

# Guest Editorial

## Special Section on the 2022 IEEE Measurement and Networking Symposium, Padua, Italy, July 18–20, 2022

**T**HE IEEE International Symposium on Measurements and Networking (M&N) is a conference sponsored by the IEEE Instrumentation and Measurement Society (IMS). It is a privileged forum for discussing the emerging trends in the areas of measurements, communications, computer science, wireless systems, and sensor networks and fostering a debate with engineers and researchers from academia, government, and industry on the crucial role of measurements for networking and networking for measurements.

The Symposium has been promoted, among others, by IEEE IMS TC-37 “Measurements and Networking,” the IEEE Instrumentation and Measurement Society, and the IEEE Italy Section Systems Council Chapter.

The sixth edition of this biennial event, after the interruption of one year imposed by the COVID pandemic, was held in Padua, Italy, on July 18–20, 2022, in a wonderful venue, the Botanical Garden of the University of Padua, Padua, Italy. It is the oldest botanical garden managed by the University and has been a UNESCO World Heritage Site since 1997. Padua is the third largest city of Veneto. It hosts the second oldest university in Italy, founded in 1222.

The symposium attracted more than 260 authors worldwide, submitting papers to the regular track and the seven special sessions. The special sessions have been characterized by a great response from the measurement and networking communities, focusing on the following hot research subjects: 1) energy self-sufficient sensor networks and IoT devices; 2) AI/ML for network monitoring and analysis; 3) security and privacy in cyber-physical systems; 4) antenna and RCS measurements; 5) human exposure to cellular networks; 6) short range tracking and positioning; and 7) point and distributed optical fiber sensing in diverse application fields.

The technical program included 54 accepted papers, undergoing the usual review process, covering all the aspects of the subjects mentioned above. The conference was organized in six oral and two poster presentation sessions, held during the three days of the conference.

Furthermore, the technical program was enhanced by three invited keynotes, which presented to the attendance the most recent results in challenging issues such as 1) the current trends and challenges for low power wide area networks

(LPWANs) (Prof. Lorenzo Vangelista, University of Padua); 2) generalized measurements for quantum information application (Prof. Giuseppe Vallone, University of Padua); and 3) 5G communication network challenges (Dr. Alessandro Pane, Ericsson Research and Development, Italy).

During this edition, four awards have been assigned by the Technical Program Chairs to strongly encourage research in the measurement and networking fields. In particular, the following awards have been assigned:

- 1) *Best Paper Award “Domenico Grimaldi.”* This award recognizes the outstanding paper presented at IEEE M&N 2022.
- 2) *Best Paper Young Author Award.* To be a candidate for this award, a paper must be coauthored and presented by a researcher younger than 35.
- 3) *Best Poster Award.* This award recognizes the outstanding poster presented at IEEE M&N 2022.
- 4) *Standardization Paper Award.* This award recognizes the paper presented at IEEE M&N with the most perspective contribution to the international standardization in the electrotechnical, electronic, and telecommunication field, with particular focus on 1) the Wireless Internet of Things, 2) mobile communications, and 3) low-power networking solutions.

The conference is the most important event sponsored by the IMS especially focused on measurements for networking and the use of networking for supporting measurement procedures and methodologies. Other relevant topics include measurement for security in networks and issues and challenges related to standardization.

Nowadays, we can witness the development of several emerging applications and technologies that promise to interact with smart devices equipped with network capabilities, and able to implement the Internet of Things Ecosystems. In this framework, the Symposium has analyzed the new advances in measurement for networking and networking in measurement applications.

In particular, the role of distributed sensing applications has been studied in detail, presenting many solutions in different application contexts, including liquid volume measurement, energy metering, localization, and vibration analysis, just to cite a few.

Collecting data from the surrounding environment is a main concern, and the networks used for connecting them play a fundamental role. When autonomous operations in dense scenarios are taken into account, satisfying low-cost and low-power requirements is mandatory. Several papers submitted to the conference addressed these issues. Emerging standard protocols operating in license-free bands, such as Bluetooth Low Energy (for short-range connectivity) and LoRaWAN (a member of so-called Low Power Wide Area Networks or LPWANs), have been considered. Besides protocol-based approaches, such as device synchronization for efficient medium access strategies, energy harvesting is a possible solution for extending the device's useful lifetime.

Antenna and RCS measurement was a core topic of the conference considering the fundamental importance of this topic for the realization of effective communication systems.

In the networking context, security is a challenging and critical task. The Symposium has analyzed this field, investigating the measurement's role in improving network security in different applications and situations.

