Sensing, processing, computing and networking for the era of wearables

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Editorial

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Wearable mobile devices, or simply wearables, can monitor people's physiological conditions in a real-time, reliable, and non-invasive manner. They are considered as viable replacements to smartphones for a more natural physiological monitoring. Besides, by incorporating the environment and activity information, wearables can provide more value-added services including the physical and mental healthcare, wellness, entertainment, localization and navigation, user authentication and identification, etc. The research as well as commercialization in this area is becoming more and more significant due to the global population aging issue.

Technically, the rapid development of the wearables is concomitant with the emergence of enabling technologies including sensors, micro-electromechanical systems (MEMS), signal processing, wireless communications, mobile and edge computing, integrated circuits, and artificial intelligence. This dramatic growth is impacting several scientific and engineering application domains. However, when designing the wearable systems, there are several features or constraints needed to be taken into account such as the sensing and computing efficiency, accuracy and reliability, data storage and security, communication and networking strategy, power consumption, form factor, flexibility, manufacturing cost, bio-compatibility, and so on. In this context, many of the aforementioned techniques should be reformed or customized to fulfill such practical requirements, which creates broad scientific research opportunities for many traditional communities. This is the main motivation of this special issue.

This special issue includes six review papers and three original technical papers, which report a few promising research directions and recent research advancements in the selected topic. The following is a brief outline of the contents:

The first two review papers focus on the wearable devices based on photovoltaic and triboelectric mechanisms. In the paper "**Flexible Organic Photodetectors and their Use in Wearable Systems**", the authors Guo, Saifi, Fukuda, Cheng, Lou, and Xu provide a comprehensive summary of the general design principles for organic photodetectors for wearable applications, address the device architecture and signal processing relations, reveal the challenges in further improving the performance of flexible device units and the integrated systems and highlight the methodologies in concrete scenarios for precision design and optimization.

In the paper "**Triboelectric Nanogenerator-based Wearable Electronic Devices and Systems: Toward Informatization and Intelligence**", the authors Li, Dai, Zhang, Wang, You, and Zhang introduce an emerging mechanical-to-electrical conversion device, named as triboelectric nanogenerator (TENG) and review its applications in the wearable scenarios, including human body perception and human-machine interaction, personnel identification, and etc. The representative signal processing methods and key challenges are summarized and discussed as well.

In the paper "**A Survey on Edge Computing for Wearable Technology**", the authors Jin, Li, Dang, Chen, and Liu consider the computing resource limitation for wearables and provide a comprehensive review on the existing work on edge computing for wearable technology from four aspects, i.e., computation scheduling, information perception, energy-saving, and security.

The next three papers mainly consider the potential applications of the wearables. In the paper "**Sensing Beyond Itself: Multifunctional Use of Ubiquitous Signals towards Wearable Applications**", the authors Wang, Li, Jin, Wang, Yang, Li, Ni, and Ding studied the sensing techniques from a unique perspective, where the sensors are applied to sense the signal different from its original functionalities, define such sensing approach as "cross-sensing" and provide a comprehensive review on the cross-sensing towards wearable applications.

In the paper "**Vibration Sensing-Based Human and Infrastructure Safety/Health Monitoring: A Survey**", the authors Valero, Li, Zhao, Zhang, Garrido, and Han carry out an extensive survey of the current vibration-based sensing technologies for human and infrastructure safety as well as health monitoring. Due to the low-cost and low-power features, the vibration sensing technology demonstrates significant potential for indoor and outdoor monitoring.

In the paper "**Recent Advances in User Authentication for Wearable Devices: A Contemporary Survey**", the authors Liu, Shao, Li, Xu, and Song concentrate on the security and privacy issues of wearables, review and categorize recent advances in user authentication for wearable devices. Besides, the evaluation metrics for user authentication in wearable devices are summarized and discussed.

In the paper "**An Embedded Lightweight SSVEP-BCI Electric Wheelchair with Hybrid Stimulator**", the authors Na, Hu, Sun, Wang, Zhang, Han, Yin, Zhang, Chen, and Zheng present an embedded lightweight steady-state visual evoked potentials brain-computer interface (SSVEP-BCI) electric wheelchair with a hybrid stimulator. Experiments on real systems show that the proposed embedded lightweight SSVEP-BCI electric wheelchair can be successfully operated by all eight subjects with a 93.9% average success rate of command operation.

In the paper "**Classification of Fall Directions via Wearable Motion Sensors**", the authors Turan, and Barshan investigate and compare the state-of-the-art fall-detection and classification algorithms on an extensive dataset. Data acquired from only a single motion sensor unit, worn at the waist of the subject, are processed for

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experimental verification. The results obtained in this study are promising in developing real-world fall classification systems as they enable fast and reliable classification of fall directions.

In the paper "**Few-shot Learning for Cardiac Arrhythmia Detection based on Electrocardiogram Data from Wearable Devices**", the authors Liu, Yang, Fan, and Wu propose a meta-transfer based few-shot learning method to deal with arrhythmia classification with the electrocardiogram (ECG) signal from the wearable devices. The experimental results illustrate that the proposed method outperforms in accuracy than other comparison methods when handling the various few-shot tasks under the same training samples.

We hope that the reader finds this special issue informative with the proper coverage of the sensing, signal processing, computing and networking techniques as well as applications of wearable devices.

Finally, we also would like to thank the Editor-in-Chief Dr. Ercan E. Kuruoglu and the anonymous reviewers for their constructive suggestions and support for the publication of this special issue.

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