

Introductory notes for the Acta IMEKO Special Issue on the 40th Measurement Day jointly organised by the Italian associations GMEE and GMITT

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Dear Readers,

The Measurement Day is an annual Italian event, founded in 1982 by the late Prof. Mariano Cuniatti. With inspired intuition, Cuniatti conceived the event as a place where engineers, scientists, logicians, epistemologists, could talk to each other, investigating the very foundations of the act of measuring. At those times the event lasted two days and was a beloved appointment for many Italian people passionate about measurements, including scholars, professionals, and simple amateurs, with any cultural background.

In its long history, the format of the Measurement Day has evolved, adapting to the times, but always remaining a much-appreciated annual appointment for people interested in measurement. Nowadays, it actually involves public discussion of invited presentations for half a day, and is mainly centred on advancement and updates in measurement technology and standards, including activities of international metrological bodies, contributions from calibration laboratories, discussions on historical perspectives and modern trends in the measurement world, etc.

We can affirm that the Measurement Day has kept intact its vocation of bringing together people from different backgrounds, i.e. academia, industry, laboratories, accreditation bodies, etc., and is still a quite appreciated event by “measurers”.

Even if it is an event of national dimension, the Measurement Day involves high-level presentations of international level by recognized experts. Therefore, we welcomed with pleasure, on its fortieth anniversary, the invitation of prof. Lamonaca to devote a Special Section of Acta IMEKO to the event.

The 40th edition of the Measurement Day, organized in 2021 by the Italian Associations of Electrical and Electronic Measurements (GMEE) and of Mechanical and Thermal Measurements (GMITT), was titled “Comfort measurements between research, foundations, and industrial applications”. Invited contributions have been from both young and expert researchers, in fields ranging from standardized measurements to psychology. Below, we explain the rationale of the chosen theme for the 40th Measurement Day, and a brief account of the papers included in the Special Section.

We chose the theme of the event starting from the consideration that the environment affects the well-being and the health and emotional state of people, and it is therefore of great importance – and even more in times of pandemics – to guarantee the quality of the indoor life experience. For this purpose, it is essential to measure comfort accurately. But what exactly does it mean to measure comfort accurately? The question has no univocal answer, because we are not dealing with a physical quantity that can be defined regardless of the subject.

A key recent trend is to integrate the measurement of actual physiological data, for example with wearable sensory devices, with environmental measurements. The standard predictive models need to be updated, as well as the data analysis methodologies. Artificial intelligence has been successfully used in this area. Comfort measurements do not only involve an update of hardware and software technologies: they require attention to the psychological aspects. How is the problem of measuring comfort (and in general, the problem of measurement) viewed in psychology and the humanities? How does the problem fit from a psychological perspective?

The BIPM has very recently circulated the “Committee Draft” of the new International Vocabulary of Metrology, the VIM4. One of the purposes of VIM4 is precisely to bring order



to the measurement of “things” fundamentally different from the familiar physical quantities encoded in the International System, for example by introducing the definitions of measurement scale, ordinal scale, nominal scale. On what scale do the comfort measurements fit? How are they different from measurements of physical quantities, and what do these differences entail? The study of comfort measurement thus offers the opportunity to present some of the main innovations of the new Vocabulary.

As regards the papers of this Acta IMEKO Special Section, there are five manuscripts that expand the scientific concepts and applications presented during the event, held online on the 30th of March 2021.

In the manuscript *‘Is our understanding of measurement evolving?’*, authored by Mari, an analysis is proposed, from an evolutionary perspective, trying to answer to some fundamental questions, such as: What kind of knowledge do we obtain from a measurement? What is the source of the acknowledged special efficacy of measurement? The measurement process is traditionally understood as a quantitative empirical process, but in the last decades measurement has been reconsidered in its aims, scope, and structure. Comfort measurements are an application showing the importance and relevance of a re-examination of measurement fundamentals, as suggested in this paper.

The paper *‘Application of wearable EEG sensors for indoor thermal comfort measurements’*, by Mansi et. al., presents a measurement protocol and signal processing approach to use wearable EEG (electroencephalography) sensors for human thermal comfort assessment. Results, reported from the experimental campaign, confirm that thermal sensation can be detected by measuring the brain activity with low-cost and wearable EEG devices.

The paper entitled *‘Impact of the measurement uncertainty on the monitoring of thermal comfort through AI predictive algorithms’*, authored

by Morresi et al., proposes an approach to assess uncertainty in the measurement of human thermal comfort by using an innovative method that exploits a heterogeneous set of data, made by physiological and environmental quantities, and artificial intelligence (AI) algorithms. Uncertainty estimation has been developed by applying the Monte Carlo Method (MCM), given the complexity of the measurement method.

The paper entitled *‘An IoT measurement solution for continuous Indoor environmental quality monitoring for buildings renovation’*, by Serroni et al., proposes an innovative IoT sensing solution, the “Comfort Eye”, specifically applied for continuous and real-time Indoor Environmental Quality (IEQ) measurement in occupied buildings during the renovation process. IEQ monitoring allows investigating the building’s performance to improve energy efficiency and occupant’s well-being at the same time.

Finally, considering the correlation between stress and discomfort, in the article *‘Continuous measurement of stress levels in naturalistic settings using heart rate variability: An experience-sampling study driving a machine learning approach’* Cipresso and colleagues repetitively measured physiological signals in 15 subjects in order to find a model of stress level in daily scenarios. Using the experience sampling method, Cipresso and colleagues were able to collect stressful moments reported by the 15 subjects through questionnaires. Using a machine learning approach, the Authors built a model to predict stressful situation based on physiological indexes that rely on cardiovascular measurements, that means only based on electrocardiogram or similar measures such as blood volume pulse extracted with a photoplethysmograph.

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