UT DALLAS

UT DALLAS MSP Multimodal Signal Processing Laboratory

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

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July 14th, 2011

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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

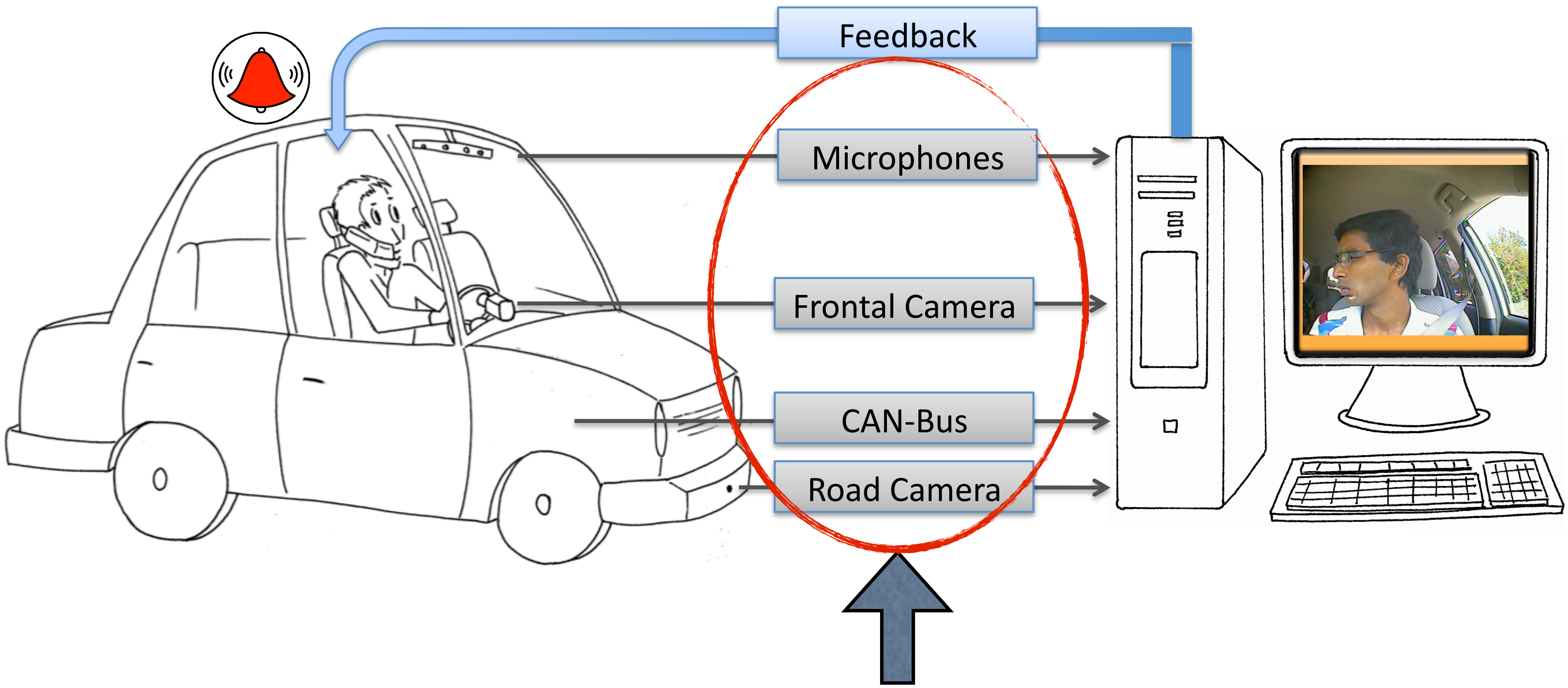
Definition of Distraction

- 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

UTDrive

- Data Acquisition Unit - Dewetron
- Data Extraction Software - Dewesoft

Protocol

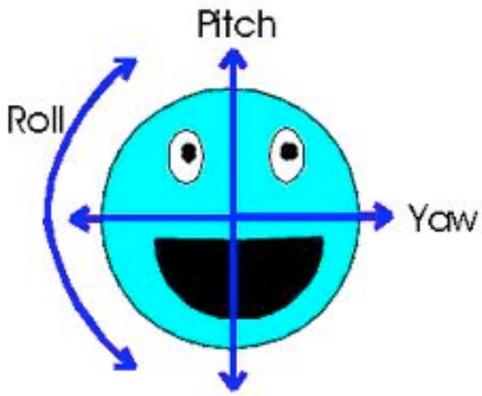
- 2 runs of driving per subject
- First run – with 7 tasks
  - Operating a Radio
  - Operating Navigation System (GPS)
    - Operating and following
  - Cell phone
    - Operating and talking
  - Describing Pictures
  - Conversation with a Passenger
- Second run – neutral driving (without tasks)

8 drivers (updated version has 20 subjects)

