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EDITORIAL

IEEE ACCESS SPECIAL SECTION EDITORIAL: BODY AREA NETWORKS

The Special Section in IEEE ACCESS on Body Area Networks (BAN) collects the extended versions of the best manuscripts submitted to and presented at "Bodynets 2016," a conference that "aims to provide a world-leading and unique opportunity for bringing together researchers and practitioners from diverse disciplines to plan, analyze, design, build, deploy and experiment with/on Body Area Networks (BANs)" http://bodynets.org/2016/show/home, held in December 2016 in Torino, Italy.

Recent findings in BAN related bio-medical engineering research, in the fields of electronics, medicine, materials science, electromagnetics, signal processing, computing, etc., and more importantly the significance of the interdisciplinary aspects between them that provides a successful solution are put together through 13 high-quality publications authored by experts from all around the globe (USA, Germany, China, Finland, Italy, etc.). Even as this Editorial was written, many of the articles had already received a very large number of views, clearly demonstrating the challenge of the considered subject.

Some articles have tried to answer the novel requirements of the healthcare sector, facing, among other issues, the strong demographic changes associated with the elderly population, presenting researchers with new and exciting challenges. Advanced electronic and networked systems allowing real time monitoring can strongly reduce medication time and costs. Timely intervention of physicians on individuals living alone (whose number is constantly increasing), or in remote areas, is possible if appropriate data transmission infrastructure is guaranteed. One part of this complex architecture is the so-called Body Area Network (BAN), i.e. the part of the communication infrastructure that directly interacts with the human body. It should be able to support both the sensing part, connected to the relative data transmission from the person under inspection, to the physician, and the possibility to receive notifications and/or alerts once the data has been processed. Such technologies are already starting to enter into routine clinical practice. However, novel technologies such as nano-communication, intra/extra body communication, and others open the door for more and more accurate future diagnostics. Today's research activity is strongly driven by non-invasive exploration of living bodies. Wide-band reflectometry using adequate antennas system represents a possible way, but sometimes more accuracy is required, which can be achieved by the use of implantable sensors that can more closely investigate the interested tissues and are able to communicate with the external systems. For some applications, this communication can be unidirectional for monitoring purposes, but even in these cases, the transceiver should be carefully designed to obtain the necessary data while generating as low as possible radiofrequency power within the tissues. The received signal is processed locally or sent to a remote medical center for further processing. The algorithms to extract the information are quite complex, and the low signal-to-noise ratio makes the analysis even more challenging. A bi-directional communication on the other hand represents a considerable advancement, when the sensor nodes are remotely controlled based on the feedback of the received data, for controlled drug release applications, as an example. Nevertheless, the reduced transmitter-receiver distance and the presence of different high-loss tissues introduce strong reflections. Healthcare is very likely the main but not the only application domain for BANs. Wellness, social interactions, emergency and rescue, as well as military are other important application areas for BANs; all of them would profit from advances in BANs and in how BANs will be developed and deployed in real-working, even large scale, testbeds.

The invited article of Felicetti, *et al.*, (Congestion control in molecular cyber-physical systems) discusses the performances of a new class of engineered systems based on interactions between cyber and physical components, by integrating three main components: communications, control, and computing. When these systems are brought to the nanoscale, some design and implementation issues arise. A high level of complexity is due to the use of biological components in a cyber-physical system (CPS), such as engineered cells, which may play the role of sensors, actuators, or even controllers. In this article, the study of the effectiveness of control solutions implemented through the usage of molecular communications in a biological nanoscale CPS, where a biological nanomachine plays the role of actuator that releases drug molecules, and another acts as both sensor and controller, is discussed.

The article by Davis, *et al.*, (Effects of ambient lighting displays on peripheral activity awareness), which received the Best Conference Paper Award, discusses the development of "smart" everyday objects, which offer tremendous opportunities for maintaining the quality of life in ambient assisted living (AAL) environments. In particular a peripheral activity-based awareness system that captures human activity information and renders this information to enhance context awareness and support social connectedness between the elderly and their caregivers has been envisaged.

