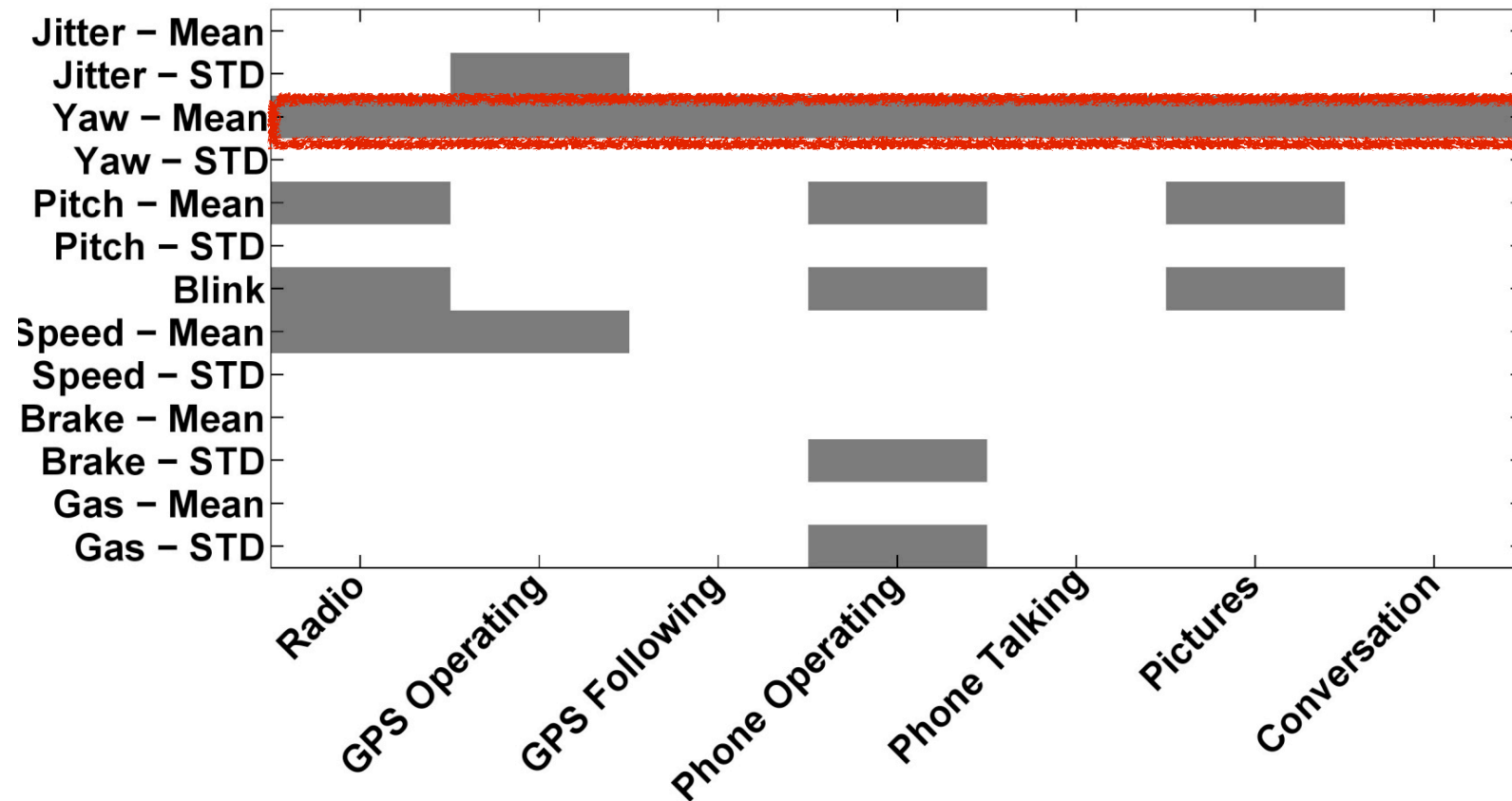
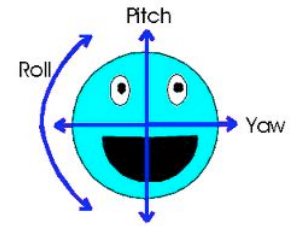
- Approach
 - Extract the mean and standard deviation of features over 5 sec windows
 - For each task and for each subject, evaluate the difference between normal and task conditions
 - Matched pairs Hypothesis Testing across speakers