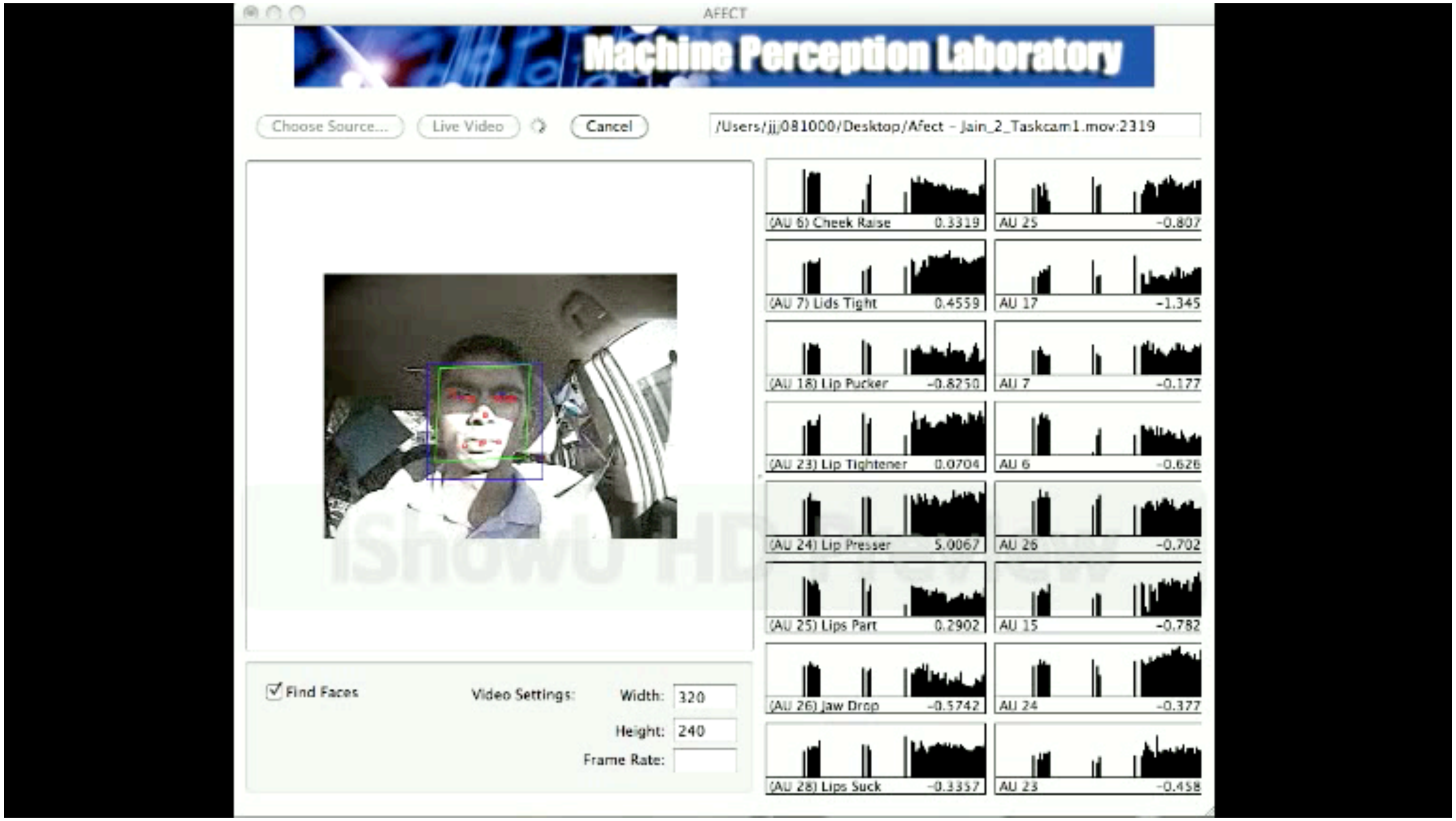
Good Day light, dry weather conditions to reduce environmental factors