Li, *et al.*, (A neuro-fuzzy fatigue-tracking and classification system for wheelchair users) discuss the functionalities of smart wheelchairs as mobility assistive equipment issues related to the increasing elderly and disabled population worldwide. The article suggests a neuro-fuzzy fatigue tracking and classification system and applies this method to classify fatigue degree for manual wheelchair users, considering both physiological and kinetic data, collected by surface electromyography, electrocardiography, and acceleration signals. The necessary features are then extracted from the signals and integrated with a self-rating method to train the neuro-fuzzy classifier.

Reliability is one of the most important communication metrics in wireless BANs especially for medical applications. However, traditional one-hop transmission power control methods failed to guarantee the reliability when the transmission distance is large. Zhang, *et al.*, (A relay-aided transmission power control method in wireless body area networks) propose a relay-aided transmission power control method providing reliable transmission and simultaneously alleviating the relaying burden on relay nodes. The proposed technique automatically switches transmitter's transmission strategy between the direct transmission and the relay-aided transmission based on the channel condition to consider the long distance problem, and then adaptively adjusts the transmission power according to the received signal strength indicator feedback, to guarantee the reliable transmission as much as possible and conserve the energy of relay nodes. Additionally, in the proposed method, parameters are tunable according to the application scenarios to make the tradeoff between reliability and energy efficiency.

The article authored by Genovese, *et al.*, (A smartwatch step counter for slow and intermittent ambulation) is concerned with the development and the preliminary validation of a step counter (SC) designed to operate also in conditions of slow and intermittent ambulation. The SC is based on processing the accelerometer data measured by a Gear 2 smartwatch running a custom wearable app. Data is compared with two different commercial SCs, and an error is limited to 5%, which is significantly lower than errors of 20%-30% incurred by the two other SCs.

Wu, *et al.*, (An autonomous wireless body area network implementation towards iot connected healthcare applications) proposes a wearable sensor node with solar energy harvesting and Bluetooth low energy transmission that enables the implementation of an autonomous wireless BAN (WBAN). Multiple sensor nodes can be deployed on different positions of the body to measure the subject's body temperature distribution, heartbeat, and to detect falls. A web-based smartphone application is also developed for displaying the sensor data and fall notification. To extend the lifetime of the wearable sensor node, a flexible solar energy harvester with an output-based maximum power point tracking technique is used to power the sensor node. Experimental results show that the wearable sensor node works well when powered by the solar energy harvester. The autonomous 24h operation is achieved with the experimental results. The proposed system with solar energy harvesting demonstrates that long-term continuous medical monitoring based on WBAN is possible provided that the subject stays outside for a short period of time in a day.

Through 154 references, Särestöniemi, *et al.*, (An overview of the electromagnetic simulation based channel modeling techniques for wireless body area network applications) present a general overview, including recent progresses, of the electromagnetic simulation-based WBAN channel modeling techniques. Advantages, disadvantages, and the most appropriate applications are described. Furthermore, the features of the different techniques are compared.

The article of Zhang, *et al.*, (HeartID: A multiresolution convolutional neural network for ECG-based biometric human identification in smart health applications) presents some application of the BAN related to health applications in the new era of smart cities. To meet increasing security and privacy requirements, physiological signal-based biometric human identification is gaining tremendous attention. To enable a data-independent and highly generalizable signal processing and feature learning process, a novel wavelet domain multiresolution convolutional neural network is proposed, which allows for blindly selecting a physiological signal segment for identification purpose, avoiding the intricate signal fiducial characteristics extraction process.

Matekovits, *et al.*, (Mutual coupling reduction between implanted microstrip antennas on a cylindrical bio-metallic ground plane) propose and compare different methods to reduce the mutual coupling between two antennas within a multilayer cylindrical body model that includes highly lossy body tissues into which a biocompatible metal implant is inserted. This cylindrical bio-metal implant serves as the common ground plane for the conformal low profile antennas. The mutual coupling between two such conformal microstrip antennas is studied and quantified for different spacing between them.

Properties of the next generation of cooperative wearables are the topic of the article authored by Seiffert, *et al.*, (Next generation cooperative wearables: Generalized activity assessment computed fully distributed within a wireless body area network). More in detail, a generalized trainable activity assessment chain (AAC) for the online assessment of periodic human activity within a WBAN is presented. Qualitative assessment with human knowledge by projecting the AAC on the hierarchical decomposition of motion performed by the human body as well as establishing the assessment on a kinematic evaluation of biomechanically distinct motion fragments is performed.

