Guest Editorial: Special Issue on (Industrial) Internet-of-Things for Smart and Sensing Systems: Issues, Trends, and Applications

SMART and sensing systems represent a significant research theme that has motivated a number of research initiatives around the world. Smart systems typically consist of different components, including sensors for signal acquisition, communication units for data transmission between components, control, and management units for decision-making, and actuators to perform the appropriate actions. They have impacted applications in many fields, such as manufacturing, healthcare, energy, environment, logistic, defence, monitoring, and mobility. As the complexity of such systems continue to grow, the challenge of developing integrated smart and sensing systems has surpassed the design complexity of their individual components. A smart and sensing system may include a large number of heterogeneous components, subsystems, smart and intelligent sensors, and may combine several correlated functionalities. Thus, the main issue of developing smart and sensing systems lies in the complexity to integrate and to manage these different components, technologies, and goals across a wide spectrum. In recent years, the emergence of the Internet of Things (IoT) has amplified the capacity of sensing the world through a network of connected devices using the existing network infrastructure. Grouping together smart and sensing systems in an IoT setting to form large-scale distributed cyber-physical systems has tremendous potential in bringing smart systems to many application domains.

This JOURNAL's Special Issue (SI) aims to promote relevant research related to strategic views, problems, trends, solutions, and applications of IoT for smart and sensing systems. This represents a more specialized area of interest than the wide application of IoT. This SI focuses more specifically on how industrial IoT contributes to the development of smart and sensing systems.

Fifty submissions from around the world were received in response to the Calls for Papers on this SI. During the review process, each paper was assigned to and reviewed by at least two experts in the related areas, with a rigorous review process. Thanks to the great support of the Editor-in-Chief of this JOURNAL, Prof. Sherman Shen, guest editors were able to accept 20 selected papers covering issues, trends, and applications of IoT for Smart and Sensing Systems.

In the paper "Real-Time Monitoring of Bone Fracture Recovery by Using Aware, Sensing, Smart, and Active Orthopaedic Devices" the authors explore the use of IoT technologies in the field of orthopaedics. It presents an aware, sensing, smart and active external fixation device for fractured bone treatment.

To enable collaboration among supply chains in all sectors, the paper "Trustworthy Industrial IoT Gateways for Interoperability Platforms and Ecosystems" presents a device driver security architecture used in the virtual factory open operating system (vf-OS) platform, orientated to manufacturing and logistics companies.

A major challenge in Industrial IoT (IIoT) for smart and sensing systems is the critical role that energy efficiency plays in widespread deployability of IoT applications. To address this challenge, the paper "cDIP: Channel-Aware Dynamic Window Protocol for Energy-Efficient IoT Communication" proposes a new generalized channel-aware link layer communication strategy that exploits temporal variations of the communication channel to improve on energy efficiency.

The paper entitled "Ontology-Based Framework Enabling Smart Product-Service Systems: Application of Sensing Systems for Machine Health Monitoring" proposes embedded sensing systems tailored to industrial product-service system (PSS) and the use of these systems in providing customized services. It presents a sensing system ontology as a framework to support the smart services in PSS.

In the paper "Closed Loop Controlled Precision Irrigation Sensor Network" the authors propose a closed-loop irrigation system demonstrating that it fully automates the delivery of irrigation water and calculates in real time, the water requirement from satellite images. Results demonstrate that combining closed-loop automation and analytics can improve water use efficiency and increase yield on existing agricultural lands.

For monitoring the nitrate concentration in a field, the authors of the paper "An Internet-of-Things Enabled Smart Sensing System for Nitrate Monitoring" designs a smart sensing node, which can collect the water from lake, stream, or river, measure the instant nitrate concentration, and transfer the data through the gateway to a user-defined cloud server.

In the paper "IoT for Next-Generation Racket Sports Training" the authors present the application of an IoT framework in the development of a smart badminton actions recognition system that includes a wearable sensor, a mobile app,

Digital Object Identifier 10.1109/JIOT.2018.2887349

and cloud server. The results demonstrated that the proposed smart system can classify the clear distinction between different badminton strokes with an average accuracy of 97%. The system can automatically provide data statistic of badminton players, which can help coaches and athletes themselves to learn about the real condition change during a match or a training.

Considering the compact operating systems required on low-end IoT devices, the authors of the paper "RIOT: An Open Source Operating System for Low-End Embedded Devices in the IoT" provide a comprehensive overview of RIOT covering the key components of interest to potential developers and users. RIOT is a free open source software platform that can reach a good balance between protecting end-users and supporting industry, at large scale and in the long run.

In the paper "Inter-Community Detection Scheme for Social Internet of Things: Compressive Sensing Over Graphs Approach" the authors investigate the intercommunity detection issue in the social IoT scenarios and present a compressive sensing over graphs-based intercommunity detection scheme for the social IoT.