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



AFECT



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

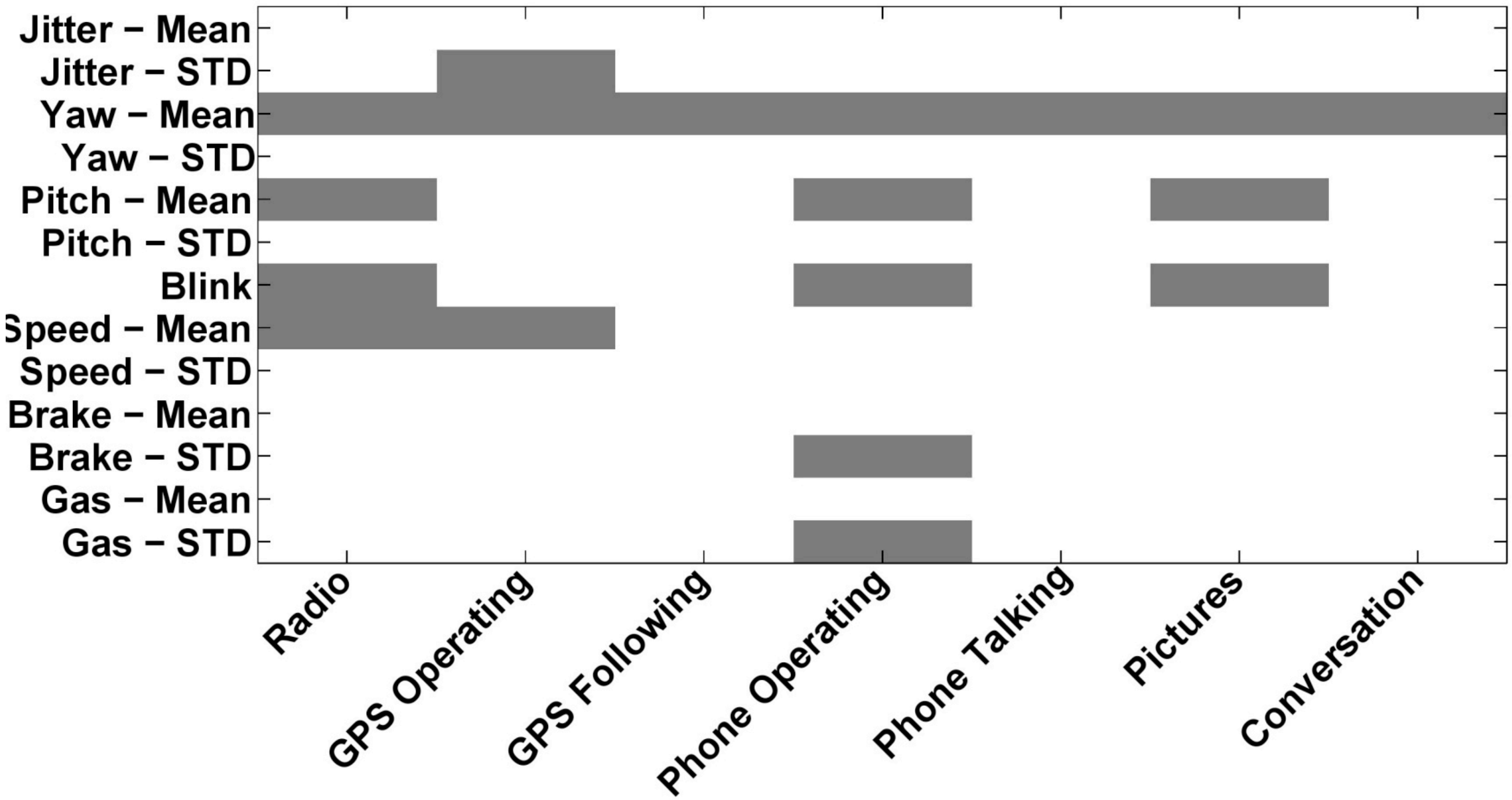
Analysis of Driver Behavior

- 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

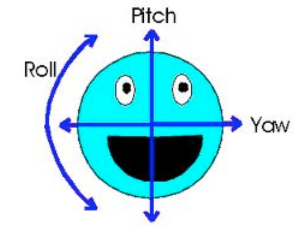
- Approach
  - Extract the mean and standard deviation of features over 5 sec windows
  - For each task and for each subject, evaluate the different between normal and task conditions
  - Matched pairs Hypothesis Testing across speakers

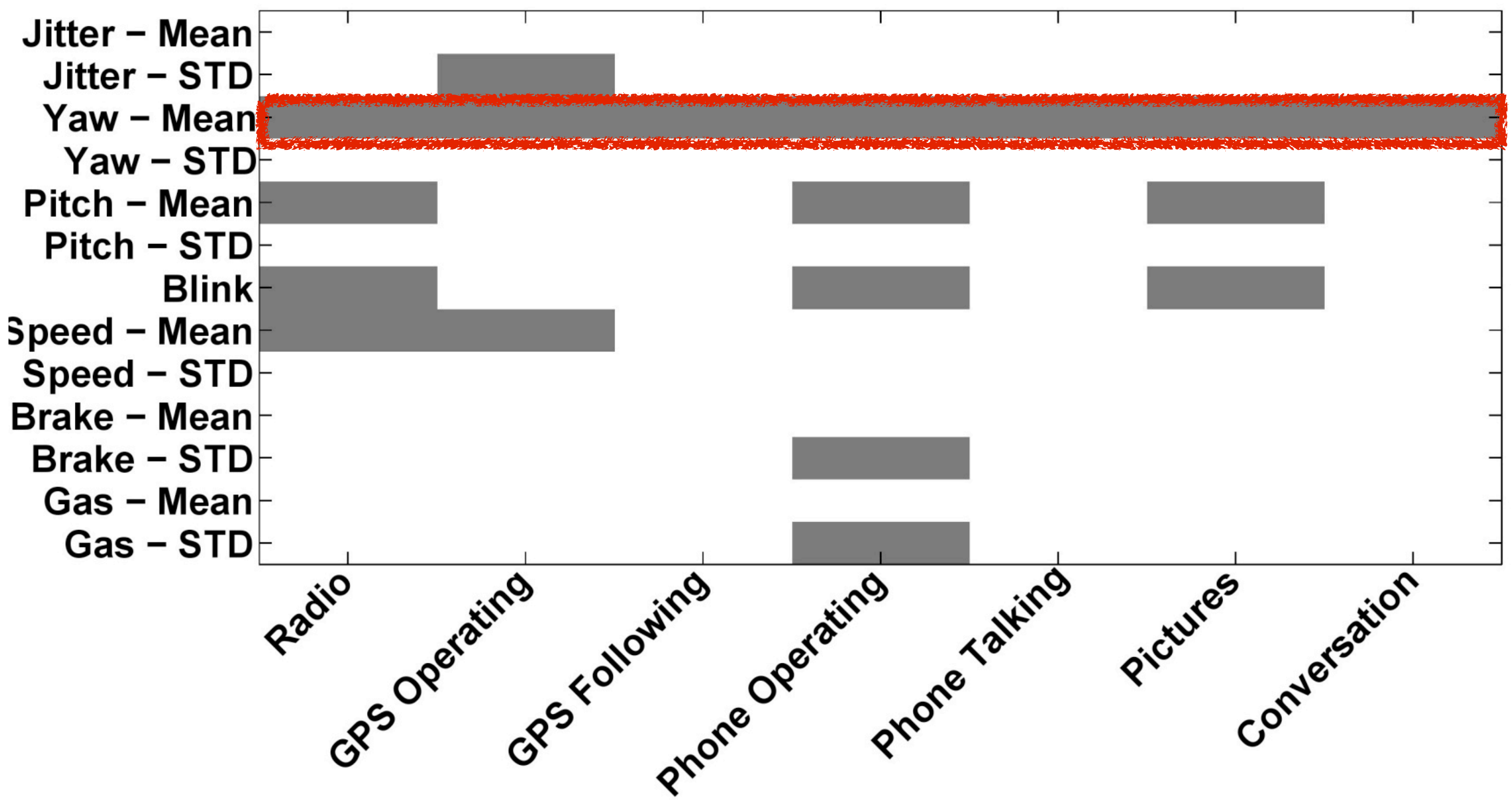
Hypothesis Testing



- Matched pairs Hypothesis Testing (p = 0.05)