Hypothesis Testing



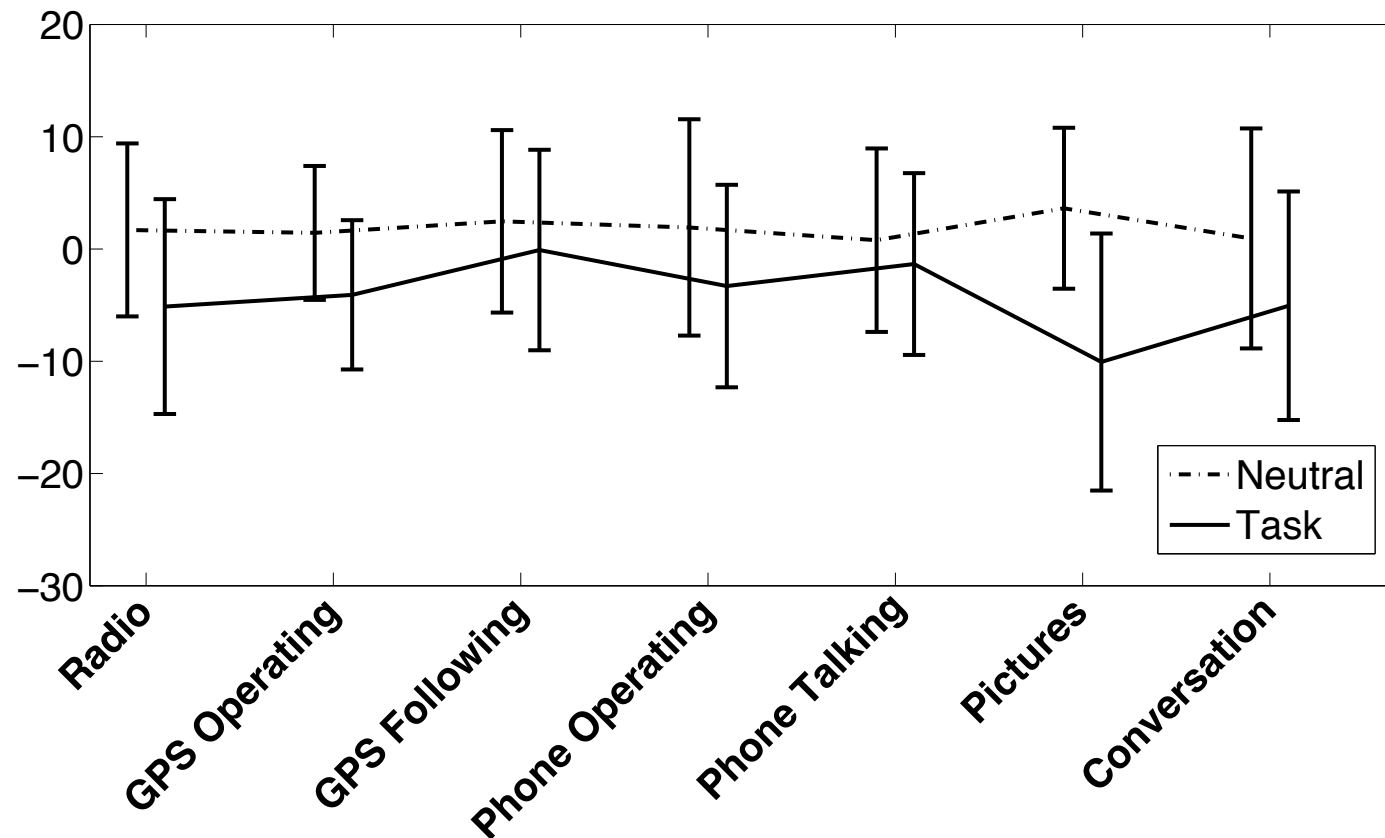
- Matched pairs Hypothesis Testing ($p = 0.05$)

