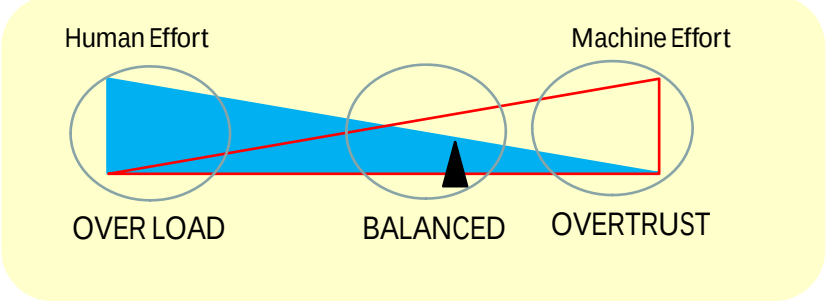
Modeling and detecting overtrust from behavior signals

Nagoya University,
Fujitsu Co., Ltd, DENSO Co., Ltd.

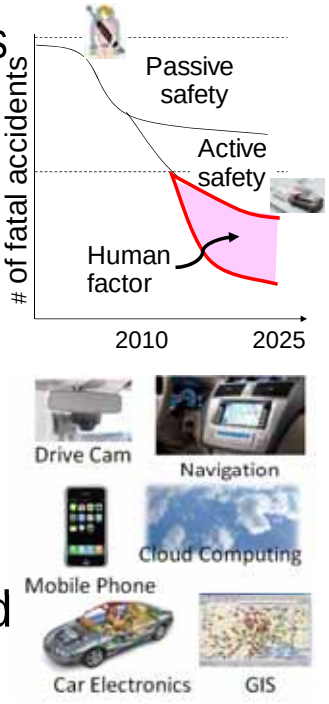
Aim of the Project

- Developing computational model of human behavior based on signal processing technology for building better man-machine cooperative systems.
- Members are from speech, computer vision, cognitive infomatics, ubiquitous system and mechatronics.
- Typical issue of man-machine mismatch is *over-trust*.