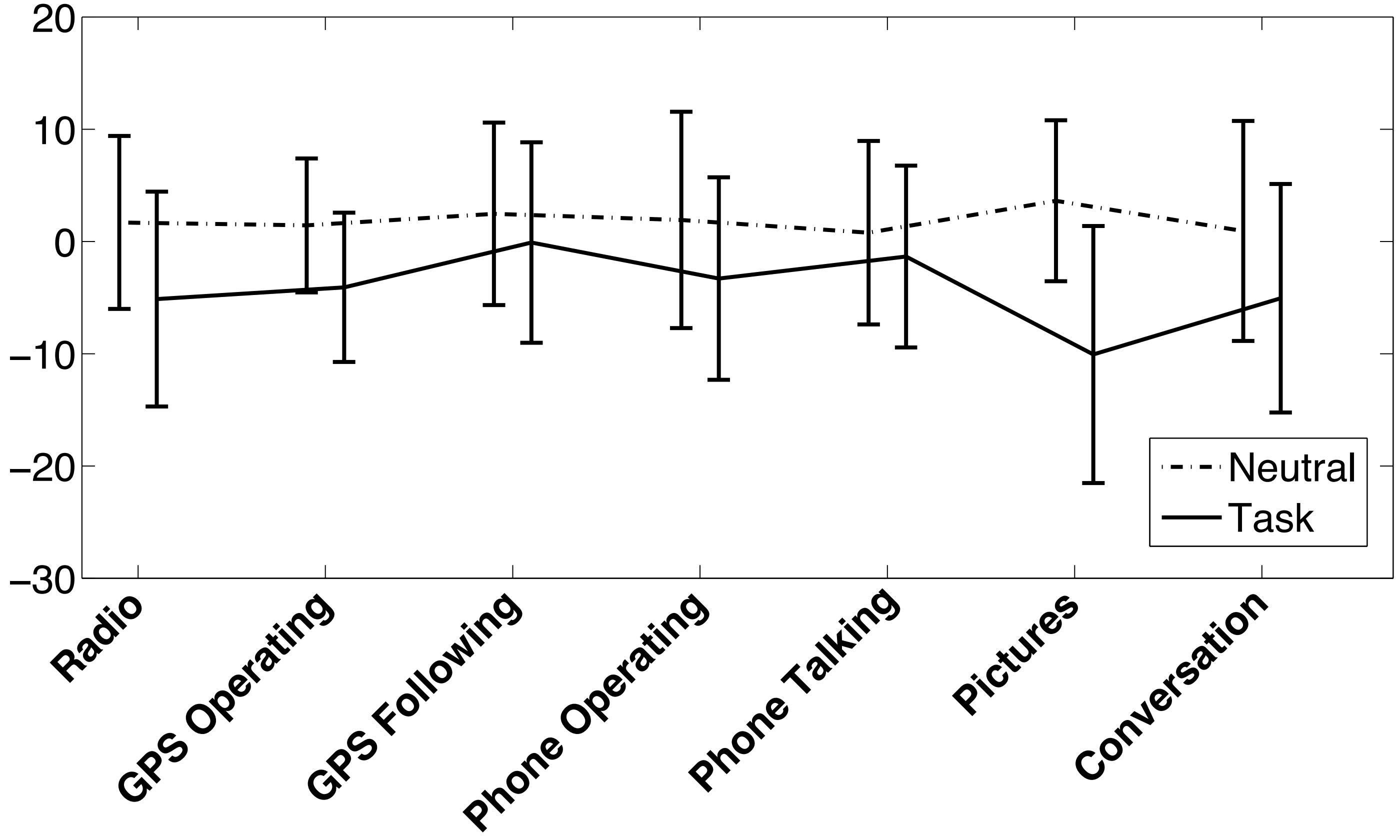
Hypothesis Testing





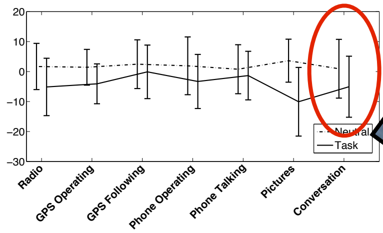
- The mean of head - yaw is an important feature