Hypothesis Testing



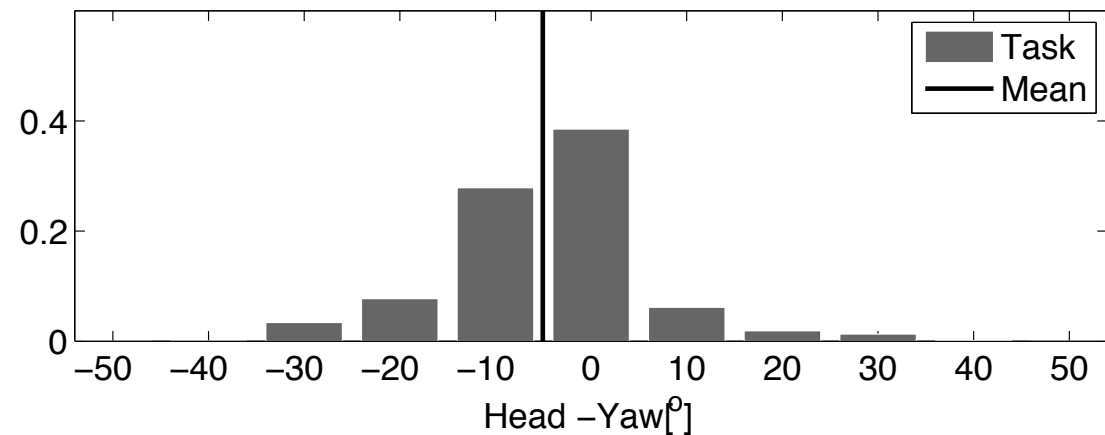
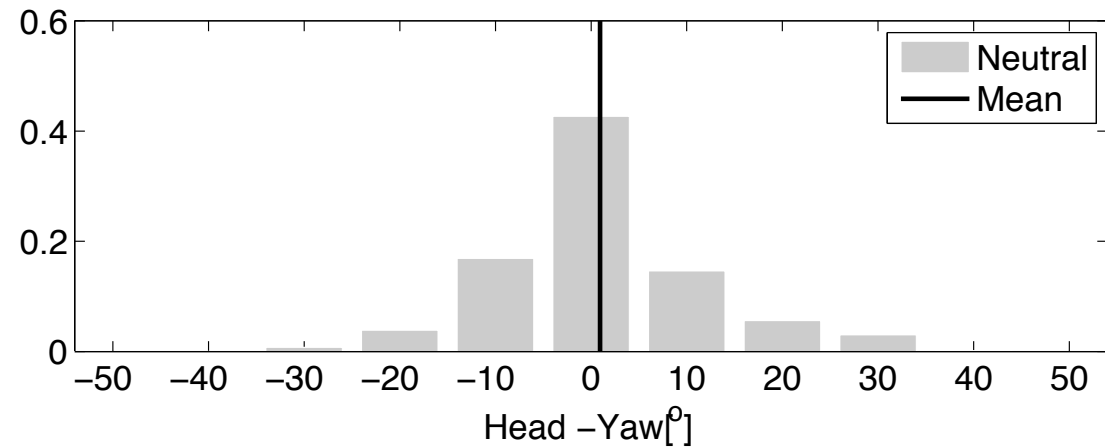
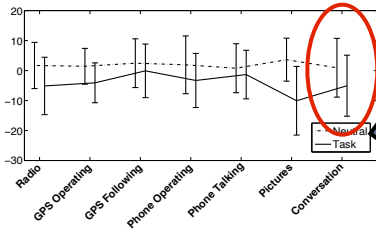
- The mean of head - yaw is an important feature

