IEEE Access
Multidisciplinary | Rapid Review | Open Access Journal

SPECIAL SECTION ON ADVANCED INFORMATION SENSING AND LEARNING TECHNOLOGIES FOR DATA-CENTRIC SMART HEALTH APPLICATIONS

Digital Object Identifier 10.1109/ACCESS.2021.3057527

EDITORIAL

IEEE ACCESS SPECIAL SECTION EDITORIAL: ADVANCED INFORMATION SENSING AND LEARNING TECHNOLOGIES FOR DATA-CENTRIC SMART HEALTH APPLICATIONS

I. INTRODUCTION

Smart health is bringing vast and promising possibilities on the road to comprehensive health management. Smart health applications are strongly data-centric and, thus, empowered by two key factors: information sensing and information learning. In a smart health system, it is crucial to effectively sense individuals' health information and intelligently learn from its high-level health insights. These two factors are also closely coupled. For example, to enhance the signal quality, a sensing array requires advanced information learning techniques to fuse the information, and to enrich medical insights in mobile health monitoring, we need to combine ''multimodal signal processing and machine learning techniques'' and ''nonintrusive multimodality sensing methods.'' In new smart health application exploration, challenges arise in both information sensing and learning, especially their areas of interaction.

This Special Section in IEEE ACCESS aimed to bring in academic and industrial experts to make their contributions to information sensing and learning in smart health systems. Studies were expected to build new bridges on many gaps between human subjects and their health insights, leveraging information sensing, and learning technologies, such as physiological sensing, motion sensing, multimodal signal processing, health data representation techniques, machine learning, deep learning, data mining, computing platforms, and other related techniques. These technologies are required to build a whole data flow from humans to the health insights that we pursue. This Special Section allows readers to identify advancements, challenges, and new opportunities in information sensing and learning for emerging smart health applications.

This Special Section collected research contributions from May 2018 to October 2018, in an early stage of smart health sensing and learning areas. After observing increasing submissions, we then extended the collecting period to last until February 2019.

The Call for Papers raised great enthusiasm in the scientific community, and we received more than 50 submissions. After a rigorous peer-review process, 20 have been accepted for inclusion in the Special Section.

II. SMART SENSING AND LEARNING ALGORITHMS

In the article ''Automated non-contact detection of head and body positions during sleep,'' by Akbarian *et al.*, the authors investigate how deep learning can facilitate obstructive sleep apnea detection by intelligently estimating head position from infrared images taken during sleep. Results show that the lateral and supine head positions are robustly detected, indicating the potential of non-contact sleep monitoring and analysis.

In the article ''Optimizing remote photoplethysmography using adaptive skin segmentation for real-time heart rate monitoring,'' by Fouad *et al.*, the authors propose an adaptive skin segmentation approach which can filter out non-skin pixels from region-of-interest in the remote photoplethysmograph image, thereby significantly improving the heart rate estimation accuracy.

In the article ''Dynamic ECG signal quality evaluation based on the generalized bSQI index,'' by Liu *et al.*, the authors research effective methods to analyze wearable ECG signal quality for cardiac disease monitoring applications. This study analyzes different QRS detectors and their combinations to derive the signal-quality-index (SQI) and recommend the optimal setting of QRS detectors.

In the article ''A novel low-cost sensor prototype for nocturia monitoring in older people,'' by Taramasco *et al.*, the authors develop a system to detect micturition events for older people, incorporating a Data Capture module and an eHomeseniors Server module. Experiments show that the system is effective for nocturia monitoring.

In the article ''Syndrome differentiation and treatment algorithm model in traditional Chinese medicine based on disease cause, location, characteristics, and conditions,'' by Chen *et al.*, the authors propose a Syndrome Differentiation and Treatment System to assist the treatment processes of traditional Chinese medicine and improve the service quality of doctor diagnosis and treatment.

In the article ''A small file merging strategy for spatiotemporal data in smart health,'' by Xiong *et al.*, the authors propose a small file merging and access approach, aiming to accommodate the rapid development of smart health that brings huge amounts of data from sensors and wearable

devices. A spatiotemporal clustering strategy is leveraged to effectively manage the distributed and small heath files.