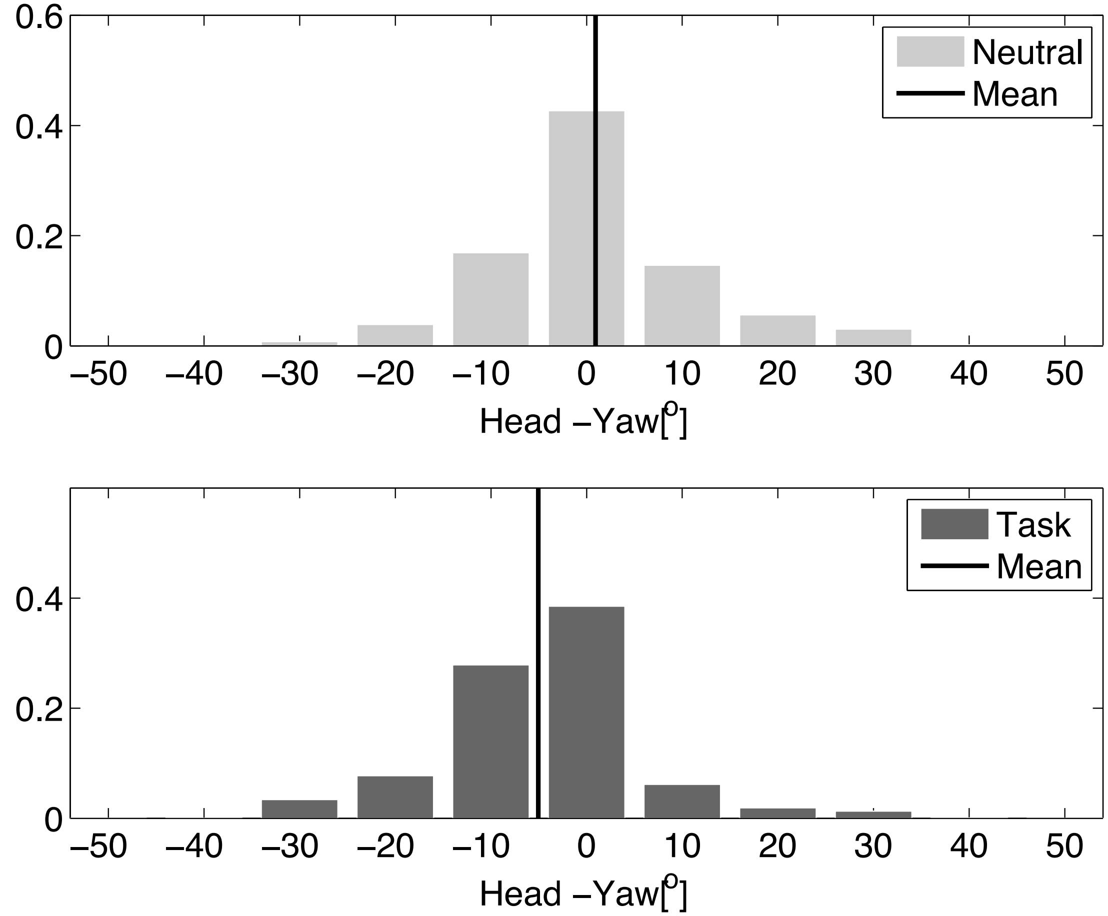
Hypothesis Testing



- Error plot for the mean of head - yaw

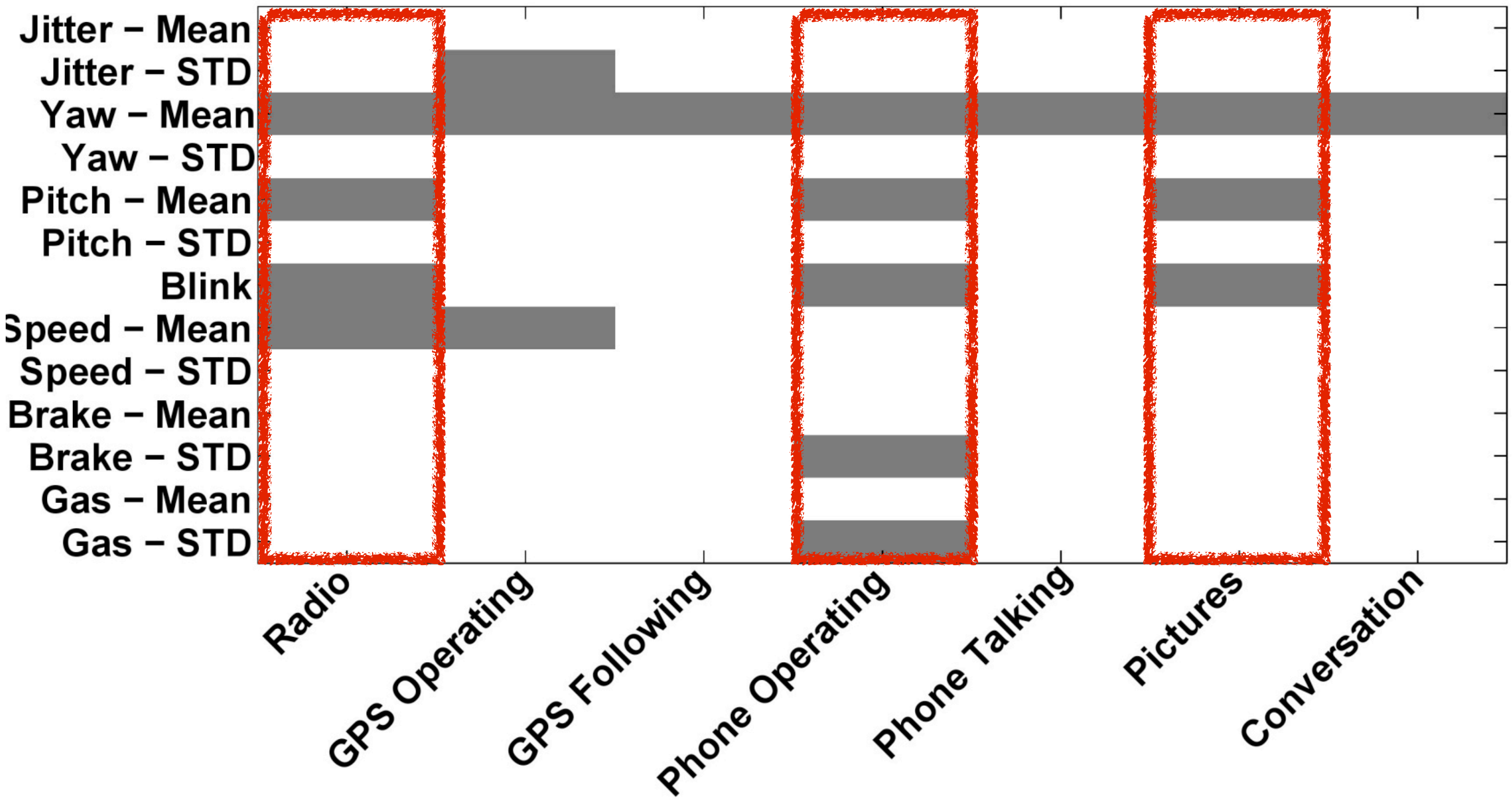