Hypothesis Testing



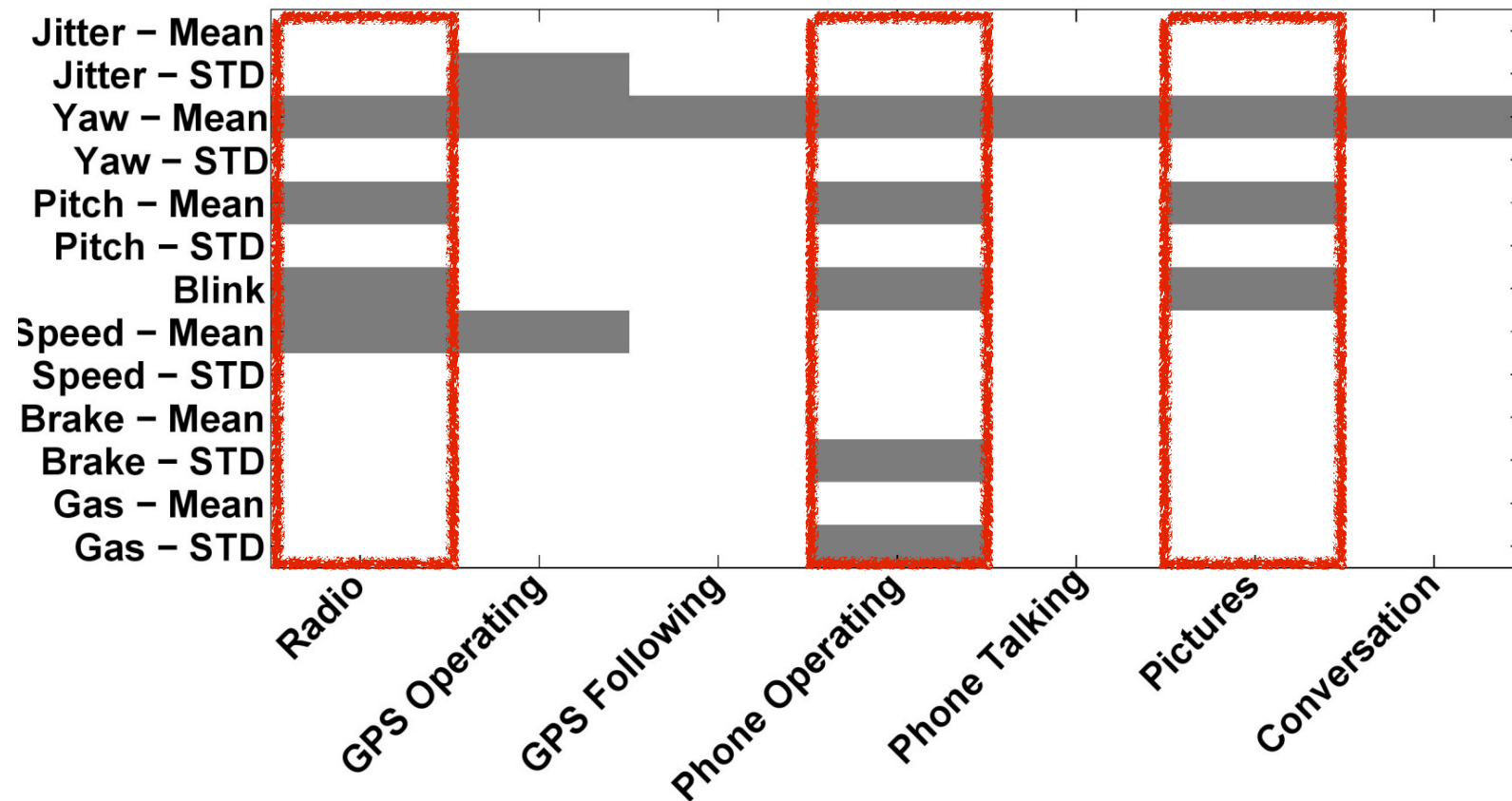
- Error plot for the mean of head - yaw