For the efficient allocation of carrier and computing resources in smart manufacturing system, the authors of the paper "Internet of Things for Smart Manufacturing System: Trust Issues in Resource Allocation" propose a Vickrey–Clarke–Groves auction-based hierarchical trust computing algorithm. Results demonstrated experimentally that the utility is maximized when the IIoT devices and gateways make the smart manufacturing system be trustful.

The paper entitled "Building Data-Aware and Energy-Efficient Smart Spaces" discusses the current research in smart spaces and the challenges that arise in the execution of these smart spaces in real time. The authors propose a smart space that considers and addresses the challenges and tradeoffs between data requirements and energy-efficient data collection, along with hardware constraints.

To show how IoT could have a tangible impact on communities with reliance on sustaining infrastructures, the paper "Agile IoT for Critical Infrastructure Resilience: Cross-Modal Sensing As Part of a Situational Awareness Approach" presents a method and a model for agile IoT for resilience.

In the paper "TriboMotion: A Self-Powered Triboelectric Motion Sensor in Wearable IoT for Human Activity Recognition and Energy Harvesting" the authors present a new motion sensor system in wearable IoT for human physical activity recognition without any signal conditioning circuits. The triboelectricity-based physical model is explored in designing the motion sensor.

The paper entitled "Device-Free People Counting in IoT Environments: New Insights; Results and Open Challenges" presents a new open dataset with wireless signals captured over diverse physical IoT environments and explores different features and ML models so as to draw empirically informed conclusions about their performance and predictive potential for IoT scenarios and cases.

In the paper "City Scanner: Building and Scheduling a Mobile Sensing Platform for Smart City Services" the authors present the City Scanner project to capture the spatiotemporal variation of environmental parameters. City Scanner is a specific drive by sensing approach with several key benefits, such as a nonintrusive, self-contained, and portable sensing components.

To allow the security community to better understand SCADA specific risk, the authors of the paper "IIoT Cybersecurity Risk Modeling for SCADA Systems" presents a customizable SCADA risk prioritization schema. Considering the distinct properties of SCADA systems, a data-driven prioritization schema helps researchers identify security gaps specific to this software subclass.

The paper entitled "Industrial Internet of Things: A Systematic Literature Review and Insights" presents results and insights of a systematic literature review (SLR) that systematically addresses IIoT. The SLR is based on questions related to who is working on IIoT, the main standards and technologies to support communications, and the main research efforts and IIoT implementations.

In the paper "IoT-Based Vibration Analytics of Electrical Machines," the authors propose an IoT based model for real-time condition monitoring of electrical machines, which addresses challenges of data storage and scalability. The proposed framework can enhance the machine condition monitoring functionality with methodologies of scalable and platform independent data aggregation and collaborative analysis that the real-time industrial applications demand extensively.

Considering the limitations in the capacity of the batteries of the wireless sensor networks (WSNs), which severely limit continuous monitoring based IoT applications, the authors of the paper "SBL-Based Adaptive Sensing Framework for WSN-Assisted IoT Applications" presents a novel sparse Bayesian learning-based adaptive sensor selection framework to substantially increase the lifetime of a densely-deployed WSN for monitoring spatio-temporally varying signal.

In the paper "Prediction of Frost Events Using Machine Learning and IoT Sensing Devices," the authors present a new approach to predict frost events which considers that frost prediction in one location could be improved by using the information of the most relevant neighboring sensors. The authors propose to use machine learning algorithms such as Bayesian networks and Random Forest in which the training set includes new samples using synthetic minority oversampling technique.

The Guest Editors of this SI of this JOURNAL would like to express their gratitude to the authors for their excellent contributions. We are also very grateful to all of the reviewers for their dedicated efforts in reviewing these papers, and for their valuable comments and suggestions that significantly improve the quality of them. We hope that this SI will serve as a good reference for researchers, scientists, engineers, and academicians in the field of industrial IoT.

HERVÉ PANETTO, *Guest Editor*
CNRS, CRAN
Université de Lorraine
54000 Nancy, France

PAULO CÉZAR STADZISZ, *Guest Editor*
Department of Computer Science
Federal University of Technology—Paraná
Curitiba 80230, Brazil

WENCHAO LI, *Guest Editor*
Department of Electrical and Computer Engineering
Boston University
Boston, MA 02215 USA

QING-SHAN JIA, *Guest Editor*
Centre for Intelligent and Networked Systems
Department of Automation
Beijing National Research Centre for Information
Science and Technology
Tsinghua University
Beijing 100084, China

Hervé Panetto was born in Nancy, France. He received the Ph.D. degree in production engineering from the University Henri Poincaré, Nancy, in 1991.

