Guest Editorial
Special Section on IEEE MeMeA 2021

THE 16th edition of the IEEE International Symposium on Medical Measurements and Applications was held on June 23–25, 2021. The Symposium, whose first edition was held in 2006 in Benevento, Italy, has become an annual meeting for researchers from academia and industry working in the field of medical measurements and instrumentation. The Symposium offers them the opportunity to work together to design and develop feasible and effective measurement solutions and instrumentation for data processing, medical diagnosis and patient healthcare.

In the past years, the Symposium was physically organized in Europe, Canada, the United States, and in Turkey. As was the case of the edition of 2020 (planned in Bari, Italy), in 2021, the Symposium was scheduled to be held in Neuchâtel, Switzerland, but due to the COVID-19 pandemic and the consequent travel restrictions, it was held virtually. The safety and well-being of all conference participants is a priority of the IEEE Instrumentation and Measurement Society and the MeMeA Steering Committee that worked together to organize a successful event despite the COVID-19 outbreak. After the official Symposium dates, the MeMeA 2021 virtual platform allowed all attendees a broad access to all presentations and speakers contacts, an excellent opportunity to exchange knowledge and experiences.

The MeMeA 2021 Technical Program allocated more than 130 high-quality peer-reviewed papers by more than 500 authors mainly from academia and industry, from Europe, Asia and the Middle East, Canada, and America. Four Special Sessions were also successfully organized on the following topics: advanced measurement techniques and methodologies for the quantitative assessment of gait function in health and pathology, measurements for movement analysis, wearable sensors for remote and continuous monitoring of physiological and physical parameters, solutions and challenges for a micro- and nanoscale precision and personalized medicine, and measurement and assessment of well-being during the COVID-19 pandemic, with a focus on neurosciences, psychology, and psychiatry.

To strengthen the connection between the measurements for medical applications and the engineering aspects and highlight the relevance of measuring systems also for the clinical practice, the symposium has welcomed two keynote speakers from both the medical and engineering fields. They have presented their experience on the topics of endoscopic luminescent imaging for oncological surgery, and on the potential of fiber optic sensors in medical applications.

Two tutorials were also offered to the audience, one in the field on charge measuring electronics in medical applications, and the other one on the design of experiments.

Authors of the manuscripts accepted for publication in the *MeMeA 2021 Proceedings* were invited to extend their work and submit their manuscripts to this Special Section, which intends to promote the best results presented at the symposium from the perspective of instrumentation and measurement. A collection of 14 manuscripts were submitted for peer review and five manuscripts were accepted for publication. The articles selected for this special session cover many topics related to the design of novel sensors, the use of machine learning for estimating parameters of interests in the field of life sciences, a novel peak detector technique applied to physiological signals, and analysis of reproducibility and repeatability on measurements related to characteristics of surgical masks.

In [A1], Uguz *et al.* proposed the novel design of an electrode intended for capacitive electrocardiogram (cECG). Typically, cECG is affected by motion artifacts, so the authors devise a solution based on the amplitude modulation of the biopotential signal. In simple words, the time-variant coupling impedance of the cECG results from the variations in the contact pressure of through-clothing cECG measurements, due to the motion artifacts. The interaction between the source ECG signal and the coupling impedance modulates its amplitude, thus making it possible to retrieve the ECG signal. This new technique is named modulated ECG (mECG), as the ECG signal is merged into the envelope of the resulting carrier wave. The solution has been at first studied through numerical simulations, and then experimentally validated.

In [A2], Di Nardo *et al.* presented an approach for simplifying the experimental protocols implemented to measure the stride-time with surface electromyographic sensors, and optimize the data used by a machine learning algorithm used for the analysis. The aim was to find the best tradeoff between the minimum number of sensors and the best prediction performances. The authors estimated that the optimal number of sensors employed in the gait analysis is two, a result that has a positive impact on patient comfort and on the reduction of clinical costs. The results of their machine learning algorithm were successfully tested on 30 volunteers.

In [A3], Taborri *et al.* assessed the breathability (i.e., a measure of the air permeability of the mask) and related parameters of different surgical masks employed as a prevention measure for limiting the spread of respiratory viral diseases, such as COVID 19. In particular, the authors evaluated the uncertainty and reproducibility in the breathability measurement, and the effects induced by the number and location of the

Digital Object Identifier 10.1109/TIM.2022.3181317

measurement points on 300 masks from different providers, based on the UNI EN 14863:2019. Results showed that more than 60% of the tested masks did not satisfy the standard requirements in terms of breathability.

In [A4], Galli *et al.* reported on a novel processing technique to extract the single-cell action potential. They faced a challenging task since this scenario presents the simultaneous presence of overlapped action potential. To overcome this hurdle, the authors proposed a three stages-morphological peak detector based on a denoising stage, a threshold-based classifier devoted to identifying the peaks that could correspond to an action potential, and a morphological classifier that uses a support vector machine technique. The results collected on simulated data showed promising performance and encouraged the validation of the proposed method using real working devices.