Hypothesis Testing



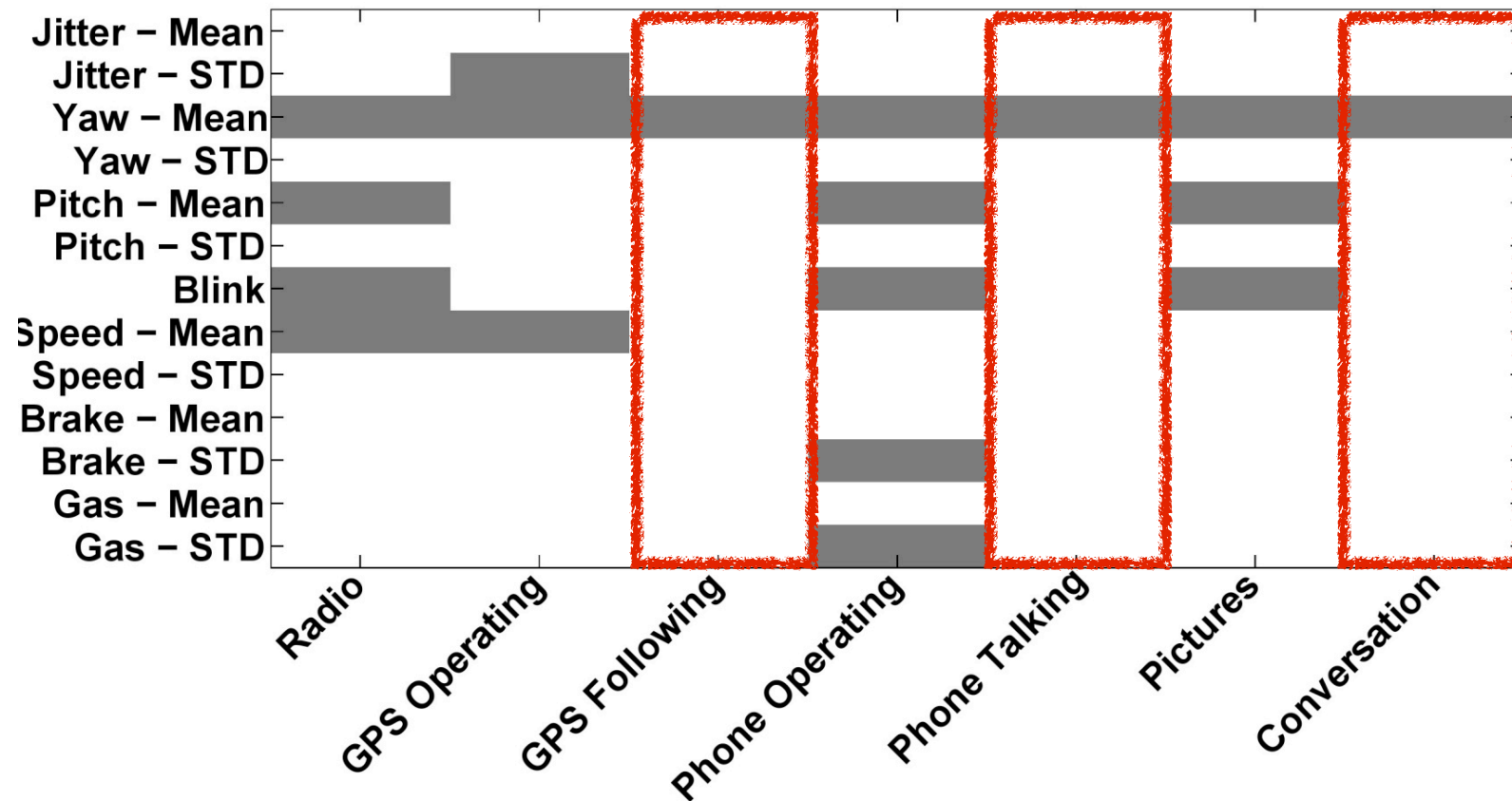
- Histogram head yaw mean for Conversation