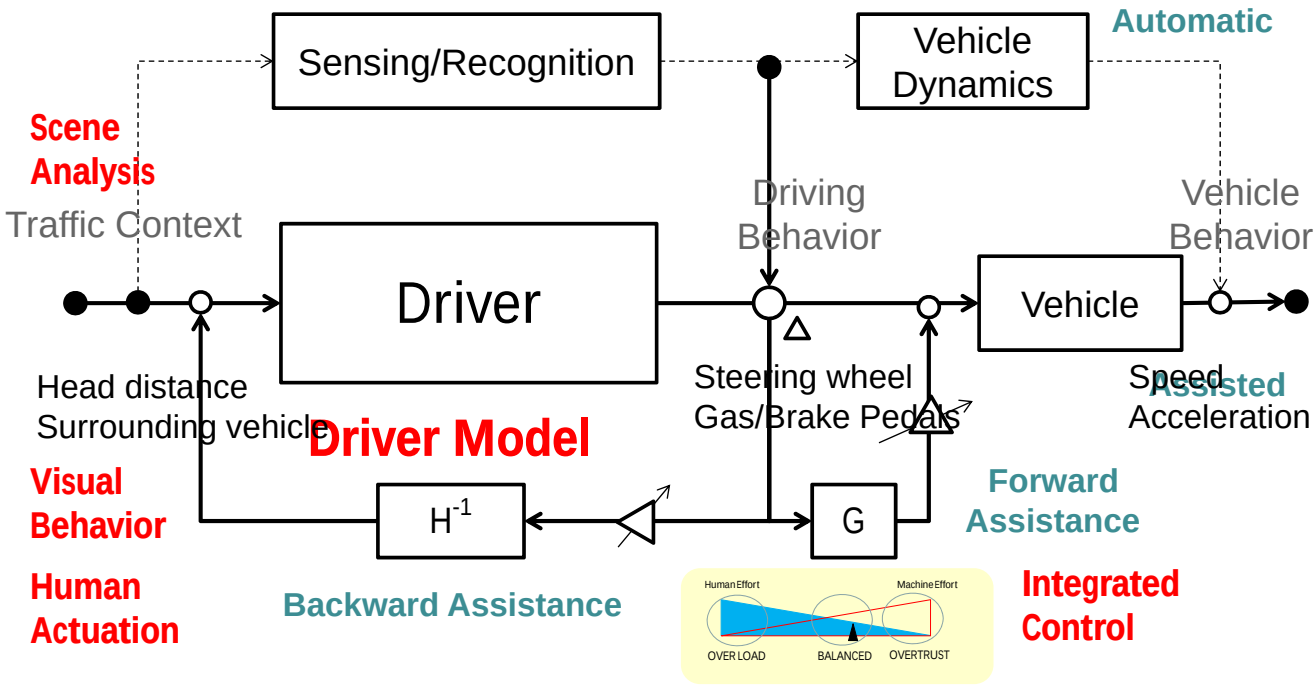


Main Application Field: Driving

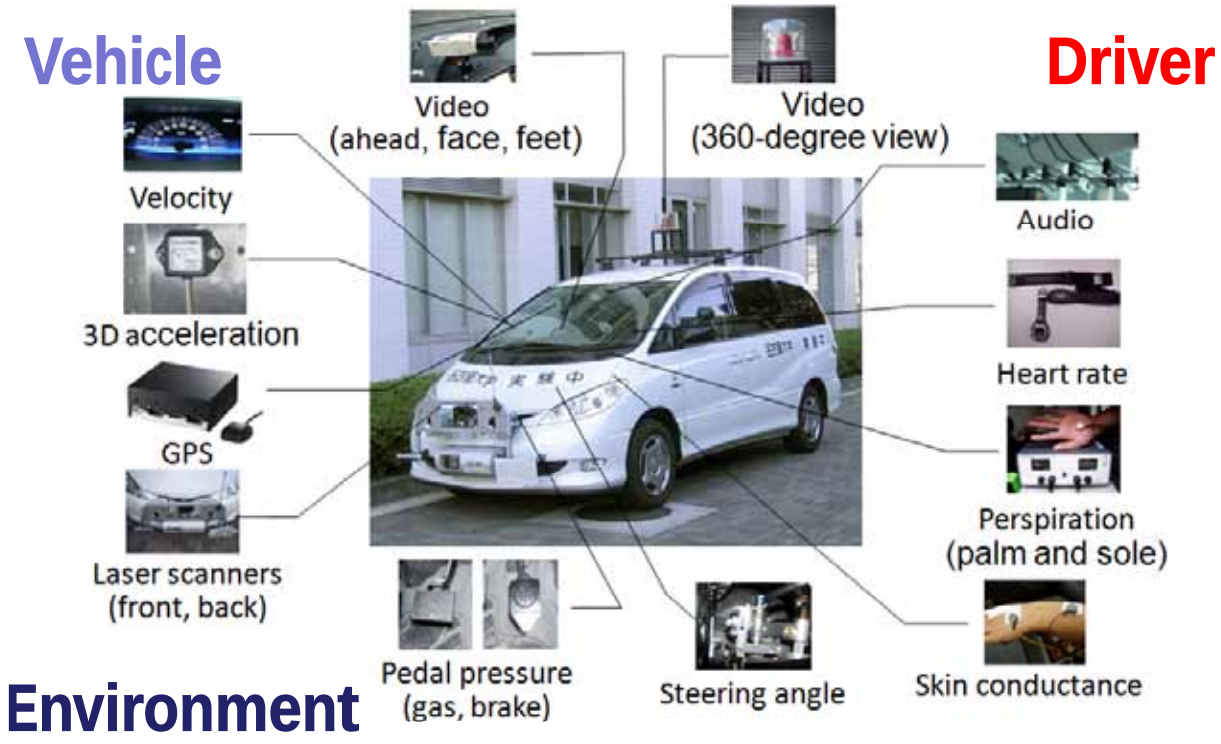
- The human factor (driver behavior) plays an important role in future automotive technologies aimed at both improving traffic safety and preserving the environment.
- Socio-motivated signals of human origin occurring in the physical world have not received much study, due to the lack of large amounts of signal data. The latest vehicles, equipped with rich sensors, and connected to the Internet are now making it possible.



