

# Editorial to selected papers from 2019 IEEE international workshop on “Metrology for Industry 4.0 and IoT”

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Dear Reader,

This Issue of Acta IMEKO is dedicated to papers that have been selected from those presented at “2019 IEEE International Workshop on Metrology for Industry 4.0 and IoT” held in Naples in June 2019. MetroInd4.0&IoT aims to discuss the contributions both of the metrology for the development of Industry 4.0 and IoT and the new opportunities offered by Industry 4.0 and IoT for the development of new measurement methods and apparatus. MetroInd4.0&IoT aims to gather people who work in developing instrumentation and measurement methods for Industry 4.0 and IoT. The central objective of this Workshop was to present the latest achievements in the new technology for metrology-assisted production in Industry 4.0 and IoT, Industry 4.0 and IoT component measurement, sensors and associated signal conditioning for Industry 4.0 and IoT, and calibration methods for electronic test and measurement for Industry 4.0 and IoT. Participants have had an excellent opportunity to meet top specialists from industry and academia all over the world and to enhance their international cooperation. Twenty selected papers from MetroInd4.0&IoT 2019 are presented in two Sections (Part 1 and Part 2).

## Part 1 – Section Editor: Leopoldo Angrisani

The first Section, edited by Leopoldo Angrisani, includes the following ten scientific contributions.

The first paper by Alessandro Massaro et al, “*Maintenance and Testing Protocols in Railway Industry*”, introduces new maintenance and testing protocols regarding processes in the context of railway industry. The first protocol is general and can be applied to industries working in similar production processes. The second and the third protocols are more specific to railway industry and concern the turning machine production line and the pneumatic test of the train braking system, respectively. The study has been performed within the framework of an industry

research providing the design of intelligent control and actuation systems suitable for auto-adaptive Industry 5.0 facilities.

The second paper by Luciano Fratocchi and Cristina Di Stefano, “*Industry 4.0 technologies and manufacturing back-shoring: An European perspective*”, aims to shed new light on the role that Industry 4.0 technologies may play as a driver or an enabling factor for companies which are evaluating RSD alternatives. A two-steps explorative approach is implemented. In the first step, a theoretical approach is followed by developing a structured literature review based on 115 Scopus indexed journal articles. The second step of the methodology is based on empirical evidence belonging to European countries based on the UnivAQ Manufacturing Reshoring Dataset. Collected data provide evidence of the growing interest of scholars in this issue; however, attention has been mainly focused on two single technologies, namely production automation and additive manufacturing.

In the third paper, edited by Susanna Spinsante et al, “*A Field Measurements Based LoRa Networks Planning Tool*”, after comparing different path loss models based on a field measurement campaign of LoRa Received Signal Strength Indicator (RSSI) values within a University campus, two main modifications of the LoRa Simulator tool are implemented. They are aimed at improving its accuracy in the prediction of the number of sustainable nodes, according to the target Data Extraction Rate set. Simulations based on field measurements show that by an improved path loss evaluation, and using three gateways, the number of nodes could increase theoretically from about 100 to about 6000.

In the fourth paper, edited by Luca Di Angelo et al, “*An advanced GCode analyser to predict build-time in AM components*”, an accurate method to predict in advance the build-time in Additive Manufacturing (AM) technology is proposed. This method is based on an advanced GCode analyser written in Python following an Object-Oriented paradigm for scalability and maintainability. Some examples were used to demonstrate the

reliability of the algorithm and possible use-cases of it are illustrated.

In the fifth paper, edited by Mariorosario Prist et al, “*Cyber-Physical Manufacturing Systems: an Architecture for Sensors Integration, Production Line Simulation and Cloud Services*”, following the paradigm of new smart factories, the main challenges of the CPS complexity have been faced by developing: from one hand, a new modular, extensible and interoperable software architecture based on OSGi framework for managing heterogeneous devices, simulation and HIL prototype; on the other hand, a Cloud Computing to manage and analyse data, as well as to expose business data and services via external APIs interfaces. In detail, a testing of a smart production line, before the production deployment, has been developed.

In the sixth paper, edited by Pierpaolo Fucile et al, “*Strategies for the design of additively manufactured nanocomposite scaffolds for hard tissue regeneration*”, a systematic study on the design of PCL/HA scaffolds for hard tissue regeneration was reported. In particular, 3D PCL/HA scaffolds were designed and analysed according to a strategy already reported for additive manufacturing of PCL scaffolds involving techniques based on extrusion/injection methods. The procedure was extended to PCL/HA considering that the difficulties in processing nanocomposite materials are usually greater than those found for the neat polymers. Benefiting from all the results, as well as from the reverse engineering approach, the feasibility to design customized scaffolds for mandibular defect regeneration (i.e., ramus and symphysis) was reported.