Hypothesis Testing



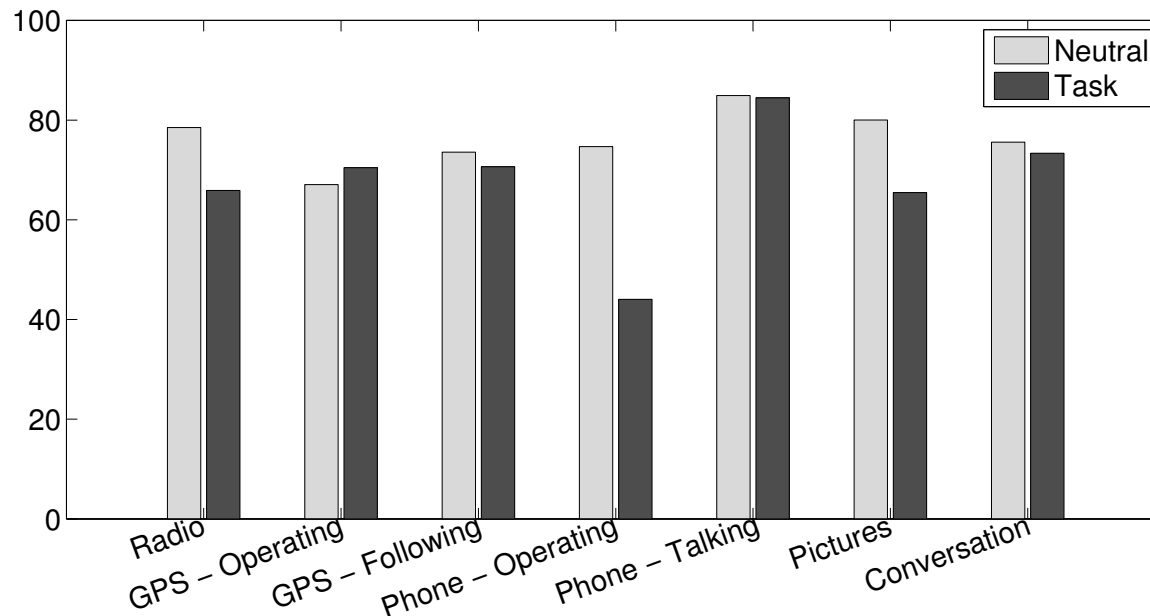
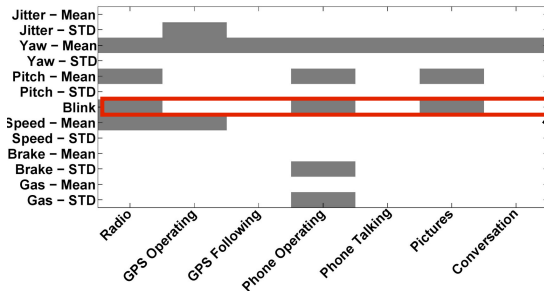
- Some tasks produce higher deviation in the features from normal conditions

Hypothesis Testing



- Other tasks produce small or no deviation in the features from normal conditions