The challenging topic of antenna placement on the body is studied by Brumm, *et al.*, (On the placement of on-body antennas for ultra wideband capsule endoscopy). Ultra wideband communication is proposed as an alternative to increase the data rate for in-body to on-body communications compared with existing narrowband standards. Since there are no reproducible models available in literature that enable the calculation of the channel capacity, a new channel modeling technique based on a plane wave propagating through a multilayered dielectric is proposed and discussed. Results show that a single receive antenna gives nearly no improvement compared to existing standards. However, if the number of antennas is increased to 5, the 10%-outage capacity can be improved by several orders of magnitude.

In recent years, cloud-assisted body area network technologies have made their entrance in the Smart healthcare field, such as Smart home environment, and play a significant role for healthcare data storage, processing, and efficient decision making. The article written by Hassan, *et al.*, (Resource provisioning for cloud-assisted body area network in a smart home environment) is related to this hot topic, where they consider a fast and robust cloud resource allocation model for body sensor devices to ensure Quality of Service (QoS) for Smart home healthcare applications. The proposed resource allocation algorithm is developed using agent-based modeling (ABM) and ontology. The results from the implementation are compared with those of existing algorithms and found to be promising.

A subject-adaptive unsupervised signal compressor for wearable fitness monitors is proposed by Hooshmand, *et al.*, (SURF: Subject-adaptive unsupervised ECG signal compression for wearable fitness monitors). Recent advances in wearable devices allow non-invasive and inexpensive collection of biomedical signals including electrocardiogram (ECG), blood pressure, and respiration, among others. Collection and processing of various biomarkers are expected to facilitate preventive healthcare through personalized medical applications. The proposed method leverages unsupervised learning techniques to build and maintain, at runtime, a subject-adaptive dictionary without requiring any prior information on the signal, giving rise to reduced energy consumption, hence a longer service time. The algorithm, with artifact prone ECG signals, allows for typical compression efficiencies (CE) in the range $CE \in [40, 50]$, which means that the data rate of 3 kbit/s that would be required to send the uncompressed ECG trace is lowered to 60 and 75 bit/s for $CE = 40$ and $CE = 50$, respectively.

LADISLAU MATEKOVITS, *Associate Editor*
Department of Electronics and Telecommunications
Politecnico di Torino
10129 Turin, Italy
ladislau.matekovits@polito.it

GIANCARLO FORTINO, *Associate Editor*
Department of Informatics, Modeling,
Electronics and Systems
University of Calabria
87036 Rende, Italy
giancarlo.fortino@unical.it

ZHELONG WANG, *Guest Editor*
Dalian University of Technology
Dalian 116024, China
wangzl@dlut.edu.cn

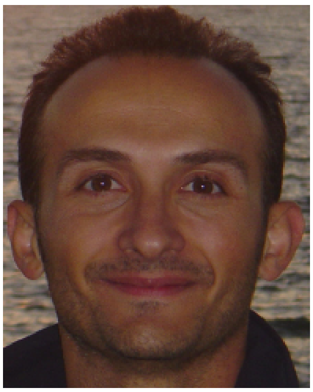
HASSAN GHASEMZADEH, *Guest Editor*
Washington State University
Pullman, WA 99164, USA
hassan@eecs.wsu.edu

VALERIA LOSCRÌ, *Guest Editor*
Inria Lille–Nord Europe
59650 Villeneuve-d'Ascq, France
valeria.loscri@inria.fr

ILDIKO PETER, *Guest Editor*
Department of Applied Science and Technology
Politecnico di Torino
10129 Turin, Italy
ildiko.peter@polito.it

MATTI HÄMÄLÄINEN, *Guest Editor*
University of Oulu
FI-90014 Oulu, Finland
matti.hamalainen@oulu.fi