With the development of new wireless communication systems, analyzing the effect of radiated emissions on human beings is a matter of fundamental importance. The Symposium has also discussed this topic, presenting many measurement solutions which can be applied to the analysis of electromagnetic emissions from modern base stations.

Furthermore, network monitoring and analysis is an important aspect for developing modern communication networks. During the Symposium, the role of the measurement and its contribution to this topic was investigated in-depth, providing interesting results which are ready for being applied.

The "M&N 2022" IEEE Transaction on Instrumentation and Measurement Special Section consists of five articles, accepted after a peer-review process that satisfies the requisites of the journal. They are an extended version of the papers presented during the Symposium, including additional original research results.

The first one addresses recent advances in wearables wirelessly connected for health monitoring and diagnostic purposes. It proposes a novel multichannel architecture for electroencephalography (EEG) over BLE, paying attention to low power consumption requirements. A near-lossless EEG compression algorithm and a simple channel encoding scheme are devised to both minimize energy consumption and improve network performance. The experiments confirm the proposed approach's feasibility, resulting in an 86-day lifetime for the 64-channel system, with latency below 35 ms [A1].

The second article presents a robust visible light localization (VLL) technique for wireless sensor networks with 2-D indoor positioning (IP) capabilities based on embedded machine learning (ML) running on low-cost, low-power micro-controllers. The VLL technique uses four optical sources, and signal strengths (RSSs) of optical signals are evaluated by fast Fourier transform (FFT) to estimate the target position within the workspace. The test results performed in a  $1 \times 1$  m workspace show an overall mean accuracy of about 1 cm with a standard deviation below the centimeter and a maximum error of around 3 cm [A2].

Measurement of micro/nano volumes is the subject of the third paper. Such a topic is of high interest for many application domains, such as the calibration of micropipettes for biochemical uses or to examine volume variations to prevent liquid leakage. Two different sensor configurations are discussed, leveraging polymeric light diffusing fibers (P-LDFs) patches. In detail, one configuration is based on a polishing process, while the other one exploits five micro-holes manufactured along the patch. Therefore, the resonance wavelength changes depending on the micro/nano-liquid volume in the sensitive area. The proposed solutions were tested using water micro-volumes in the range from 1 to 5  $\mu\text{L}$ , showing a volume resolution in the order of 80 nL. Such a value is seven times smaller than obtainable resolution using the same P-LDF patch without modifications [A3].

Cybersecurity is the focus of the fourth paper. Whatever the IoT application, nodes are exposed to cyberattacks. Heartbleed allows to capture sensitive information from an estimated 24%–55% of popular HTTPS sites. The problem can be solved, in most of the cases, by releasing suitable patches, but this solution is not ever applied to avoid the patch influencing the ordinary operability of the systems, especially in industrial scenarios. The article proposes a novel measurement method for inline detecting intrusions due to heartbleed and heartbleed-like attacks, based on an effective rule that does not require decoding the payload that can be straightforwardly implemented and included in either IoT sensor nodes or IoT gateways. Tests on a real network show performance comparable (in some cases better) with the heavier machine learning-based methods [A4].

The last article regards the development and characterization of a solution capable of evaluating the 2-D relative position of a wireless device belonging to a sensor network. Possible applications include multi-robot cooperative localization and formation control scenarios. Ranging is carried out using ultrawideband (UWB) technology, complemented by the use of BLE for data acquisition purposes. The relative position is actually obtained numerically solving a nonlinear least squares problem. The proposed approach works both in static and dynamic scenarios. Limits in the estimation procedure are discussed deriving the Cramer Rao Lower bound (CRLB). In particular, real-world experiments have been carried out implementing a network consisting of four nodes; considering an update rate of 10 Hz, the accuracy is in the order of 3 cm [A5].

#### ACKNOWLEDGMENT

It has been our great pleasure to be the Guest Editors of this Special Section. We owe to thank all the people who have made this special section possible. First of all, a particular thank is for the authors for their effort to prepare these excellent contributions. We are also glad to the Associate Editors and Reviewers who have supervised the revision process of each submitted paper, warranting a rigorous review. We would also like to thank the Editor-in-Chief of IEEE TRANSACTIONS ON INSTRUMENTATION AND MEASUREMENT, Prof. Ruqiang Yan, for inviting us to serve as Guest Editors and for his support to this Special Section. Finally, we would also like to thank Mrs. Reta Wehmeir, for her fundamental support.