Hypothesis Testing



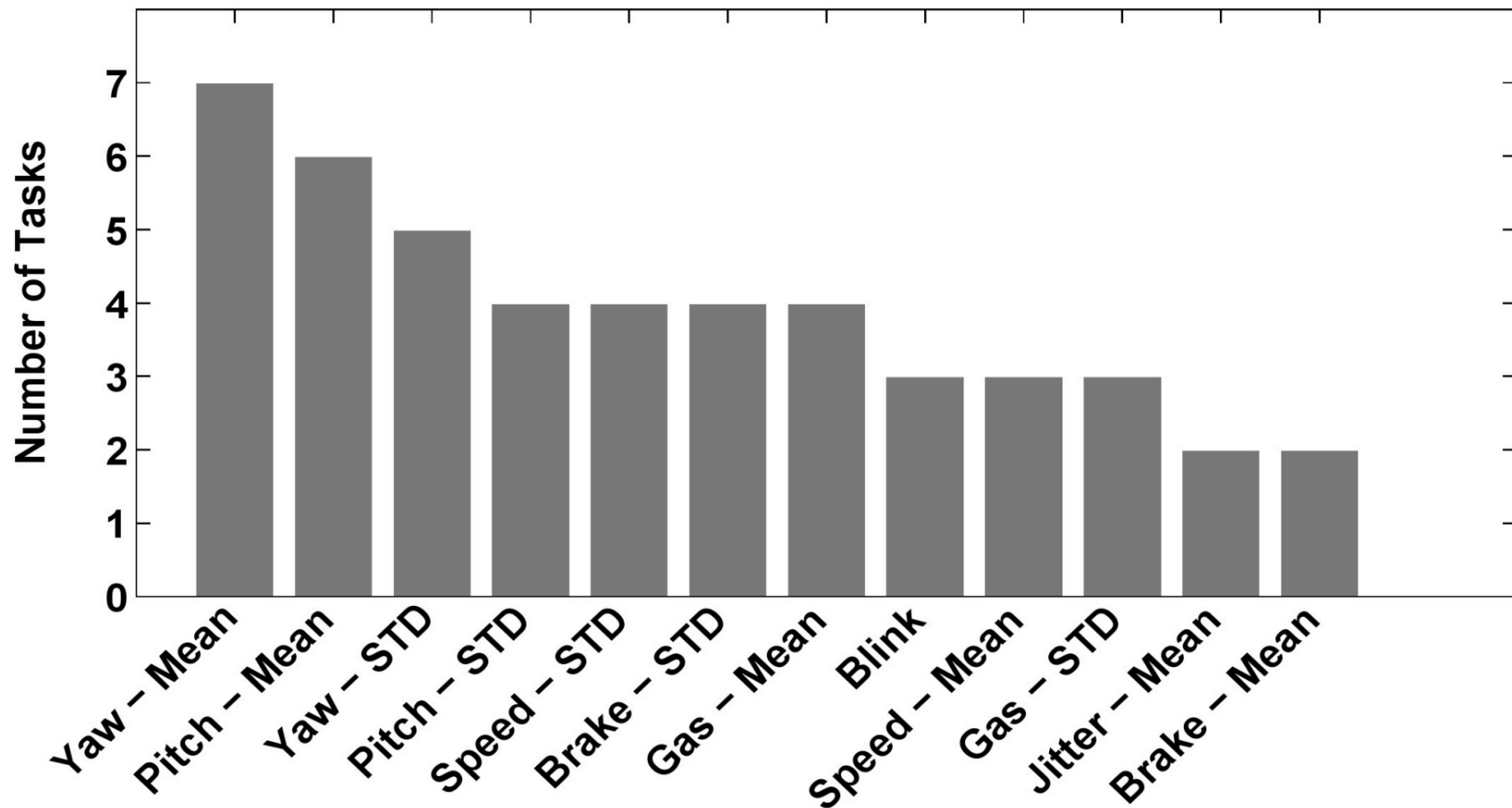
- Percentage of eye closure in task and normal conditions
 - Defined as percentage of frames in which the eyelids are lowered below a given threshold