Automatic, Assisted and Co-operative Driving



Corpus Collection

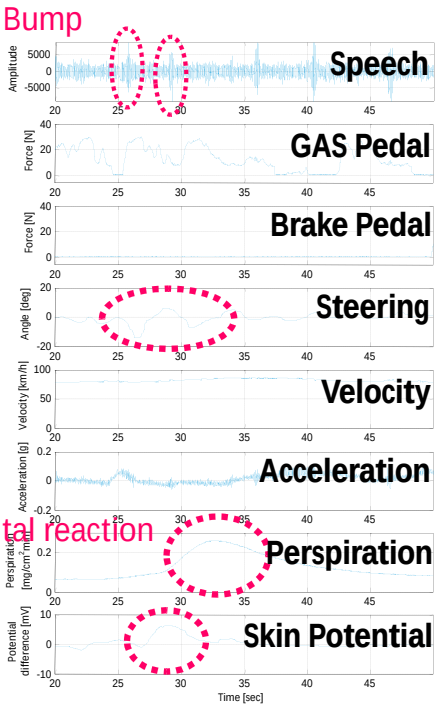


Signal Examples and Data Tags

- Lane change on a highway

Tags

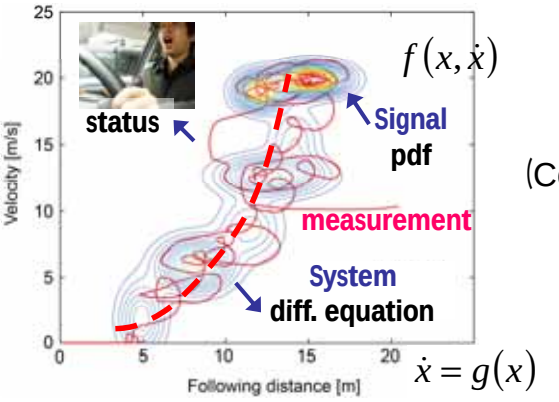
HWY、NO_TSK、DRZ、
LN_*、POS_LN_*、LOS_AB:、
LN_ENDS_IN、CAR_FOLLOW、
FACE_POS、HEAD_OTHER



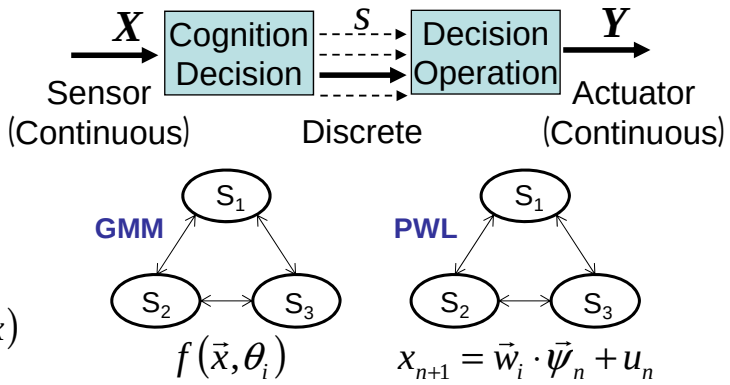
800 drivers, 800 hrs. 5 year collection

Modeling Driving Behavior

- Joint distribution of a variable and its time derivative is equivalent to a differential equation.
- Mathematical models of discrete/continuous hybrid systems are important for behavior modeling.



Signal model of dynamic system



Cognition/Decision/Operation

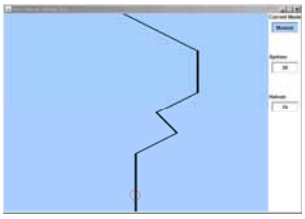
Driver Behavior SP research topics

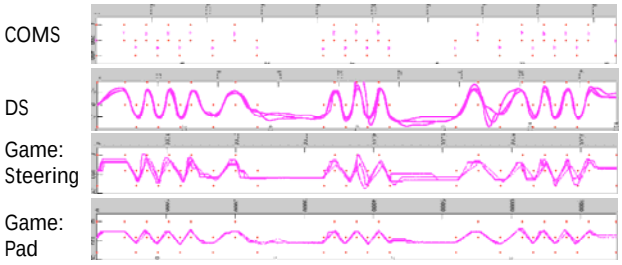
(1) Driver identification using pedal signals (2002-)
(2) Prediction of pedal patterns (2004-)
(3) Driver risk evaluation using EDR (2006-)
(4) Hazardous point detection from sensor signals(2006-)
(5) Prediction of lane-change trajectories (2008-)
(6) Detection of drivers' frustration (2008-)
(7) Driving data browser (2008-)
(8) Similarity measure for driving scenes (2009-)
(9) Driver coach system with detecting potentially dangerous events (2010-)

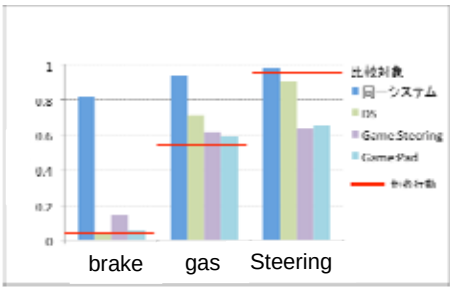
(1) Multiplatform Data Collection

- Corpus based approach for generalizing working hypotheses suggested by experimental psychology.