Hypothesis Testing





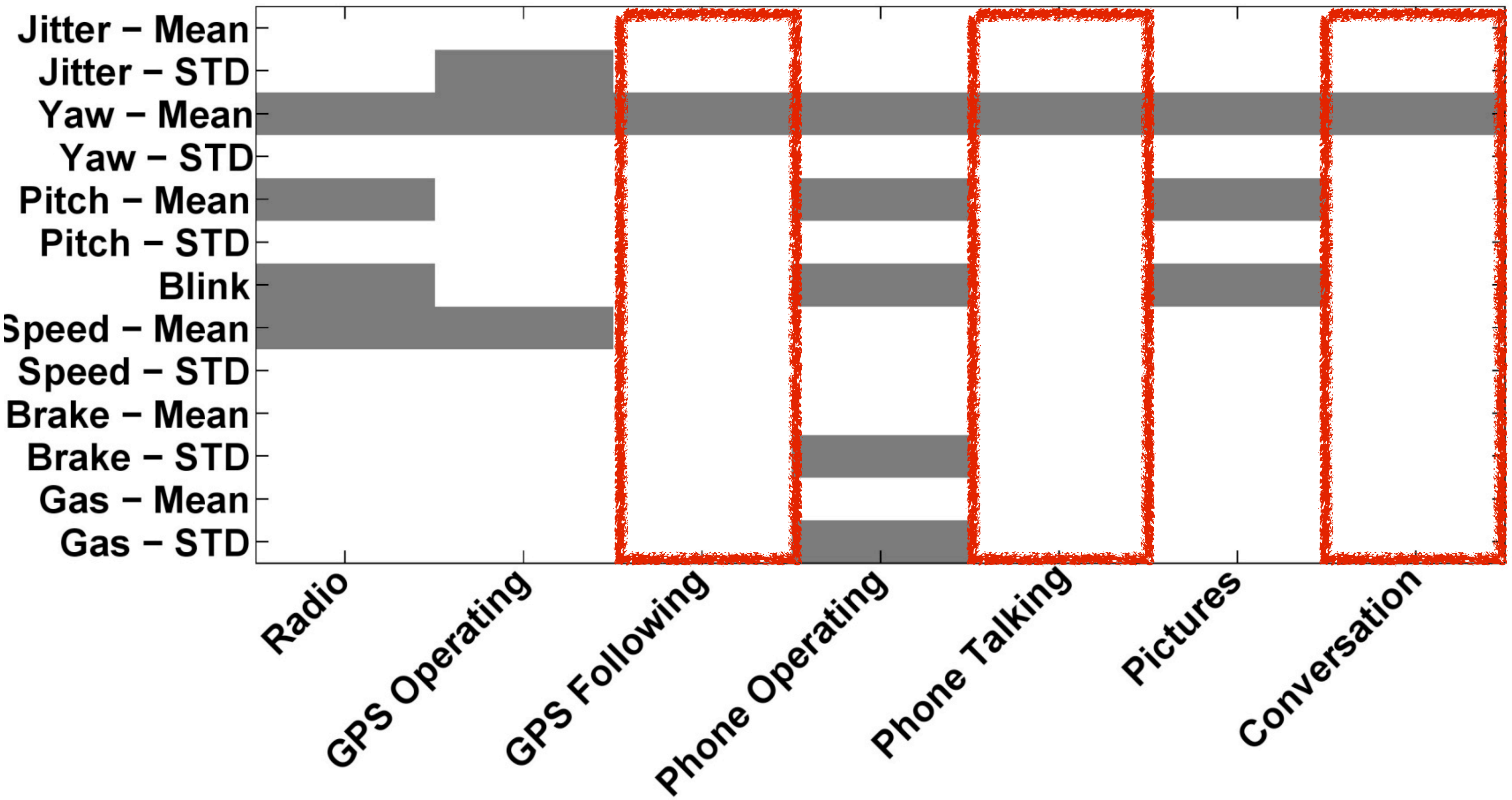
- Histogram head yaw mean for Conversation