In the seventh paper, Salvatore Surdo et al, “*Acoustically-shaped laser: a machining tool for Industry 4.0*”, present a method to parallelize laser direct-write systems (LDWs) by using acoustically shaped laser light. They use an acousto-optofluidic (AOF) cavity to generate acoustic waves in a liquid causing periodic modulations of its refractive index. Such acoustically controlled optical medium diffracts the incident laser beam into multiple beamlets that, operating in parallel, result in enhanced processing throughput. In addition, the beamlets can interfere mutually, generating an intensity pattern suitable for processing an entire area with a single irradiation. Their results demonstrate the AOF technology can broaden the usage of lasers as machine tools for industry 4.0.

In the eight paper, edited by Domenico Solari, “*Novel concepts and strategies in skull base reconstruction after endoscopic endonasal surgery*”, an insight into the development of novel strategies and devices for skull base defects was provided by integrating rheological/mechanical concepts, image capture and analysis techniques, CAD-based approach and additive manufacturing. Specifically, a systematic study on the design of multifunctional systems in the form of injectable tools and “solid” customized devices was reported in the current research. The focus was set on the importance of viscoelastic properties and flow behaviour of materials in the case of injectable systems, as well as on the potential to start from the geometry of skull base defects for designing additive manufactured closure devices with tailored properties (i.e., flexibility, strength) for skull base reconstruction after endoscopic endonasal surgery.

The ninth paper, edited by Nicola Rocco et al, “*Additive manufacturing and technical strategies for improving outcomes in breast reconstructive surgery*”, dealt with challenges, principles and methods to develop 3D additive manufactured structures in breast reconstructive surgery. Specifically, the aim was to design 3D additive manufactured poly ( $\epsilon$ -caprolactone) scaffolds with different architectures (i.e., lay-down patterns). Preliminary

mechanical and biological analyses showed the effect of the lay-down pattern on the performances of the manufactured structures.

The last paper of the Part 1, edited by Castrese Di Marino et al, “*A new approach for an anthropocentric design of human-robot collaborative environment*”, deals with collaborative robotics by highlighting the main issues linked to the interaction between humans and robots. A critical study of the in-force standards on Human-Robot Interaction (HRI) and the current principles of the workplace design for Human-Robot Collaboration (HRC) are presented. The paper focuses on an anthropocentric paradigm, where the human becomes the core of the workplace in combination with the robot, and it presents a basis for designing workplaces through two key concepts: (i) the introduction of human and robot spaces as elementary spaces, (ii) the dynamic variations of the elementary spaces in shape, size and position. According to this approach, the limitation due to the safety-based approach, introduced by the standards, are overcome by positioning the human and the robot inside the workplace and managing their interaction through the elementary spaces.

## Part 2 – Section Editor Francesco Bonavolontà

The second Section, edited by Francesco Bonavolontà, includes the remainder ten papers.

The first paper, edited by Marianne Silva et al, “*Performance Evaluation of a Vehicular Edge Device for customer feedback in Industry 4.0*”, investigates a performance evaluation of an Edge OBD-II device which collects data from vehicles in an autonomous way in order to provide customer feedback and tracking. Different sets of OBD-II Parameter IDs (PIDs), responsiveness, driver behaviour and CO<sub>2</sub> pollution estimate were the metrics evaluated. For validation purposes, the results obtained from vehicles were compared with an OBD-II Emulator which demonstrated the accuracy of experiments.

The second paper, edited by Giulio D’Emilia et al, “*Uncertainty assessment for measurement and simulation in Selective Laser Melting: A case study of an aerospace part*”, analyses the additive manufacturing process SLM with the aim to realize a complex piece for aerospace applications. In particular, the effect of the manufacturing process and of the following thermal treatments on the dimensions of the workpiece is evaluated. The study is based on a hybrid approach including the whole manufacturing process simulation by advanced software packages and dimensional measurements by Coordinate Measuring Machine (CMM) of the realized pieces.

Enrico Petroli and Fabio Leccese, in the third paper, “*Precise Takagi-Sugeno fuzzy logic system for UAV longitudinal stability: an Industry 4.0 case study for aerospace*”, show how the architecture of the drone based on a “flying wing” allows discharging the complexity of the longitudinal stability equations (critical for that type of architecture). They used a very reliable simplification due to the fuzzy logic. Their approximate method allows them to have a very “light” calculation effort at the price of a negligible error in terms of the size and dynamics of the vehicle so lowering the inescapable activities of the telecommunication segment that manages the departing and landing manoeuvres.