LADISLAU MATEKOVITS (M'94–SM'11) received the degree in electronic engineering from the Institutul Politehnic din Bucureşti, Romania, and the Ph.D. degree in electronic engineering from the Politecnico di Torino, Italy, in 1992 and 1995, respectively. From 2009 to 2011, he was a Marie Curie Fellow with Macquarie University, Sydney, NSW, Australia, where he is currently a Honorary Fellow. In 2014, he was a Visiting Researcher with Tsinghua University, Beijing, China. Since 1995, he has been with the Electronics Department, Politecnico di Torino, where he was appointed as an Assistant Professor in 2002, and an Associate Professor in 2014, respectively. He has authored over 300 publications in journals, conferences, workshops, and book chapters. His main research activities concern computational electromagnetics, optimization techniques, and active and passive metamaterials with a special focus on cloaking and bio-electromagnetics. He has delivered seminars on these topics all around the world: Europe, USA, Australia, China, and Russia. He is a member of the Organizing Committee of the International Conference on Electromagnetics in Advanced Applications and the technical program committees of several conferences. He was a recipient of various awards including, the 1998 URSI Young Scientist Award and the Best AP2000 Oral Paper on Antennas, ESA-EUREL Millennium Conference on Antennas & Propagation. He was the General Chair of BodyNets 2016, Turin, Italy. He was the Assistant Chairman and the Publication Chairman of the European Microwave Week 2002, Milan, Italy. He serves as an Associate Editor for the IEEE ACCESS, the IEEE ANTENNAS AND WIRELESS PROPAGATION LETTERS, the *IET Microwaves, Antennas & Propagation* and a reviewer for various journals.



GIANCARLO FORTINO (SM'12) received the Ph.D. and Laurea (M.Sc. and B.Sc.) degrees in computer engineering from the University of Calabria (Unical), Rende, Italy. He holds the Italian Scientific National Habilitation for Full Professorship. He is a High-End Foreign Expert of China and an Adjunct Professor with the Wuhan University of Technology, China. Since 2006, he has been an Associate Professor of computer engineering with the Department of Informatics, Modeling, Electronics and Systems, Unical. He has been a Visiting Researcher with the International Computer Science Institute, Berkeley, CA, USA, and a Professor with the Queensland University of Technology, Brisbane, QLD, Australia. He is the Co-Technical Coordinator of the EU-funded H2020 INTER-IoT Project. He is the Co-Founder and the CEO of SenSysCal S.r.l., a spin-off of Unical, developing the innovative IoT-based systems for e-health and domotics. He has participated in many local, national, and international research projects. He has authored over 350 publications in journals, conferences, and books. He is the Founding Editor of the Springer Book Series *Internet of Things: Technologies, Communications and Computing*. His main research interests include agent-based computing, wireless sensor networks, pervasive and cloud computing, multimedia networks, and Internet-of-Things (IoT) technology. He has organized over 32 special issues in well-known international journals. He has participated in the TPC of over 400 conferences. He was a recipient of the 2014 Andrew P. Sage SMC Transactions Paper award. He is the Chair of the IEEE SMC Italian Chapter and the Founding Chair of the IEEE SMC Technical Committee on Interactive and Wearable Computing and Devices. He has co-chaired over 80 international conferences/workshops. He is currently serving as an Associate Editor on the Editorial Board of the IEEE TRANSACTIONS ON AFFECTIVE COMPUTING, the IEEE TRANSACTIONS ON HUMAN-MACHINE SYSTEMS, the *Journal of Network and Computer Applications*, *Engineering Applications of Artificial Intelligence*, and *Information Fusion*.

ZHELONG WANG received the B.Sc. and M.Sc. degrees in automatic control from the Dalian University of Technology, Dalian, China, in 1996 and 1999, respectively, and the Ph.D. degree in robotics from Durham University, U.K., in 2003. In 2004, he joined the School of Electronic and Information Engineering, Dalian University of Technology, where he is currently a Professor, a Ph.D. Supervisor, and the Director of the Laboratory of Intelligent Systems. He was a Visiting Scholar with Stanford University, USA, from 2013 to 2014. He has authored or co-authored over 90 peer-reviewed papers. His research interests include wearable intelligent system, robotics, mechatronics, and wireless sensor networks. His research was funded by the National Natural Science of China, the National Hi-Tec Program, the National Earthquake Research Funds, the Dalian Information Technology Bureau, and various industrial collaborators. He is a member of the IEEE Technical Committee on Interactive and Wearable Computing and Devices, the IEEE Technical Committee on Computer Supported Cooperative Work in Design, and the Electrical Technique Committee of China Petrochemical Industry. He received the Second Prize for Scientific and Technological Progress from the China Petroleum and Chemical Industry Association, three first prizes from the Liaoning Province Natural Science Foundation, an Excellent IT Tutor Award from the Dalian Information Technology Bureau, and a Research Award from the Audi Foundation. He is the Vice Director of the Dalian Wireless Sensor Network Engineering Lab. He serves as an Associate Editor for the IEEE TRANSACTIONS ON HUMAN-MACHINE SYSTEMS and the Editorial Board Member for the *Information Fusion*, *Industrial Robot*, and the *International Journal of Sensor Networks and Data Communications*. He was supported by the Program for Excellent Talents in Liaoning Higher Education Institutions and Liaoning Hundred, Thousand and Ten Thousand Talents Project. He was selected as a Dalian Outstanding Expert in 2013.

