Bio-Signal Analysis for Human Machine Interaction

Yinfeng Fang, Jianhua Zhang, Naoyuki Kubota and Houxiang Zhang

The convergence of biometrics, signal processing, pattern recognition produces exciting new ideas for solving a variety of complex problems in human-machine interaction. During the last decades, growing interest has been aroused in exploiting electrical nature of the human nervous-muscular system for human-machine interfacing, using electromyography (EMG), electroencephalography (EEG), etc. In addition to the nerve-driven signals, researchers employ extrinsic physiological channels including facial expression, body skeleton, hand gestures, and gaze direction to approach human-machine interaction. The combination of these modalities can be successfully applied to human-like decision making.

In the special issue, we solicited original papers from different domains, e.g. human motion interpretation, bio-signal analysis and classification techniques, facial expression recognition, data fusion in daily healthcare environments. After a strict peer-review process, 14 papers are accepted for publication in this special issue. Key topics are summarized as following:

1. **Hardware development for bio-signal sensing and robotic joint control.** M. Hulea et al. propose a bio-inspired spiking electronic neural network for robotic joints control. The network includes several excitatory neurons that naturally determine the contraction force of the actuators, and unevenly distributed inhibitory neurons that regulate the excitatory activity. The results show that the electronic neural network is able to intelligently activate motion with high precision. M. Xu et al. propose a real-time high-sensitivity bio-magnetic field sensor for muscular activity detection in a challenging condition that magnetic shielding is not supplied. Taking advantage of the giant magneto-impedance effect theory, miniaturized magnetic probe, and the multistage signal amplification and noise suppression technologies, the proposed sensor receives pT level magnetic resolution.

2. **Convolutional neural network application for human motion detection.** J. Li et al. present a two-stream convolutional neural network (CNN)-based facial expression recognition system, utilizing both RGB and depth information from a RGB-D sensor. W. Yang et al. assess the effects of various window sizes and two different EMG representations for a convolutional neural network, and found that the frequency spectra derived from raw EMGs is more suitable as model input in the task of gesture classification. R. Tong et al. propose a dual-°ow deep neural network to extract EMG features for hand gesture classification, where both CNN and long short-term memory (LSTM) are utilized to extract EMG features from two different views. More than 6% accuracy improvement is received comparing to the baseline CNN. X. Wang et al. introduce a new deep learning network for automatic carotid artery detection, in which Attention Layer Part (ALP) is integrated into a basic Faster Region-CNN system for better assembling feature maps of different layers. Experimental results on carotid dataset show that the method surpasses other state-of-the-art object detection systems.

3. **EMG channel optimization.** EMG signal has been widely accepted to interact with prosthetic hands, but it is not clear if optimally placing the EMG electrodes could reduce system's complexity. Z. Wang et al. propose a genetic algorithm to optimize EMG channels and the corresponding positions on the forearm. The experimental results show that selecting nine out of sixteen EMG channels only reduces the accuracy by 3% in inter-day hand gesture recognition scenario, and the selected channel position also functions in intersubject scenario. Similar experimental result is also obtained by J. Hua et al. in different EMG database.

4. **Human behavior analysis.** M. Xia et al. provide a novel solution for aggressive driving detection leveraging the wrist-mounted smartwatch. An adaptive algorithm is designed to process the acceleration signal to detect aggressive driving behavior. C. Guo et al. propose a crowd feature perception algorithm based on a sparse linear model for crowd abnormal event detection, and the experimental results demonstrate its promising future. S. Liu et al. propose a 3D motion detection and long-term tracking system with simultaneous 3D reconstruction of dynamic objects. The proposed approach is robust to occlusion and out-of-view application scenarios. C. Guo et al. propose a multi-scale collaborative network for human pose estimation with novel loss function to satisfy the multi-scale properties.

5. **Bio-signal driven rehabilitation strategy.** D. Wu et al. construct an automatic seizure detection system, which combines the predicting result of multi-domain feature with the predicting result of spike rate feature to detect the occurrence of epileptic seizures from the EEG signal. The proposed method is applied to do seizure warning and recording to help the family member to take care of the patients and the doctor to adjust the antiepileptic drugs. Q. She et al. propose a time-frequency domain copula-based Granger Causality method to assess corticomuscular coupling characterization between motor cortex and muscles through EEG and EMG signals, which provides a potential quantitative analysis measure for motion control and rehabilitation evaluation.

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Guest Editors

Yinfeng Fang

Hangzhou Dianzi University, China

yinfeng.fang@hdu.edu.cn

Jianhua Zhang

Zhejiang University of Technology, China

zjh@zjut.edu.cn

Naoyuki Kubota

Tokyo Metropolitan University, Japan

kubota@tmu.ac.jp

Houxiang Zhang

Norwegian University of Science and Technology, Norway

hozh@ntnu.no