In the article "VERB: VFCDM-based electrocardiogram reconstruction and beat detection algorithm," by Bashar *et al.*, the authors propose a Variable-Frequency-Complex-Demodulation (VFCDM)-based method to detect ECG heartbeats and a position-dependent adaptive thresholding method to refine the results, which yield robust heartbeat detection accuracy.

In the article "Algorithmic bias in clinical populations—Evaluating and improving facial analysis technology in older adults with dementia," by Taati *et al.*, the authors investigate how age factors cause an algorithmic bias in the facial analysis of dementia. The training process is then enhanced by augmenting the representative samples to mitigate this bias.

In the article "A review of approaches for sleep quality analysis," by Mendonca *et al.*, the authors review sleep quality measurement methods from the past two decades, and formulate and analyze methods for sleep quality assessment and measures for sleep quality estimation. Key findings and challenges in this field are detailed in this review study.

In the article "A hyperdimensional computing framework for analysis of cardiorespiratory synchronization during paced deep breathing," by Kleyko *et al.*, the authors propose a feature-based analysis method to assess the similarity between heart rate and respiration. This hyperdimensional computing method is effective in analyzing the cardiorespiratory synchronization.

The article "Self-identification respiratory disorder based on continuous wave radar sensor system," by Van *et al.*, studies a contactless vital signal detection system, which leverages a continuous wave radar system to detect breathing rate without disturbing users' comfort. Both short-time Fourier transform and wavelet transform are implemented to extract the features from the radar signals.

The article "Early detection of lower MMSE scores in elderly based on dual-task gait," by Aoki *et al.*, investigates the machine learning of Kinect whole-body movements and gait in order to predict the mini-mental stage exam (MMSE) scores used for assessing cognitive status in the elderly. This research aims to support early and automated diagnosis of cognitive impairment.

In the article "Real-time detection of acute cognitive stress using a convolutional neural network from electrocardiographic signal," by He *et al.*, the authors propose a convolutional neural network framework to detect the acute cognitive stress from ECG signals and show that with a super-shot window, false stress sample detection is decreased by deep learning.

The article "Coronary arteries segmentation based on 3D FCN with attention gate and level set function," by Shen *et al.*, reports a 3-D fully convolutional network to segment and examine the coronary arteries in medical images for artery stenosis and plaque detection. An attention gate is introduced to enhance the region of interest, and the results are further optimized by level set functions.

The article "Automatic detection of cry sounds in neonatal intensive care units by using deep learning and acoustic scene simulation," by Severini *et al.*, proposes a deep learning framework for cry detection in professional medical environments and investigates whether synthetic data sets can replace massive data collection and enable retargeting of the deep learning framework.

The article "Discriminative models of spontaneous kicking movement patterns for term and preterm infants: A pilot study," by Fry *et al.*, studies machine learning methods for classifying gross kicking activity for infants and discusses factors including sensor placement locations, age-to kicking time correlations, and bilateral/unilateral patterns.

The article "Patient-specific physiological monitoring and prediction using structured Gaussian processes," by Zhu *et al.*, introduces Bayesian hierarchical Gaussian processes to infer hidden latent structures of the vital sign's trajectory for patient individuals or groups, which enables pattern identification, targeting the challenges induced by temporal variability and inter-subject variability.

The article "Remote monitoring of human vital signs using mm-wave FMCW radar," by Alizadeh *et al.*, proposes an electromagnetic radar system operating at 77 GHz in a bedroom environment to extract respiration rate and heart rate. Phase unwrapping manipulation methods are introduced for radar signal analysis.

The article "gwSPIA: Improved signaling pathway impact analysis with gene weights," by Bao *et al.*, incorporates three signaling pathway-based gene weight merits that reflect genes importance in different aspects and attempts to associate the general importance with related diseases. The results suggest an effective association between genes and related diseases.

The article "ECG arrhythmias detection using auxiliary classifier generative adversarial network and residual network," by Wang *et al.*, proposes a deep learning framework for ECG arrhythmia detection by combining the Auxiliary Classifier Generative Adversarial Network and the Residual Network. The results verify the robustness and accuracy of the proposed deep learning framework.