H. Terai





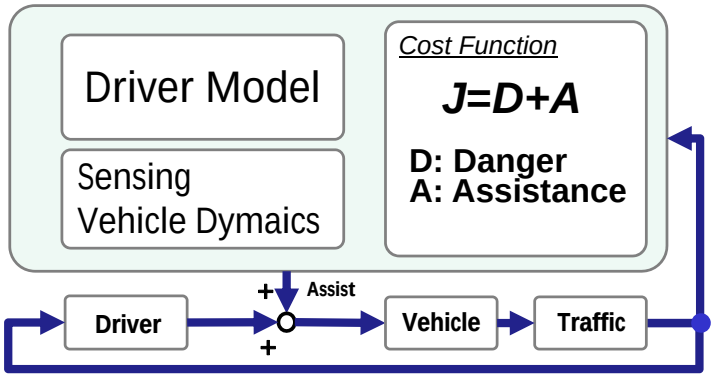


Coherence in operation: BRAKE<GAS

(2) Driver Model in Control Loop

- An experimental vehicle implementing forward assistance with the driver model has been built.
- Collecting Data under the multiplatform experimental environment.

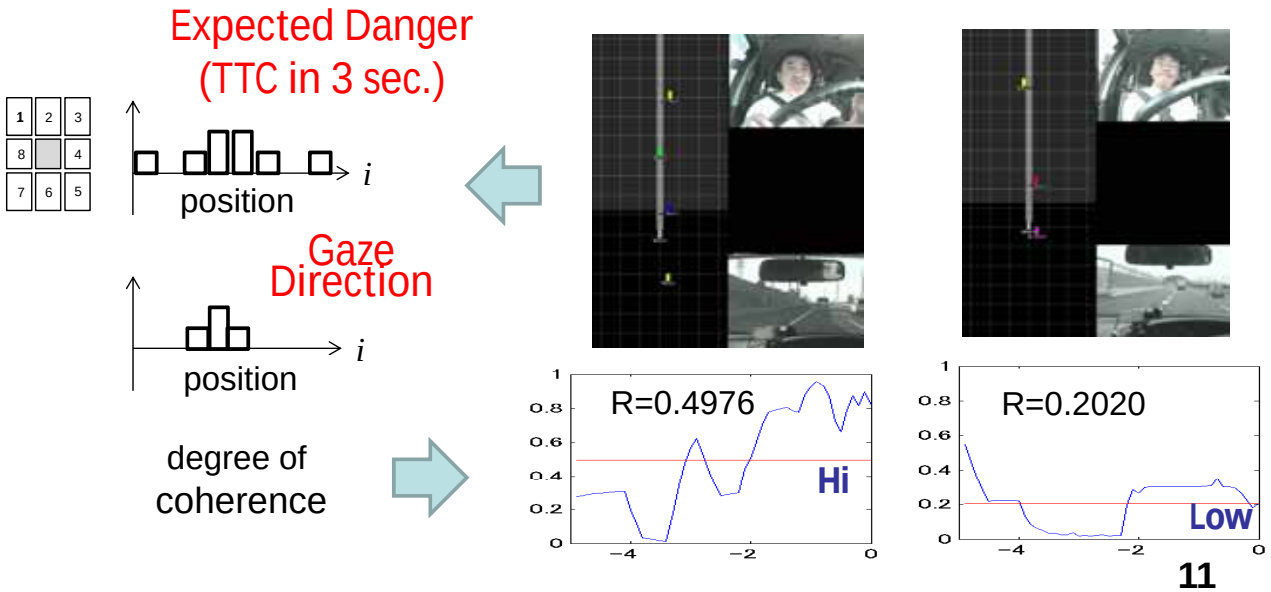
H.Okuda



(3) Visual Behavior Analysis

- Building a measure of the coherence between the visual behavior and the expected danger for detecting driver's distraction.

