Guest Editorial
Wireless Sensing Circuits and Systems for Healthcare and Biomedical Applications

THE rapid advancement of radio-frequency (RF), infrared, and optical technologies has enabled many wireless-sensing approaches for novel biomedical applications, such as implantable medical devices, characterization of biological materials, wireless neural prostheses, non-contact health monitoring, and remote-human-motion classification. Some applications entered human daily life shortly after their invention, significantly improving the productivity and life quality in our society. Some emerging applications have shown great potential to benefit the wellbeing of humans but are still under development to overcome technical challenges and incorporate human-factor considerations. With solutions ranging from sensor-on-chip to bench top systems, biomedical wireless sensing has drawn enormous interests from researchers and practitioners in private organizations, academic institutions, and industrial research centers.

This Special Issue aims to highlight recently-emerging techniques for circuits and systems that enable wireless healthcare based on sensing and control of parameters, including but not limited to: biological material properties, vital signs, activity data, location, and gestures. Most of the technical solutions presented in this special issue directly interact with human subjects or biological materials. Promising applications in high-impact areas, such as telemedicine, human tracking, biometrics, and wireless neural interface, will be presented.

This special issue features a total of 18 contributed papers on technology and application themes. The first paper provides an overview of recent developments on wireless sensing circuits and systems for healthcare and biomedical applications. The next three papers present state-of-the-art works on wireless neural interface. Paper "A high-voltage-tolerant and power-efficient stimulator with adaptive power supply realized in low-voltage CMOS process for implantable biomedical applications" realizes a stimulator in a 0.18-μm 1.8-V/3.3-V CMOS process. With a DC input voltage of 3.3 V, the chip provides an adjustable DC output voltage between 6.7 and 12.3 V at a step of 0.8 V, which results in a maximal system power efficiency of 56% at a 2400-μA stimulus current. In-vivo experiments verified that epileptic seizures could be suppressed by the electrical stimulation provided by the proposed stimulator. Paper "A low-noise, wireless, frequency-shaping neural recorder" reports a neural recorder with 2.2-μV input-referred noise integrated from 300 Hz to 8 kHz and 98-μW maximum power. In animal experiments, the output data of the neural signal processor were serialized and connected to a customized Wi-Fi data link with up to 10 Mbps data rate. In-vivo experiments demonstrated brain recordings with microelectrodes. Paper "Selective CS: An energy-efficient sensing architecture for wireless implantable neural decoding" developed a selective compressive sensing architecture for energy-efficient wireless implantable neural decoding based on compression analysis and deep learning. Extensive experimental results demonstrated more than 60% energy savings than conventional compressive sensing architecture.

For disease detection and patient monitoring, paper "Development of IoT-based impedometric biosensor for point-of-care monitoring of bone loss" reports a quick and inexpensive device for the quantification of type-1 collagen (CTx-1) levels in serum, which is an important parameter for bone loss detection. Paper "A miniature configurable wireless system for recording gastric electrophysiological activity and delivering high-energy electrical stimulation" developed and validated a miniaturized system that can wirelessly acquire gastric electrical activity, which are called "slow waves", and deliver high-energy electrical pulses to modulate its activity. The authors of the paper "Motion and noise artifact-resilient atrial fibrillation detection using a smartphone" developed a motion and noise artifacts (MNA)-resilient smartphone-based atrial fibrillation (AF) detection solution and evaluated the performance with 99 human subjects. In "A 60 GHz low power self-mixing receiver in 65-nm cmos for a radio-triggered battery-less monolithic wireless sensor", a radio-triggered battery-less monolithic wireless sensor based on millimeter-wave wireless power transfer technique was introduced. The single-chip millimeter-wave receiver was implemented in a 65 nm CMOS technology, achieving 16.4-mA current consumption from a 1-V power supply. In addition, paper "Broadband wireless sensing system for non-invasive testing of biological samples" proposed an RF system comprising of an ultra-wideband transmitter-receiver antenna and a highly-sensitive planar sensor for wireless sensing of glucose and saline concentration.

This special issue also includes several papers on biomedical radar sensors. In "Noncontact sleep stage estimation using a CW Doppler radar", the authors designed a continuous-wave (CW) Doppler radar to accurately measure sleep-related signals, including respiration, heartbeat, and body movement. 11 all-night polysomnography (PSG) recordings from 13 healthy examinees were used to validate the ability of the radar sensor to detect sleep stage information.

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In "Indoor localization for passive moving objects based on a redundant SIMO radar sensor", a single-frequency CW radar sensor with a redundant single-input multiple-output (SIMO) architecture is proposed to solve the challenges for short-range localization of passive moving objects in indoor environments. The authors of "Noncontact measurement of the instantaneous heart rate in a multi-person scenario using x-band array radar and adaptive array processing" developed a system with a two-dimensional planar wide-beam antenna array with a four-channel network analyzer. The direction of arrival was estimated using the Capon method, followed by the directionally-constrained minimization-of-power algorithm. The system was tested for noncontact measurement of the heart rate of a specific person when multiple people were present. Paper "A miniature reconfigurable inductorless IR-UWB transmitter-receiver for wireless short-range communication and vital-sign sensing" reports a miniature inductorless impulse-radio ultra-wideband transmitter-receiver and a radar system for wireless short-range communication and vital-sign sensing. Another work on UWB biomedical radar is reported in "Non-contact human motion recognition based on UWB radar". Paper "Sensor fusion of capacitively-coupled ECG and continuous-wave Doppler radar for improved unobtrusive heart rate measurements" investigates sensor fusion based on simultaneous and synchronous acquisition of four ccECG channels and I-Q radar signals. The challenges and solutions for using biomedical radar sensors on an unmanned aerial vehicle (UAV) can be found in paper "Motion compensation for an unmanned aerial vehicle remote radar life sensor", while the electromagnetic modeling problems for biomedical radar sensors can be found in "An electromagnetic model of human vital signs detection and its experimental validation". Finally, paper "Doppler radar techniques for accurate respiration characterization and subject identification" reports recent research works towards accurate remote characterization of respiration for human identification.

We would like to thank all the authors who have submitted papers to this special issue. We also express our sincere gratitude to the reviewers for providing high-quality reviews in a timely fashion. We are indebted to the Editor-in-Chief Dr. Yen-Kuang Chen, the Deputy Editor-in-Chief Dr. Eduard Alarcon, and the JETCAS editorial team for their consistent support throughout the review, selection, and publication process. We hope that the readers will enjoy the papers in this special issue!

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