Hypothesis Testing



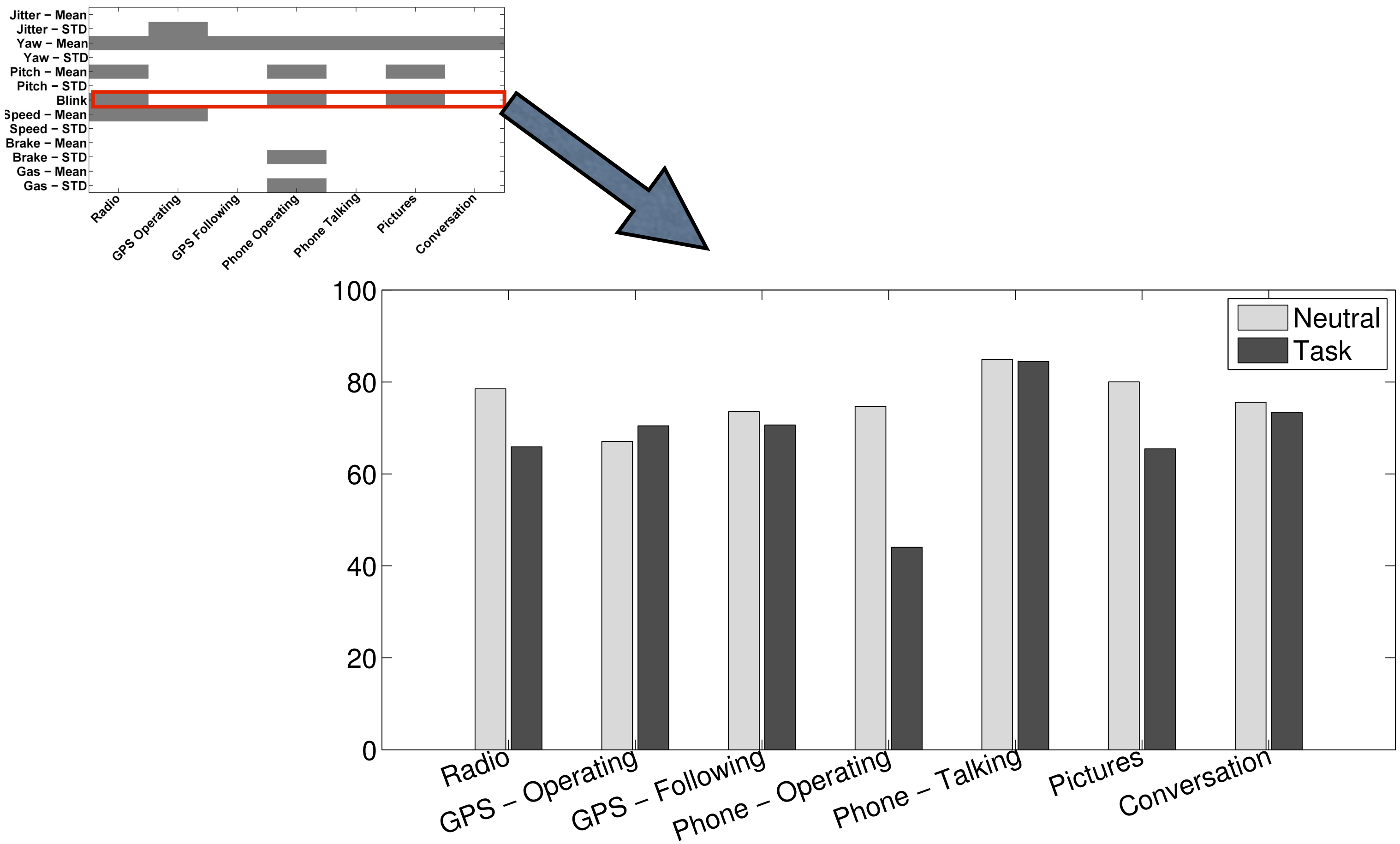
- Some tasks produce higher deviation in the features from normal conditions

Hypothesis Testing



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

Hypothesis Testing



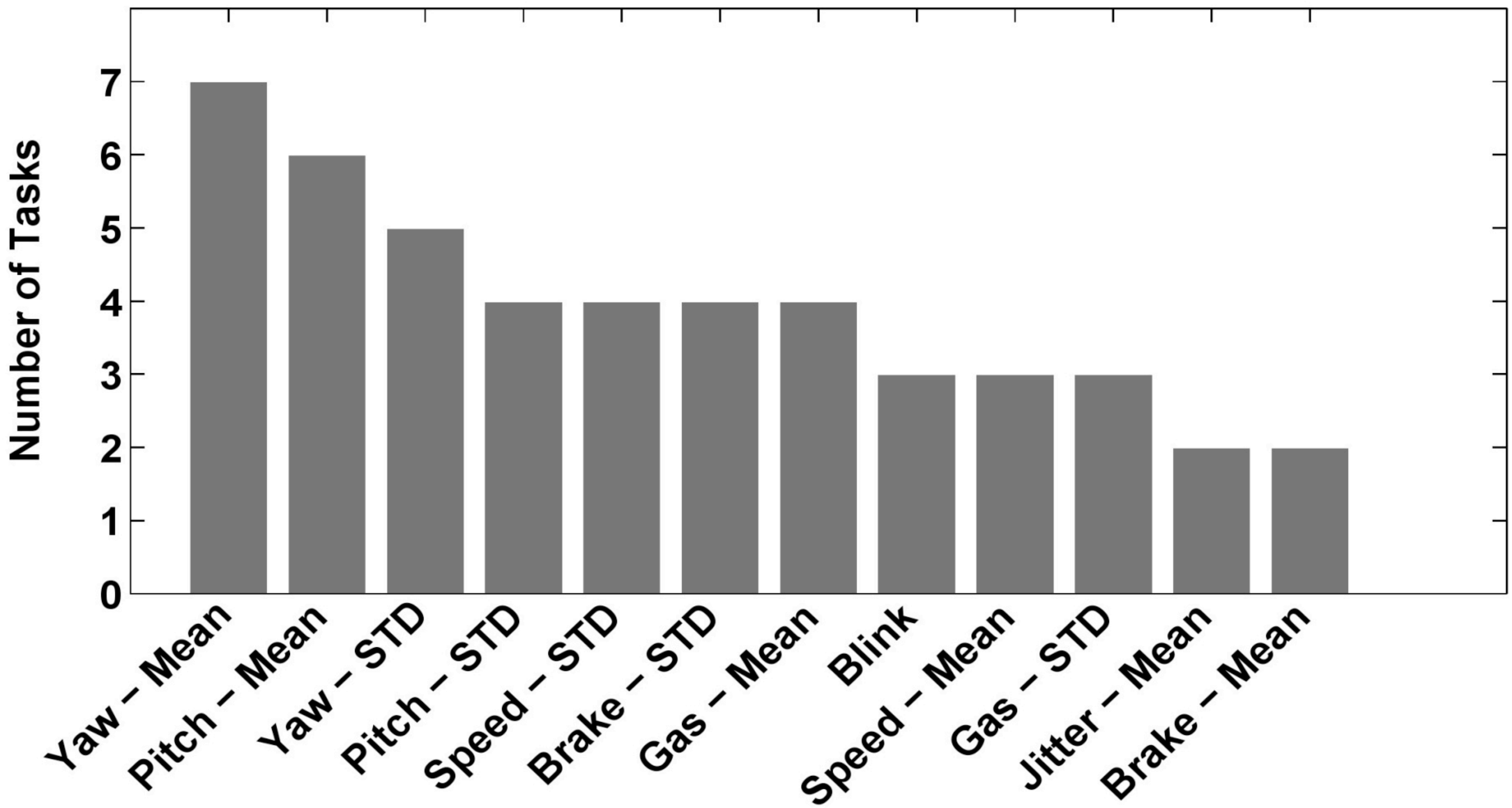
- Percentage of eye closure in task and normal conditions
  - Defined as percentage of frames in which the eyelids are lowered below a given threshold

