

# UTDrive: The Smart Car Project

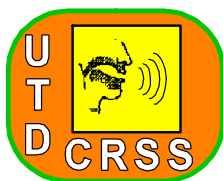
## Next Generation

## Driver Behavior Modeling



John H.L. Hansen, Ph.D.  
Principal Investigator

Dr. Pongtep Angkititrakul, Dr. Wooil Kim, Dr. Pinar Boyraz



The Center for Robust Speech Systems (CRSS)  
University of Texas at Dallas  
Phone: 972-883-2910 Fax: 972-883-2710  
Email: [John.Hansen@utdallas.edu](mailto:John.Hansen@utdallas.edu)



**PROJECT OVERVIEW REPORT**  
March 1, 2008

## UTDrive Project Brief Introduction

This brief report gives an overview of the research activities in University of Dallas at Texas (UTD) as a partner of on-going internationally funded NEDO project including Japan, USA, Turkey, Italy and Singapore. The main aim of the project is to understand the driving behaviour using multi-channel sensor data from CAN-bus, GPS, video, audio and additional gas/brake pedal pressure signals. In order to reach this aim, the objectives are set as follows:

- Design and implement the data collection vehicle
- Establish data-collection procedure and design the scenarios of driving
- Collect data and segment and re-arrange data sets via transcription for a specific task analysis
- Apply the state-of art signal processing methods to extract information and to build systems for: *Driver Identification*, *Driver Distraction Detection* and *Driver Maneuver Recognition*.

As a consequence of these efforts, future in-vehicle technologies will be designed to reduce the mental load of driving and decrease the driver distraction via speech prompted driver assist systems or semi-autonomous controller structures. The collaborative study will also result in effective models of driver behavior that will allow for new advancements in smart vehicle systems.

### 1. Data Collection Vehicle and Corpus

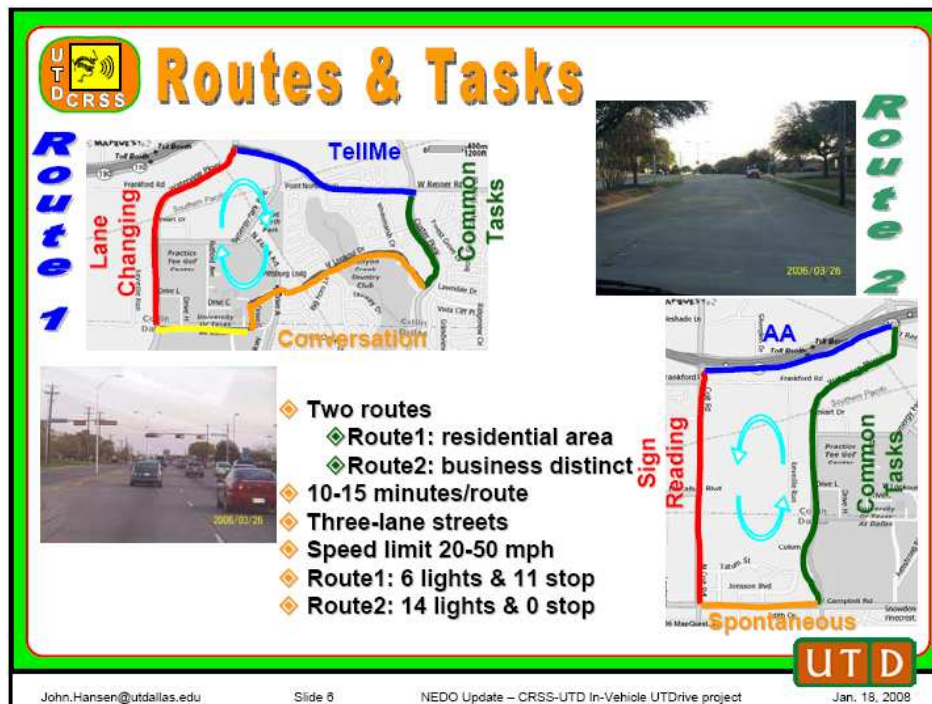
The vehicle used in data collection is a TOYOTA RAV4 customized with a variety of input channels for multi-modal data acquisition on cruise. Recorded data include audio, video, pedal pressures, following distance, CAN-Bus information and GPS information. From these channels audio and video are very rich in information content and this can be reached by further analysis such as stress level measurement in speech signal and driver's eye and head movements for gaze analysis. Data can be interpreted at multi-levels and can be fused with different combinations of signals to open new areas in inter-disciplinary driver behaviour analysis research and to bring deeper understandings in driver behavior, resulting in new in-vehicle technologies. Data collection vehicle and the sensors applied can be seen in Figure 1.