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#### APPENDIX: RELATED ARTICLES

- [A1] F. Battaglia, G. Gugliandolo, G. Campobello, and N. Donato, "EEG-Over-BLE: A low-latency, reliable, and low-power architecture for multichannel EEG monitoring systems," *IEEE Trans. Instrum. Meas.*, vol. 72, pp. 1–10, 2023, doi: [10.1109/TIM.2023.3268471](https://doi.org/10.1109/TIM.2023.3268471).
- [A2] I. Cappelli et al., "Enhanced visible light localization based on machine learning and optimized fingerprinting in wireless sensor networks," *IEEE Trans. Instrum. Meas.*, vol. 72, pp. 1–10, 2023, doi: [10.1109/TIM.2023.3240220](https://doi.org/10.1109/TIM.2023.3240220).
- [A3] F. Arcadio, D. D. Prete, A. Minardo, C. Marzano, L. Zeni, and N. Cennamo, "Micro-liquid volume measurements exploiting specialty optical fibers and plasmonic phenomena," *IEEE Trans. Instrum. Meas.*, vol. 72, pp. 1–7, 2023, doi: [10.1109/TIM.2023.3298414](https://doi.org/10.1109/TIM.2023.3298414).
- [A4] A. Amodei, D. Capriglione, G. Cerro, L. Ferrigno, G. Miele, and G. Tomasso, "A measurement approach for inline intrusion detection of heartbleed-like attacks in IoT frameworks," *IEEE Trans. Instrum. Meas.*, vol. 72, pp. 1–10, 2023, doi: [10.1109/TIM.2023.3282662](https://doi.org/10.1109/TIM.2023.3282662).
- [A5] V. Brunacci, A. De Angelis, G. Costante, and P. Carbone, "Development and analysis of a UWB relative localization system," *IEEE Trans. Instrum. Meas.*, early access, Aug. 22, 2023, doi: [10.1109/TIM.2023.3305661](https://doi.org/10.1109/TIM.2023.3305661).



**Gianfranco Miele** (Senior Member, IEEE) received the M.S. degree (cum laude) in telecommunication engineering and the Ph.D. degree in electrical and information engineering from the University of Cassino, Cassino, Italy, in 2004 and 2008, respectively.

Since 2019, he has been an Associate Professor with the Department of Electrical and Information Engineering, University of Cassino and Southern Lazio, Cassino. He has authored and coauthored about 80 journal and conference papers in instrumentation and measurement. His current research interests include electrical and electronic measurements, and, in particular, the design and implementation of innovative methods for performance assessment of RF telecommunication systems and communication networks, image-based measurement systems, measurement of electromagnetic compatibility, and Digital Signal Processing (DSP)-based measurement systems.

Prof. Miele is a member of the Italian Association "Electrical and Electronic Measurements Group," the IEEE Instrumentation and Measurement Society, the IEEE 802.22 Working Group, and the IEEE 802.15.22 task group. He was a recipient of the Carlo Offelli Prize for the best Ph.D. dissertation in electronic measurement titled "Design and implementation of an apparatus for reliable and repeatable power measurement in DVB-T systems" in 2008.



**Emiliano Sisinni** (Member, IEEE) received the M.Sc. degree in electronics engineering and the Ph.D. degree in electronic instrumentation from the University of Brescia, Brescia, Italy, in 2000 and 2004, respectively.

He is currently a Full Professor of electronics with the Department of Information Engineering, University of Brescia. His research interests include wireless and wired networking for Internet-of-Things (IoT) applications.

Dr. Sisinni is a member of the IEEE IMS Technical Committee TC-37 Measurements and Networking working group of the IEEE Instrumentation and Measurement Society. Since 2008, he has been an Expert Member of the Technical Committee 65 (Control and Measurement in Industrial Processes) and the Subcommittee 65C (Digital Communications for Control Systems) of the International Electrotechnical Commission (IEC). He is also a member of the TCFA Committee of the IEEE Industrial Electronics Society.



**António Espirito-Santo** received the M.Sc. degree in electrotechnical engineering from the University of Coimbra, Coimbra, Portugal, in 2002, and the Ph.D. degree in electrotechnical engineering from the University of Beira Interior, Covilha, Portugal, in 2008.

He is an Assistant Professor with the Electromechanical Department, Faculty of Engineering, University of Beira Interior, Portugal, where he has been a Faculty Member since 1997. His research interests lie in the scientific area of instrumentation and measurement, ranging from theory to design and implementation. He actively collaborates with other researchers worldwide in other disciplines, promoting interdisciplinarity.

Dr. Espirito-Santo is an Integrated Member of the Institute of Telecommunications (IT). He also chairs the IEEE P21451-002 Working Group in Low-Power Smart Transducers, sponsored by the IEEE-Industrial Electronics Society (IES) and co-sponsored by the IEEE Instrumentation and Measurement Society.