III. CONCLUSION

The Guest Editors hope that this Special Section will benefit the scientific community and contribute to the knowledge base, and would like to take this opportunity to applaud the contributions of the authors. The 20 accepted articles have demonstrated various research efforts and directions that facilitate smart health applications by leveraging smart sensing and/or learning technologies.

The Guest Editors highly appreciate the contributions of the reviewers for their constructive comments and suggestions. The Guest Editors would also like to acknowledge the efforts from IEEE ACCESS Editor-in-Chief and staff members.

QINGXUE ZHANG, *Lead Editor*
Cardiovascular Research Center
Harvard University
Cambridge, MA 02238, USA
Department of Electrical and Computer Engineering
Indiana University–Purdue University Indianapolis
Indianapolis, IN 46202, USA

VINCENZO PIURI, *Guest Editor*
Department of Computer Engineering
University of Milan
20122 Milan, Italy

EDWARD A. CLANCY, *Guest Editor*
Department of Electrical and Computer Engineering
Worcester Polytechnic Institute
Worcester, MA 01609, USA

Department of Biomedical Engineering
Worcester Polytechnic Institute
Worcester, MA 01609, USA

DIAN ZHOU, *Guest Editor*
Department of Electrical and Computer Engineering
The University of Texas at Dallas
Richardson, TX 75080, USA

THOMAS PENZEL, *Guest Editor*
Interdisciplinary Center of Sleep Medicine
Charite University Hospital
10117 Berlin, Germany

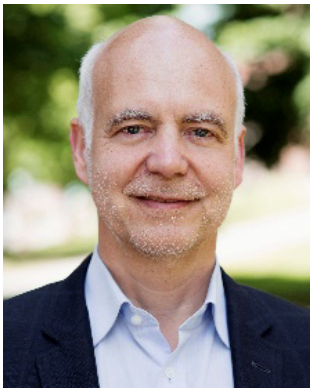
WENCHUANG WALTER HU, *Guest Editor*
Department of Electrical and Computer Engineering
The University of Texas at Dallas
Richardson, TX 75080, USA

QINGXUE ZHANG (Member, IEEE) received the B.Sc. and M.Sc. degrees from Xi'an Jiaotong University, China, in 2004 and 2007, respectively, and the Ph.D. degree in electrical and computing engineering from The University of Texas at Dallas, Richardson, TX, USA, in 2017. He is currently an Assistant Professor with the Department of Electrical and Computer Engineering, Purdue School of Engineering and Technology, Indiana University–Purdue University at Indianapolis. He has worked in industry and at Harvard for seven years. His research leverages deep learning to uncover the power hidden in big data and also leverages wearable computers and the IoT devices to capture physiological, behavioral, and biological signs from human subjects for big data applications. His research interests include pervasive embedded intelligence, artificial intelligence, wearable intelligence, mobile health, edge computing, medical IoT Platforms, wearable sensing, physiological signal processing, and smart health/home/world big data. He has published numerous journals and conference papers in the above areas, and received the Featured Article Award from IEEE Access, the Best Paper Award at the IEEE UEMCON Conference, and the Early Career Travel Award at the American Heart Association Conference. He also serves on multiple IEEE Conference Committees and is an Associate Editor of IEEE Access.