**Figure 1:** Data collection vehicle and the applied sensors in UTDrive Project

## 2. Methodology and Driving Scenarios

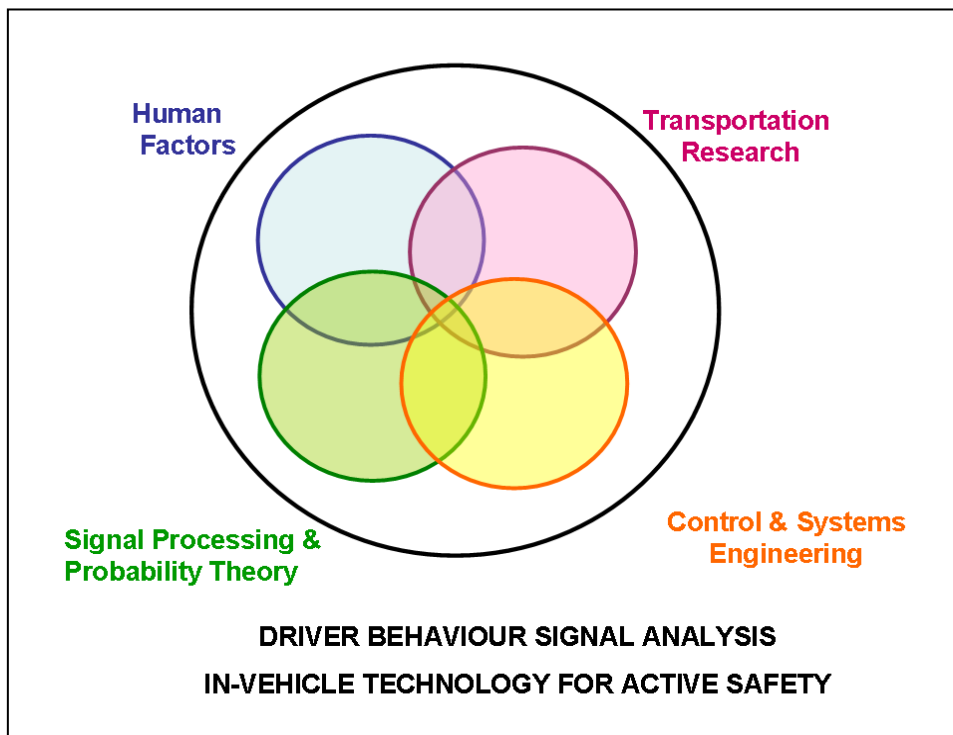
Methodology of this research is based on the assumption that normal and distracted driving sessions of a particular driver should differ significantly. Another factor affecting the driver behaviour is the environment and the traffic around the vehicle. Therefore, to include the driver's distraction level and the effect of the environmental conditions on the driving two routes are designed with and without distractions. These routes can be seen in Figure 2.



**Figure 2:** Routes designed for observing the effects of urban (residential) and highway (business) driving

## 3. Research Realm and Preliminary Results

Driver behavior signal analysis combines research efforts from different realms as depicted in Figure 3. These areas are mainly human factors, transportation research, signal processing and probability theory and control & systems engineering. In UTD Drive project the approach is to model driving behaviour using signal processing and probability theory concepts. Hidden Markov Models, Gaussian Mixtures and statistical data analysis methods have widely been used in the project. From these modeling efforts, some important preliminary results have been found distinguishing distracted drivers from neutral (non-task distracted) drivers, and classifying different maneuvers of the driver such as left turn, right turn, and lane change. Further research will improve those methods and will include artificial intelligence and control theory approaches to analyse the data for specific task models in more extensive ways.