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

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

- 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%

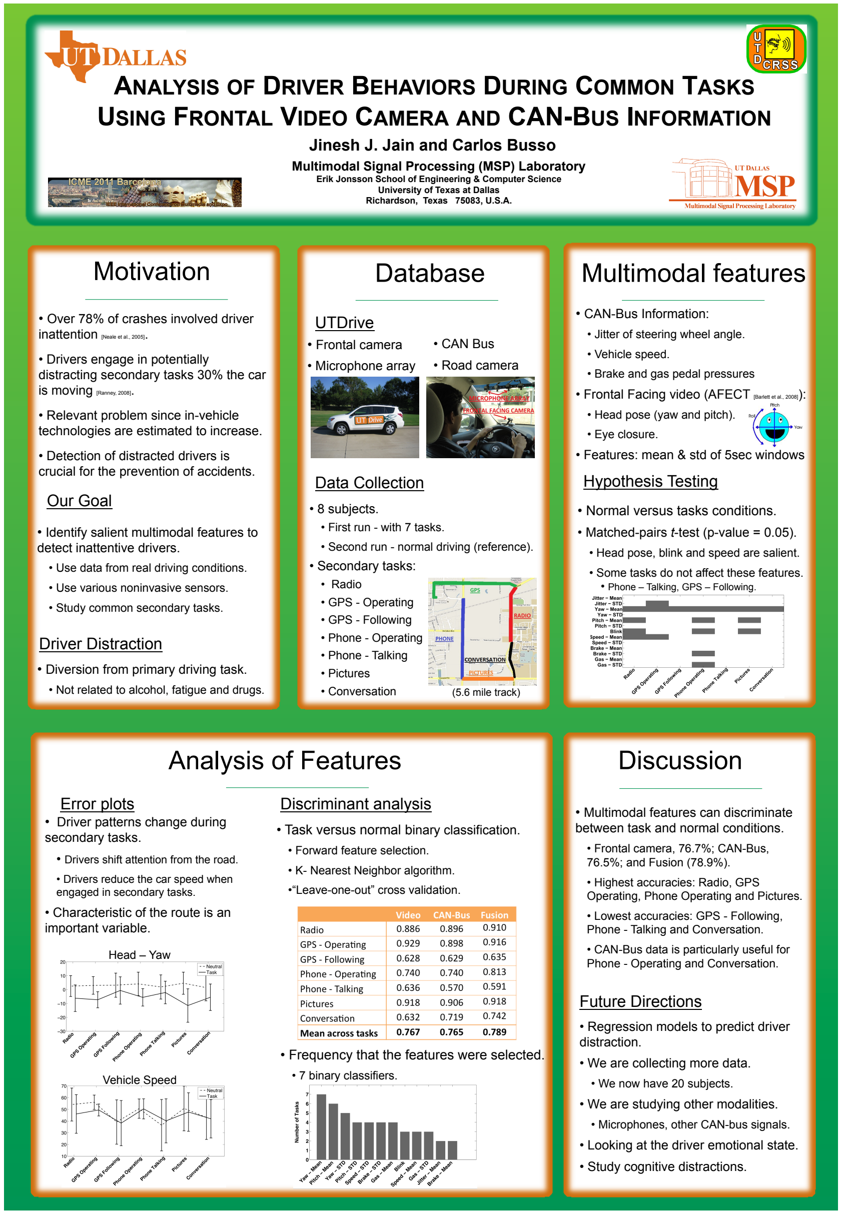
Conclusion and Discussion

- 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.

Discussion & Questions



THANK YOU!

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