In the fourth paper Giovanni Bucci et al, “*An IoT system based on Powerline Technology for Pulse Oximetry measurement*”, propose the use of the Powerline network as an alternative to the realization of IoT systems. In particular, an application case of use an IoT system for monitoring of pulse oximeter values in a hospital setting will be described and discussed. The novelty of the

proposed system is the adoption of the powerline communication in the medical environment.

The fifth paper, edited by Marco Carratù et al, "*Smart wearable devices for human exposure vibration measurements on two-wheel vehicles*", discloses an original solution to allow the driver of motorcycles to know the exposure to the vibration during a ride using a low-cost wearable device (smartwatch). A suitable measurement system has been designed and tested on a real motorcycle. Different indexes proposed in the literature are adopted for the comfort analysis. They are experimentally compared with the hand transmitted vibrations measured through a fixed accelerometer according to show the feasibility of the proposed approach in typical application conditions.

In the sixth paper, Daniel Chicayban Bastos et al, "*On pseudorandom number generators*", present a new result which leads to recommend against the use of the NIST SP 800-22 statistical test suite for testing random number generators, which has the practical impact for anyone using random number generators, thus anyone making direct or indirect use of computer sampling or simulations. The NIST SP 800-22 statistical test suite, last revised in 2010, was designed to test and reject random number generators with poor randomness. Being a very popular software package, researchers using this software package may be getting a false sense of security. The section "on the insufficiency of the NIST SP 800-22 package" proves NIST SP 800-22 software package is not correctly implemented and shows all the details necessary for reproducing the experiment.

The seventh paper by Andrea Rega et al, "*A sensor data fusion-based locating method for large-scale metrology*", tackles the problem of big-size object measurement proposing a method to correctly locate and track a handling device for reverse engineering systems. The method aims to improve accuracy of point cloud realignment tracking a reverse engineering system which jointly moves with a handling device. The proposed method is based on sensor data fusion of redundant sensors by means the Kalman filter. The method was verified through hardware-in-the-loop simulation, using an Arduino Uno rev3 board programmed in MatLAB/Simulink® environment. The results show that the sensor data fusion accuracy is better than the simulated single sensors.

In the eighth paper, R. La Rosa et al, "*An Integrated Circuit to null Standby by using energy provided by MEMS Sensors*", addressed a "Zero-Energy Standby" solution which is able to supply the power requested by the measurement equipment to turn on appliance only when needed. In particular, an integrated circuit (IC) solution suitable to be used with MEMS scale transducers has been pursued. Both the MEMS transducer and the integrated conditioning circuit have been simulated, designed realized and characterized, so that the "Zero-Energy Standby" solution has been experimentally studied by using the realized devices.

In the ninth paper, Giovanna Di Pasquale et al, "*Geometrical and Thermal Influences on a Bacterial Cellulose Based Sensing Element for Acceleration Measurements*", investigate the influence of the geometry and of the environmental temperature of BC based sensing elements. More specifically, the influences of such quantities on a previously investigated BC-based accelerometer are reported. An experimental campaign and the characterization of the proposed green device for several geometries and various temperatures has been addressed obtaining very intriguing results.

The last tenth paper of the Part 2, edited by Michela Borghetti et al, "*Validation of a modular and wearable system for tracking fingers movements*", shows a protocol for validating a new wearable

system for tracking finger movements. The wearable system consists of two measuring modules worn on the thumb and on the index measuring flexion and extension of the proximal interphalangeal (PIP) joint by a stretch sensor and rotation of the proximal phalanx (PP) by an inertial measurement unit. A marker-based opto-electronic system is used to validate the proposed device by capturing specific finger movements. Four movements that simulate typical tasks and gestures, such as grasp and pinch, were specifically performed. The results are useful for the data interpretation when the system is adopted for monitoring finger movements and gestures. The proposed system equipped with IMUs and stretch sensors could be adopted for monitoring finger movement tasks in a variety of conditions, also in an industrial setting, for example, in evaluating workers' tasks to improve their efficiency and safety and for virtual reality.

It was a great honour for us to act as Guest Editors for this issue of Acta IMEKO, both from the perspective of working for a high-profile scientific journal. We would like to sincerely thank all the authors for their valuable contributions, and we hope the readers could be inspired by the themes and proposals that have been elected and included in this Special Section related to innovations in metrology for Industry 4.0 and IoT.

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Guest Editors