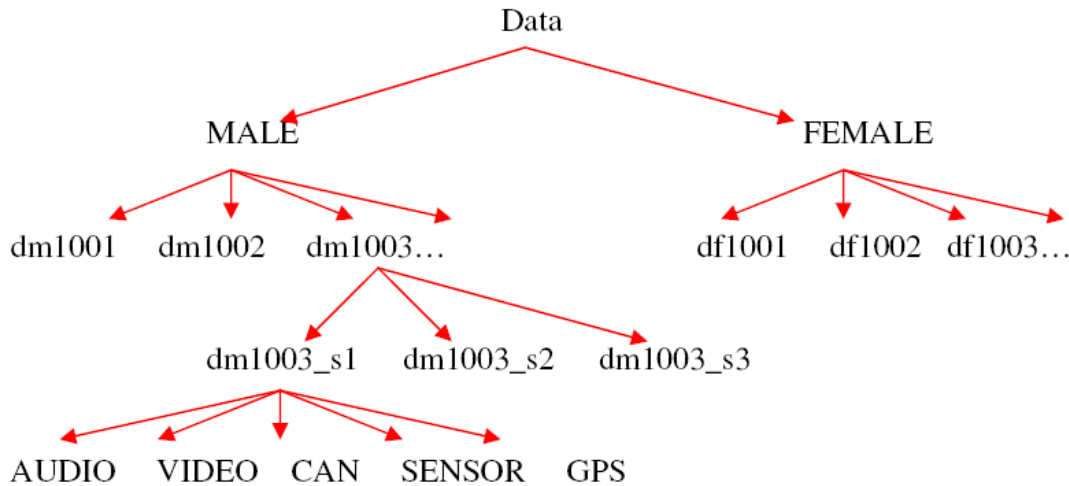
**Figure 3:** Driver behaviour signal analysis and in-vehicle technology for active safety

#### 4. Publication List

- [1] P. Angkititrakul, D.Kwak, S. Choi, J.Kim, A. PhucPhan, A. Sathyanarayana, J.H.L. Hansen, “Getting Start with UTDribe: Driver-Behaviour Modeling and Assessment of Distraction for In-Vehicle Speech Systems”, *Interspeech 2007*, Antwerp, Belgium, Sept. 2007.
- [2] P. Angkititrakul, M. Petracca, A. Sathyanarayana, J.H.L. Hansen, “UTDribe: Driver Behaviour and Speech Interactive Systems for In-Vehicle Environments”, *IEEE Intelligent Vehicles Symposium*, Istanbul, Turkey, June 13-15, 2007.
- [3] P. Angkititrakul and J.H.L. Hansen, “UTDribe: The Smart Vehicle Project”, *Biennial on DSP for In-Vehicle & Mobile System*, Istanbul, Turkey, June 2007.
- [4] W.Kim and J.H.L. Hansen, “Feature Compensation Employing Model Combination for Robust Speech Recognition in In-Vehicle Environment”, *Biennial on DSP for In-Vehicle & Mobile System*, Istanbul, Turkey, June 2007.
- [5] S.Choi, J.Kim, D. Kwak, P. Angkititrakul, and J.H.L. Hansen, “Analysis and Classification of Driver Behaviour using In-Vehicle CAN-Bus Information”, *Biennial on DSP for In-Vehicle & Mobile System*, Istanbul, Turkey, June 2007.
- [6] A. Sathyanarayana, P. Angkititrakul, and J.H.L. Hansen, “Detecting and Classifying Driver Distraction”, *Biennial on DSP for In-Vehicle & Mobile System*, Istanbul, Turkey, June 2007.

## 5. Corpus Structure

Directory structure (Data → Gender → Driver ID → Session → Signal → Files)



### Filename

“DriverID\_session\_part\_[r]\_yyyy\_mm\_dd\_ttttt\_signal.wav”

e.g., dm1001\_s1\_p1\_2007\_02\_10\_163110\_AI\_1.raw

DriverID dm1001 => Driver id number: d = Dallas, m = male, f = female,  
1001 = 1<sup>st</sup> driver (1001, 1002, 1003, ...)

session s1 => session id: s1 = session 1, ..., s3 = session 3

part p1 => part number: p1 = part 1, ..., p4 = part 4

[r] 2 => sub-sections of files (if there are more than one): 1, 2, ...

yyyy\_mm\_dd 2007\_02\_10 => date of data collection

ttttt 163110 => time of data collection (16:31:10 o'clock)

signal AI\_1 => type of signal/measurement

### Signal/Measurement & File Format

**AUDIO** (16 kHz, 16-bit linear, RAW format)

AI\_1 Far-filed Microphone (the 2<sup>nd</sup> channel of microphone array which directly faces the driver).