VINCENZO PIURI (Fellow, IEEE) received the Ph.D. degree in computer engineering from the Polytechnic of Milan, Italy, in 1989. He has been a Full Professor in computer engineering with the University of Milan, Italy, since 2000. He has also been an Associate Professor with the Polytechnic of Milan and a Visiting Professor with The University of Texas at Austin, Richardson, TX, USA, and a Visiting Researcher with George Mason University, Fairfax, VA, USA. His main research interests include artificial intelligence, computational intelligence, intelligent systems, machine learning, pattern analysis and recognition, signal and image processing, biometrics, intelligent measurement systems, industrial applications, digital processing architectures, fault tolerance, cloud computing infrastructures, and the Internet of Things. His original results have been published in more than 400 papers in international journals, proceedings of international conferences, books, and book chapters. He is a Distinguished Scientist of ACM and a Senior Member of INNS. He has been the President of the IEEE Systems Council since 2020 and IEEE Region 8 Director-elect since 2021, and IEEE Vice President for Technical Activities in 2015, the IEEE Director, the President of the IEEE Computational Intelligence Society, the Vice President of Education of the IEEE Biometrics Council, the Vice President for Publications of the IEEE Instrumentation and Measurement Society and the IEEE Systems Council, and the Vice President of Membership of the IEEE Computational Intelligence Society. He has been the Editor-in-Chief of IEEE Systems Journal from 2013 to 2019. He is currently an Associate Editor of IEEE Transactions on Cloud Computing. He has been an Associate Editor of IEEE Transactions on Computers, IEEE Transactions on Neural Networks, IEEE Transactions on Instrumentation and Measurement, and IEEE Access. He received the IEEE Instrumentation and Measurement Society Technical Award in 2002 and the IEEE TAB Hall of Honor in 2019. He is an Honorary Professor at Obuda University, Hungary, the Guangdong University of Petrochemical Technology, China, Northeastern University, China, the Muroran Institute of Technology, Japan, and Amity University, India.

EDWARD (TED) A. CLANCY (Senior Member, IEEE) received the B.S. degree from Worcester Polytechnic Institute (WPI), and the S.M. and Ph.D. degrees from the Massachusetts Institute of Technology (MIT), all in electrical engineering. He has worked in industry for medical instrumentation and analysis companies interested in EMG, EEG, ECG and blood pressure, and the defense industry (aircraft instruments and radar). He is currently a Professor of electrical and computer engineering, and of biomedical engineering, WPI. His research interests include signal processing, stochastic estimation, applied system identification, and instrumentation, particularly applied to problems in medical engineering and human rehabilitation.

DIAN ZHOU (Senior Member, IEEE) received the B.S. and M.S. degrees in physics from Fudan University, Shanghai, China, in 1982 and 1985, respectively, and the Ph.D. degree in electrical and computer engineering from the University of Illinois at Urbana–Champaign, Champaign, IL, USA, in 1990. He is currently a Professor with The University of Texas at Dallas, Richardson, TX, USA. His current research interests include smart health, machine learning, big data, the Internet of Things, VLSI design, circuit and systems, and algorithms. He was a recipient of the IEEE Circuits and Systems Society Darlington Award in 1993 and the National Science Foundation (NSF) Young Investigator Award in 1994.



THOMAS PENZEL received the degrees in physics, human biology, and physiology from the University Marburg, Germany, in 1986, 1991, and 1995, respectively. In 2006, he moved to Berlin, where he is currently the Director of research of the Interdisciplinary Sleep Medicine Center, Charité–Universitätsmedizin Berlin, Germany. In 2001, he received the BIAL Award for Clinical Medicine, Portugal, in 2008, the Bill Gruen Award for Innovations in Sleep Research by the American Sleep Research Society, and in 2014 the Distinguished Research Award by the Chinese Sleep Research Society. He is the President of the German Sleep Society and an Adcom Member of IEEE EMBS. He was the IEEE EMBC 2019 Conference Chair, Co-Chair of earlier EMBS conferences, and World Sleep Society in 2005, Berlin. He is the Editor-in-Chief of the *Sleep and Breathing Journal* and an Editorial Board Member of several IEEE journals. He has published more than 300 journal articles (Pubmed), about 80 book chapters, and has edited several books. His research interests include sleep medicine, biomedical signals, and cardiovascular and neural systems related to sleep–wake regulation.

WENCHUANG WALTER HU (Senior Member, IEEE) received the B.S. degree from Peking University, China, in 1999, and the Ph.D. degree from the University of Notre Dame, Notre Dame, IN, USA, in 2004. Then, he spent a year as a Postdoctoral Research Fellow with the Department of Electrical Engineering, University of Michigan, Ann Arbor, MI, USA. In September 2005, he joined The University of Texas at Dallas. He is currently a Professor with the Department of Electrical Engineering. His research interests include biosensors, bioelectronics, nanolithography, nanofabrication, and applications in medical, semiconductors, and renewable energy. He is a member of Sigma Xi, AVS, MRS, ACS, and SPIE.