In [A5], Bahrami and Forouzanfar ground their motivation on the importance to detect sleep apnea disorders to define adequate therapies. The authors assessed the performances of 14 conventional machine learning algorithms and 19 deep learning algorithms on the same data set. The best detection performances were shown by hybrid CNN (convolutional neural network)–DRNN (deep recurrent neural network) architectures. In particular, the highest accuracy and specificity were achieved using ZFNet-BiLSTM, while the ZFNet-GRU showed the best sensitivity.

We appreciate the work of all authors who submitted their extended papers, as well as all reviewers whose time and effort made possible the publication of this Special Section. We would like to sincerely thank the IEEE TRANSACTIONS ON INSTRUMENTATION AND MEASUREMENT staff and Prof. Shervin Shirmohammadi, Editor-in-Chief, for their precious support and invaluable services. We hope that the content of this Special Section can catch the interest of readers, not only those involved in measurements and instrumentation but also scientists and physicians.

PAOLA SACCOMANDI, *Guest Editor*
Department of Mechanical Engineering
Politecnico di Milan
20133 Milan, Italy

EMILIANO SCHENA, *Guest Editor*
Department of Engineering
Università Campus Bio-Medico di Rome
00128 Rome, Italy

APPENDIX: RELATED ARTICLES

[A1] D. U. Uguz, Z. T. Canbaz, C. H. Antink, M. Lüken, and S. Leonhardt, "A novel sensor design for amplitude modulated measurement of capacitive ECG," *IEEE Trans. Instrum. Meas.*, vol. 71, pp. 1–10, 2022.

[A2] F. Di Nardo, A. Cucchiarelli, L. Scalise, and C. Morbidoni, "Measurement of stride time by machine learning: Sensitivity analysis for the simplification of the experimental protocol," *IEEE Trans. Instrum. Meas.*, vol. 71, pp. 1–9, 2022.

[A3] J. Taborri, B. Stocchi, G. Calabrò, and S. Rossi, "On the breathability measurement of surgical masks: Uncertainty, repeatability, and reproducibility analysis," *IEEE Trans. Instrum. Meas.*, vol. 71, pp. 1–9, 2022.

[A4] A. Galli *et al.*, "A morphological peak-detector for single-unit neural recording acquisition systems," *IEEE Trans. Instrum. Meas.*, vol. 71, pp. 1–11, 2022.

[A5] M. Bahrami and M. Forouzanfar, "Sleep apnea detection from single-lead ECG: A comprehensive analysis of machine learning and deep learning algorithms," *IEEE Trans. Instrum. Meas.*, vol. 71, pp. 1–11, 2022.

Paola Saccomandi (Member, IEEE) received the Ph.D. degree in biomedical engineering from Università Campus Bio-Medico di Roma, Rome, Italy, in 2014.

In 2016, she won a postdoctoral research fellowship at the Institute of Image-Guided Surgery (IHU), Strasbourg, France, and since 2018, she is an Associate Professor of mechanical and thermal measurements with the Department of Mechanical Engineering, Politecnico di Milan, Milan, Italy. Her main research includes thermometry, fiber optic sensors and biomedical imaging for physiological parameters monitoring, and laser and light-based approaches for hyperthermal minimally invasive treatment and monitoring. In these fields, she has obtained two ERC projects (starting grant and proof of concept) and other international and national grants. She has authored more than 200 papers in international journals, proceedings of international conferences and books and is serving as an associate editor for different journals.

Since 2012, she is a member of several societies, including IEEE Instrumentation and Measurements, and Women in Engineering. She is a Co-founder and Officer of the IEEE Italy Sensors Chapter. She served as the Technical Program Chair for Medical Measurements and Applications (MeMeA) 2021 and for Metrology for Industry 4.0 & IoT (MetroInd4.0&IoT) 2020 and 2021. She was a Technical Program Committee Member of three previous MeMeA editions. She is a member of the Technical Committee on Therapeutic Systems and Technologies of the IEEE Engineering in Medicine and Biology Society. She organized more than ten workshops and special sessions at IEEE international conferences, such as MeMeA, MetroInd4.0&IoT, International Instrumentation and Measurement Technology Conference, and Engineering in Medicine and Biology Conference. Since 2022, she is a member of the committee of IEEE Women in Sensors.

Emiliano Schena (Senior Member, IEEE) received the Ph.D. degree in biomedical engineering from Università Campus Bio-Medico di Roma (UCBM), Rome, Italy, in 2009.

He is currently a Full Professor (since 2022) with the Department of Engineering, UCBM, where he is also the Rector's delegate for the Third Mission, one of the members of the committee for the assessment of the research quality at the Department of Engineering, and responsible for the Educational Laboratory of Engineering. His research interests include designing, developing, and assessing wearable systems to monitor physiological parameters and posture. He was the Principal Investigator of the project HEREMOS, a wearable system for monitoring vital signs of cardiac patients, and he is co-founder of the spin-off HEREMOS (https://www.heremos.com). He is the author of more than 300 papers in international journals, conferences, and books.

He is serving on the editorial board of several journals (e.g., IEEE SENSORS JOURNAL). He has been involved in the organization of several international IEEE conferences/workshops as General Chair, Technical Program Chair, and Organizer of Special Sessions. He is the Chair of the Italy Chapter of the IEEE Sensors Council and Counselor of the IEEE Student Branch, UCBM.