He is a Professor of enterprise information systems with the University of Lorraine, TELECOM Nancy, Nancy. He was a Visiting Professor in the frame of a Science Without Borders PVE project with PUC Parana, Brazil, from 2013 to 2015, and a Full Visiting Professor with the Federal University of Technology—Paraná, Curitiba, Brazil, in 2016. He teaches information systems modeling and development and conducts research at the Research Centre for Automatic Control (CRAN), Joint Research Unit with CNRS, where he is managing a research project on the use of ontology for formalizing models related to the interoperability of production systems, and mainly their enterprise information systems. His current research interests include information systems modeling for enterprise applications and processes interoperability, with applications in enterprise modeling, manufacturing processes modeling, and furniture data modeling.

Dr. Panetto was a recipient of many awards, including the IFAC France Award 2013, the INCOSE 2015 Outstanding Service Award, and the IFAC 2017 Outstanding Service Award. He is an Editorial Board member of the *Annual Reviews in Control*, *Computers in Industry*, the *International Journal of Computer Integrated Manufacturing*, the *International Journal on Universal Computer Science*, and the *Scientific Journal Facta Universitatis*, series Mechanical Engineering and an Associate Editor of the *International Journal of Intelligent Manufacturing* (Springer), the *Enterprise Information Systems* (Taylor & Francis), and the *Journal of Industrial Information Integration* (Elsevier). He has been a member of the Academia Europaea since 2018. He has been the Chair of the IFAC Coordinating Committee 5 on "Manufacturing and Logistics Systems" since 2014.

Paulo Cézar Stadzisz was born in Blumenau, Brazil, in 1963. He received the B.S. degree in data processing from the Federal University of Paraná, Curitiba, Brazil, in 1987, the M.S. degree in electrical engineering from the Universidade Tecnológica Federal do Paranaá (UTFPR), Curitiba, in 1991, and the Ph.D. degree in automatics from Franche-Comté University, Besançon, France, in 1997.

Since 1991, he has been an Associate Professor with the Computer Science Department, Federal University of Technology—Paraná, Curitiba. He currently directs the Centre of Technology Innovation, UTFPR. His current research interests include software and system engineering processes, requirements engineering, software and system modeling, new software paradigms, and embedded systems including Internet of Things and CPS.

Wenchao Li received the B.S., M.S., and Ph.D. degrees in electrical engineering and computer sciences and the B.A. degree in economics from the University of California at Berkeley, Berkeley, CA, USA.

He is an Assistant Professor with the Department of Electrical and Computer Engineering, Boston University, Boston, MA, USA, where he directs the Dependable Computing Laboratory. He currently holds the Peter J. Levine Career Development Professorship and a Junior Faculty Fellow with the Rafik B. Hariri Institute for Computing and Computational Science and Engineering, Boston, MA, USA. He was a Computer Scientist with the Computer Science Laboratory, SRI International, Menlo Park, CA, USA. His current research interests include dependable computing with a recent focus at the intersection of formal methods and machine learning and with applications to cyber-physical systems, design automation, and AI safety.

Dr. Li was a recipient of the ACM Outstanding Ph.D. Dissertation Award in Electronic Design Automation for his research on specification mining and the Leon O. Chua Award for Outstanding Achievement in Nonlinear Science.

Qing-Shan (Samuel) Jia (S'02–M'06–SM'11) received the B.E. degree in automation and the Ph.D. degree in control science and engineering from Tsinghua University, Beijing, China, in 2002 and 2006, respectively.

He is an Associate Professor with the Centre for Intelligent and Networked Systems, Department of Automation, Beijing National Research Center for Information Science and Technology, Tsinghua University. He was a Visiting Scholar with Harvard University, Cambridge, MA, USA, in 2006, the Hong Kong University of Science and Technology, Hong Kong, in 2010, and the Laboratory for Information and Decision Systems, Massachusetts Institute of Technology, Cambridge, MA, USA, in 2013. His current research interests include integrated data-driven, statistical, and computational approaches to find designs and decision-making policies that have simple structures and guaranteed good performance. His research relies on strong collaborations with experts in manufacturing systems, energy systems, autonomous systems, and smart cities.

Dr. Jia is an Associate Editor of the IEEE TRANSACTIONS ON AUTOMATIC CONTROL the IEEE TRANSACTIONS ON AUTOMATION SCIENCE AND ENGINEERING, and *Discrete Event Dynamic Systems: Theory and Applications*. He served as the Discrete Event Systems Technical Committee Chair of the IEEE Control Systems Society from 2012 to 2015 and currently serves as the Chair of the IFAC Technical Committee 9.3 on "Control for Smart Cities" and the Smart Buildings Technical Committee Co-Chair of the IEEE Robotics and Automation Society and the Beijing Chapter Chair of the IEEE Control Systems Society.