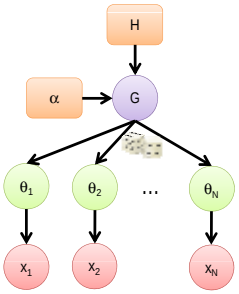
M.Hirayama



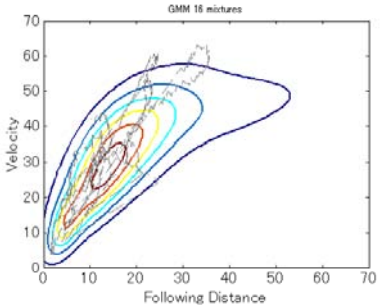
(4) Robustness of Driver Model

- Nonparametric Bayesian approach can effectively decide the optimal number of mixture components of GMM driver model regardless of driving situation.

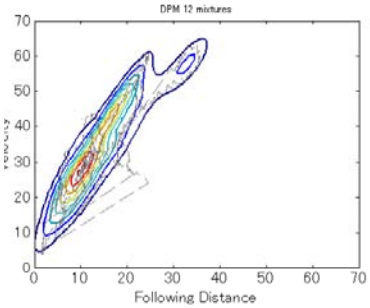
Pongtep
Angkititrakul



Dirichlet Process Mixture Model



GMM: 16 Mixtures
(UBM-MAP adapted)

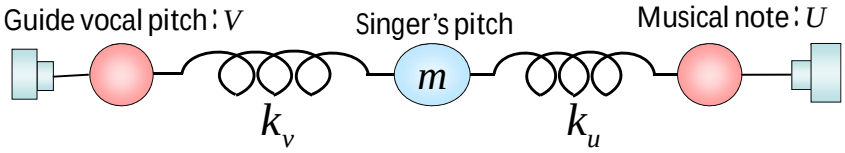


DPM: 14 Mixtures

Other Projects

(1) Building the sensor signal corpus of mobile devices.

(2) Modeling choral singing behavior.



(3) Building a bottom-up scene visibility measure.

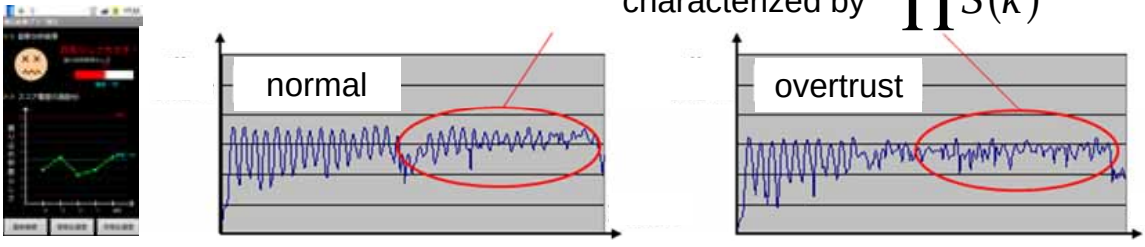
Field Tests

(1) Detecting fraud calls by combining keyword spotting and emotional speech recognition. (with Fujitsu Co., Ltd.)

Building a signal model of the speech under OVER-TRUST.

(2) Implementing an interactive automatic cruse control (ACC) which utilize both forward and backward assistance. (with DENSO Co., Ltd.)

Spectral flatness characterized by $\frac{\sum S(k)}{\prod S(k)}$



Power spectrum of LPC residual signal

Summary

- There is a ‘BIG DATA’ over the environment-machine-human interactions in the vehicular application fields.
- Signal processing techniques can build a computational methods of modeling and controlling ‘MANNED-MACHINE’.
- OVER-TRUST is an interesting mismatch.
- There are still a lot of challenges for practical applications.

Key References

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- (Driver Modeling PWARX) S. Sekizawa, T.Suzuki et al., “Modeling and Recognition of Driving Behavior Based on Stochastic Switched ARX Model,” IEEE Trans. on ITS, Vol.8(4) pp. 593-606, 2007
- (Driver Modeling GMM) C. Miyajima, Y. Nishiwaki "Driver Modeling Based on Driving Behavior and Its Evaluation in Driver Identification (Invited Paper)," Proceedings of the IEEE, Vol. 95, No.2, pp.427-437, 2007
- (Applications) C. Miyajima, P. Angkititrakul, K. Takeda, "Behavior signal processing for vehicular applications," 2011 APSIPA ASC 2011, Overview 3, 10 pages, Xi'an, China, Oct. 2011.