HASSAN GHASEMZADEH received the M.S. degree in computer engineering from the University of Tehran, Tehran, Iran, in 2001, the B.S. degree in computer engineering from the Sharif University of Technology, Tehran, in 1998, and the Ph.D. degree in computer engineering from The University of Texas at Dallas in 2010. From 2003 to 2006, he was on the Faculty of Azad University, where he served as the Chair of Computer Science and Engineering Department, Damavand Branch, Tehran. From 2010 to 2011, he was a Post-Doctoral Fellow with the West Health Institute. In 2014, he was a Research Manager with the UCLA Wireless Health Institute and an Adjunct Professor of biomedical informatics with San Diego State University. He is currently an Assistant Professor of computer science with the School of Electrical Engineering and Computer Science, Washington State University.

His research interests lie in different aspects of embedded system design, including sustainable and green computing, low-power architectures, reconfigurable computing, and system-level optimization. The focus of his current work is on processing platform design, collaborative signal and information processing, power optimization, data analytics, and algorithm design for networked embedded systems with a primary emphasis on applications in healthcare and wellness. These research challenges are regarded as some of the major obstacles that largely compromise the advantages of continued technology advancements for next-generation biomedical systems.

VALERIA LOSCRÌ received the M.Sc. and Ph.D. degrees in computer science from the University of Calabria, Italy, in 2003 and 2007, respectively. From 2006 to 2013, she was a Research Fellow with the TITAN Lab, University of Calabria. Since 2013, she has been a Permanent Researcher with the FUN Team, Inria Lille–Nord Europe. Her research interests focus on heterogeneous communication technologies and cooperation of heterogeneous devices. She has been involved in the activities of several European projects, including the FP7 EU Project VITAL and the FP6 EU Project MASCOT, Italian projects, and French projects. She is on the Editorial Board of ComNet (Elsevier), JNCA, and the IEEE TRANSACTIONS ON NANOBIOSCIENCE. She has been a Guest Editor of a Special Issue *Ad Hoc Networks* (Elsevier) and an Editor of the book *Vehicular Social Networks* (CRC Taylor & Francis Group, 2017) and *Management of Cyber Physical Objects in the Future Internet of Things* (Springer). Since 2015, she has been a member of the Committee for Technological Development, Inria Lille–Nord Europe. Since 2016, she has been Scientific European responsible for Inria Lille–Nord Europe.

ILDIKO PETER received the M.S. degree in biochemistry from the Universitá degli Studi di Torino, Italy, in 1993, and the Ph.D. degree in material science and engineering from the Politecnico di Torino, Italy, in 2006. In 2010, she was a Visiting Researcher with Macquarie University, Sydney, NSW, Australia. She has co-authored over 90 publications. She holds two patents. Her main research interest is oriented to the development/characterization of different metallic alloys for automotive/aeronautical industries and biomedical applications and the synthesis and characterization of materials for advanced electromagnetic applications. She has participated in various European and national projects. She is acting as a reviewer for several journals. Since 2015, she has served as an Associate Editor for the IEEE ACCESS.

MATTI HÄMÄLÄINEN received the M.Sc. and Dr.Sc. degrees from the University of Oulu, Oulu, Finland, in 1994 and 2006, respectively. He is currently a University Researcher and an Adjunct Professor with the Centre for Wireless Communications, University of Oulu, and an IAS Visiting Professor with Yokohama National University, Yokohama, Japan. He has over 150 international scientific journal and conference publications. He has co-authored *Wireless UWB Body Area Networks: Using the IEEE802.15.4-2011* (Academic Press) and has co-edited *UWB: Theory and Applications* (John Wiley & Sons). He holds a patent. His research interests are in UWB systems, wireless body area networks, and medical ICT.