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

	Video	CAN-Bus	Fusion	
Radio	0.886	0.896	0.910	←
GPS - Operating	0.929	0.898	0.916	←
GPS - Following	0.628	0.629	0.635	←
Phone - Operating	0.740	0.740	0.813	←
Phone - Talking	0.636	0.570	0.591	←
Pictures	0.918	0.906	0.918	←
Conversation	0.632	0.719	0.742	
Mean across tasks	0.767	0.765	0.789	

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%

Secondary tasks

- Radio
- GPS - Operating
- GPS - Following
- Phone - Operating
- Phone - Talking
- Pictures
- Conversation

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

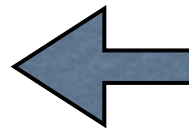
Future Direction



- 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.

Discussion & Questions

THANK YOU!



TH2: Poster 8
 Today 13:30-15:30
 Room: JHM



ANALYSIS OF DRIVER BEHAVIORS DURING COMMON TASKS USING FRONTAL VIDEO CAMERA AND CAN-BUS INFORMATION

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Motivation

- Over 78% of crashes involved driver inattention (Dreier et al., 2005).
- Drivers engage in potentially distracting secondary tasks 30% the car is moving (Hosono, 2005).
- Relevant problem since in-vehicle technologies are estimated to increase.
- Detection of distracted drivers is crucial for the prevention of accidents.

Our Goal

- Identify salient multimodal features to detect inattentive drivers.
 - Use data from real driving conditions.
 - Use various noninvasive sensors.
 - Study common secondary tasks.


Driver Distraction

- Diversion from primary driving task.
- Not related to alcohol, fatigue and drugs.

Database


UTDrive

- Frontal camera
- Microphone array
- CAN Bus
- Road camera



Data Collection

- 8 subjects.
 - First run - with 7 tasks.
 - Second run - normal driving (reference).
- Secondary tasks:
 - Radio
 - GPS - Operating
 - GPS - Following
 - Phone - Operating
 - Phone - Talking
 - Pictures
 - Conversation

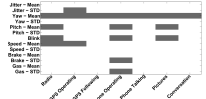


Multimodal features

- CAN-Bus information:
 - Jitter of steering wheel angle.
 - Vehicle speed.
 - Brake and gas pedal pressures
- Frontal Facing video (AFECT (Jinesh et al., 2008)):
 - Head pose (yaw and pitch).
 - Eye closure.
- Features: mean & std of 5sec windows

Hypothesis Testing

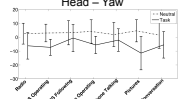
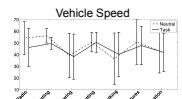
- Normal versus tasks conditions.
- Matched-pairs t-test (p-value = 0.05).
- Head pose, blink and speed are salient.
- Some tasks do not affect these features.
 - Phone - Talking, GPS - Following.



Analysis of Features

Error plots

- Driver patterns change during secondary tasks.
 - Drivers shift attention from the road.
 - Drivers reduce the car speed when engaged in secondary tasks.
- Characteristic of the route is an important variable.

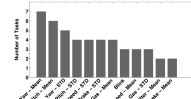



Discriminant analysis

- Task versus normal binary classification.
 - Forward feature selection.
 - K- Nearest Neighbor algorithm.
- "Leave-one-out" cross validation.

	Video	CAN-Bus	Fusion
Radio	0.886	0.896	0.910
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- Frequency that the features were selected.
 - 7 binary classifiers.



Discussion

- Multimodal features can discriminate between task and normal conditions.
 - Frontal camera, 76.7%; CAN-Bus, 76.5%; and Fusion (78.9%).
 - Highest accuracies: Radio, GPS Operating, Phone Operating and Pictures.
 - Lowest accuracies: GPS - Following, Phone - Talking and Conversation.
 - CAN-Bus data is particularly useful for Phone - Operating and Conversation.

Future Directions

- 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.
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