NEDO Project for Driver Behaviour Signal Modeling :

Research activities from Nagoya University

Our research activity focused on (1) data collection and (2) signal processing of driving behavior.

(1) Collection of real-world driving data (refer to [2],[4],[8]).

We developed a data collection vehicle equipped with various sensors for synchronous recording of speech, video, driving behavior, and physiological signals. The driving data is collected while driving on city roads and an expressway under four different task conditions: (i) reading words on signboards, (ii) being guided to an unfamiliar place by a human navigator on a cell phone, (iii) reading random four-letter strings by repeating after hearing, (iv) and interacting with a spoken dialogue system to retrieve and play music. Our goal is to collect driving data of 250 drivers.

(2) Establishment of signal processing techniques for driving behavior.

(a) Driver identification based on spectral analysis of behavior signals (refer to [7],[10],[11]).

Different drivers vary in how they hit the gas and brake pedals.We modeled such pedal operation patterns with Gaussian mixture models that represent the distributions of spectral features extracted through cepstral analysis of the pedal operation signals. We demonstrated that the driver model based on the spectral features of pedal operation signals achieved a driver identification rate of 76.8 % for 276 drivers.

(b) Generation of pedal operation patterns of individual drivers in car-following (refer to [5]).

Driving patterns of each driver were modeled with a Gaussian mixture model (GMM), which was trained as a joint probability distribution of following distance, velocity, pedal position signals and their dynamics. Gas and brake pedal operation patterns were generated from the GMMs in a maximum likelihood criterion so that the conditional probability was maximized for a given environment. Experimental results showed that car-following patterns generated from GMMs for three different drivers maintained their individual driving characteristics.

(c) Detection of potentially hazardous situations in vehicle traffic using driving behavior (refer to [1],[3],[6],[9]).

We focused on the analysis of drivers' reactions under hazardous scenarios in vehicle traffic. Driving behavior signals were utilized to detect a chain of changes in driver status and to retrieve incidents from a large real-world driving database. All the existing 25 potentially hazardous scenes in the database were hand-labeled and categorized. A new feature, based on joint-histograms of these behavioral signals and their dynamics was proposed and utilized to indicate anomalies in driving behavior. Brake pedal force-based method attained a true positive (TP) rate of 100% for a false positive (FP) rate of 4.5%, concerning the detection of 17 scenes where drivers slammed on the brakes. In 11 of the 25 hand-labeled scenes, drivers reacted verbally. Scenes where high-energy words were present were adequately retrieved by

the speech-based detection, which achieved a TP rate of 54% (6 scenes), for a FP rate of 6.4%. In addition, the proposed integration method, which combined brake force and speech signals, was satisfactory in boosting the detection of the most subjectively dangerous situations.

List of publications:

[1] Hideomi Amata, Chiyomi Miyajima, Akira Ozaki,Takanori Nishino, Norihide Kitaoka, and Kazuya Takeda, "Abrupt steering detection based on the road construction ordinance and vehicle acceleration captured with drive recorders", Proc. International Conference of Innovative Computing Information and Control (ICICIC 2008), Dalian, China, June 2008 (to appear).

[2] Akira Ozaki, Sunao Hara, Takashi Kusakawa, Chiyomi Miyajima,Takanori Nishino, Norihide Kitaoka, Katunobu Itou, Kazuya Takeda,"In-car speech data collection along with various multimodal signals," Proc. 2008 Language Resources and Evaluation Conference (LREC 2008), Marrakech, Morocco, May 2008 (to appear).

[3] Lucas Malta, Chiyomi Miyajima, and Kazuya Takeda, "Multimodal driving data integration for the analysis of driver's responses to hazardous situations," Proc. International Workshop on Tagging, Mining and Retrieval of Human Related Activity Information, Nagoya, Japan, Nov. 2007.

[4] Chiyomi Miyajima, Takashi Kusakawa, Takanori Nishino, Norihide Kitaoka, Katsunobu Itou, and Kazuya Takeda, "On-going data collection for driving behavior signal," Proc. 2007 Biennial on DSP for in-Vehicle and Mobile Systems (DSPINCARS 2007), Istanbul, Turkey, June 2007.

[5] Yoshihiro Nishiwaki, Chiyomi Miyajima, Norihide Kitaoka, Katsunobu Itou, and Kazuya Takeda, "Generation of pedal operation patterns of individual drivers in car-following for personalized cruise control," 2007 IEEE Intelligent Vehicles Symposium (IV 2007) pp.823-827, Istanbul, Turkey, June 2007.

[6] Lucas Malta, Chiyomi Miyajima, and Kazuya Takeda, "Mining potentially hazardous situations in vehicle traffic using drivers' reactions," 2007 IEEE Intelligent Vehicles Symposium (IV 2007), pp.1144-1149, Istanbul, Turkey, June 2007.

[7] Chiyomi Miyajima, Yoshihiro Nishiwaki, Koji Ozawa, Toshihiro Wakita, Katsunobu Itou, Kazuya Takeda, and Fumitada Itakura, "Driver modeling based on driving behavior and its evaluation in driver identification," Proceedings of the IEEE, vol.95, no.2, pp.427-437, Feb. 2007 (invited).

[8] Takashi Kusakawa, Chiyomi Miyajima, Takanori Nishino, Katsunobu Itou, and Kazuya Takeda, "Collection of multimodal data in real-world driving," ASA & ASJ Joint Meeting, Honolulu, Hawaii, Nov. 2006.

[9] Lucas Malta, Chiyomi Miyajima, Katsunobu Itou, and Kazuya Takeda,"Towards the detection of potentially hazardous situations in vehicle traffic using driver speech and brake pedal operation,"ASA & ASJ Joint Meeting, Honolulu, Hawaii, Nov. 2006.

[10] Chiyomi Miyajima, Yoshihiro Nishiwaki, Koji Ozawa, Toshihiro Wakita, Katsunobu Itou, and Kazuya Takeda, "Cepstral analysis of driving behavioral signals for driver identification," 2006 IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP 2006), Toulouse, France, vol.5, pp.921-924, May 2006.

[11] Toshihiro Wakita, Koji Ozawa, Chiyomi Miyajima, Kei Igarashi, Katsunobu Itou, Kazuya Takeda, and Fumitada Itakura, "Driver identification using driving behavior signals," IEICE Trans. Information and Systems, vol.E89-D, no.3, pp.1188-1194, Mar. 2006.

Links

Please refer to http://www.sp.m.is.nagoya-u.ac.jp/NEDO/ for current and future research activities.

Data Sructure

- Video file extension: "mov" --> movie
- Speech file extension: "pcm" --> PCM (pulse-code modulation)
- Driving behavior signal file extension: "ana" --> analogue
- Physiological signal file extension: "bio" --> biosignal

For further details of the directory tree, refer to pp.4-7 in
"http://www.sp.m.is.nagoya-u.ac.jp/~miyajima/NEDO/Japan_data_details.ppt"
or p.15 in
"http://www.sp.m.is.nagoya-u.ac.jp/~miyajima/NEDO/Japan_report.doc"