**VIDEO** ( 640\*480 Resolution, 15 frame/sec)

CAM\_0 front-forward camera

CAM\_1 driver-face camera

**SENSOR** (100 Hz, floating point, RAW format)

Gas\_6 Gas-pedal pressure sensor

Brake\_7 Brake-pedal pressure sensor

**CAN (100 Hz, 16-bit linear, RAW format)**

CAN\_ACC\_RPM Accelerator RPM measurement  
CAN\_BRK\_CNT Approximate slope of Brake Value  
CAN\_BRK\_HIT Sudden brake press  
CAN\_BRK\_PRESS Brake is ON or OFF  
CAN\_BRK\_VALUE Pressure value on the brake  
CAN\_STR\_DEGREE Angular degree of steering wheel  
CAN\_STR\_HOLD Steering wheel movement  
CAN\_STR\_LR Steering wheel LEFT or RIGHT turn  
CAN\_VEH\_SPEED Vehicle Speed (km/h)

**Note:**

In case of recording malfunction, multiple sub-section of CAN signal will be represented as CAN1, CAN2, CAN3...

Consequently, gathering CAN1, CAN2 ... together will represent CAN signals of the whole driving route (e.g., s1\_p1\_CAN1 + s1\_p1\_CAN2 + ... = s1\_p1\_CAN).

**CAN definition****CAN1\_ACC\_RPM.raw**

This message holds the value of engine rpm. It can be closely associated with the average accelerator pedal press. A request from the driver for increase in vehicle speed is processed by pressing the accelerator pedal to increase or decrease the engine rpm which correspondingly varies the vehicle speed. Effectively, from this message we arrive at the driver demand for vehicle speed (acceleration pedal press).

**CAN1\_BRK\_CNT.raw**

This message is a counter, which counts the brake press during one brake-press event. The count can be 1,2,3,4..., or 1,5,7 ... depends on how the driver hits the brake. Driver might hit it slowly first and then harder later, or vice versa.

**CAN1\_BRK\_HIT.raw**

This message gives information if and when there is a sudden brake, i.e., the brake pedal is hit hard (say, 80-90% press of brake pedal).

**CAN1\_BRK\_PRESS.raw**

This message tells whether brake pedal has been pressed or not. It is binary information (on/off).

**CAN1\_BRK\_VALUE.raw**

This message holds the brake pressure value which represents how hard driver hits the brake.

**6. Acknowledgements and Contacts**

This project is sponsored in part by the New Energy and Industrial Development Corporation (NEDO), Japan through its research management agreement with the Center of Integrated Acoustic Information Research at Nagoya University, Japan and the Center for Robust Speech Systems (CRSS) at University of Texas at Dallas. Additional research infrastructure support has also been generously provided by The University of Texas at Dallas under Project

EMMITT, as part of a commitment from the State of Texas to expand and enrich the research infrastructure of Electrical Engineering in new and emerging research domains.

### **Principal Investigator**

Prof. John H.L. Hansen

### **Co-Principal Investigators**

Dr. Pongtep Angkititrakul (2006-2007), Dr. Wooil Kim(2007-2008), Dr. Pinar Boyraz (2008)

### **Student Assistants**

MS Thesis Students: Amardeep Sathyanarayana, Abhishek Kumar

2007: UTDrive Senior Design Team: Sangjo Choi, Jeonghee Kim, Anh Phuc Phan, Donggu Kwak

2006 UTDrive Senior Design Team: Tyler Creek, Paul Grein, Jeremy Hayes, Jeonghee Kim, Donggu Kwak, Wayne Lanham, Perter Moreno, Levi Noecker, Anh Phuc Phan, Vitali Ruder.

### **Contacts:**

**Prof. John H.L. Hansen:** [john.hansen@utdallas.edu](mailto:john.hansen@utdallas.edu)

**Dr. Pinar Boyraz:** [pinar.boyraz@utdallas.edu](mailto:pinar.boyraz@utdallas.edu)



Undergraduate UTDrive Student Senior Design Team (2006)