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Introductory notes for the Acta IMEKO fourth issue 2023

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Dear Readers,

The end of the year is coming and as Editor in Chief of Acta IMEKO it is my pleasure and duty to thank all of you for your support to the journal as Readers, Authors, Reviewers, Editorial Board Members. Thank to you, Acta IMEKO is further increasing its reputation. Indeed, according to SJR ranking [1], in the last year the Journal passed from the fourth to the third quartile also in *instrumentation* category and it is stable in third quartile both in the field of *Electrical and Electronic Engineering* and of *Mechanical Engineering*.

In recognition of his outstanding service as a Reviewer, this year the Best Reviewer Award goes to Prof. Carmelo Scuro. It is also my pleasure to announce the names of the Top Reviewers in 2023:

- Laura Fabbiano
- Álvaro Silva Ribeiro
- Domenico Luca Carnì
- Tatjana Tomić
- Fabio Leccese
- Cristian Zet
- Gabriele Bocchetta
- Rosario Schiano Lo Moriello.

This Acta IMEKO issue comes with the special Issue on *Metrology for Archaeology and Cultural Heritage,* section editors Prof. Michela Ricca, Prof. Leonardo Iannucci, and Prof. Yuval Goren and the Thematic Issue on *Measurements and Applications in Veterinary and Animal Sciences,* section editors Prof. Leopoldo Angrisani, Prof. Francesco Lamonaca and Prof. Gianluca Neglia.

As usual, also this issue includes a General Track aimed to collect contributions that do not relate to a specific event. As Editor in Chief, it is my pleasure to give you an overview of these papers, with the aim of encouraging potential authors to consider sharing their research through Acta IMEKO.

Some solids are seldom studied analytically, unlike spheres, cylinders, and parallelepipeds. When researchers are interested in them, approximations by discretised meshes and numerical calculations are proposed. One of those is the cylindrical segment, which has applications in novel tilt-based industrial hydrometers. More specifically, the cylindrical segment has two means of being characterised: by measuring the radius, the middle height, and the cutting angle; and by measuring the radius and both the minimum height and the maximum height. In [2], one equation from the literature about the cylindrical segment is corrected, and the two measurement forms are compared, along with their impact on the uncertainty of the volume and barycenter of this solid. Particular results depend on specific input uncertainties, measurements, and objectives. Still, for most cases, it turned out that measuring the minimum and maximum heights generally provides lower uncertainty values for the evaluated calculations, especially the centroids.

In [3], Authors integrated within a specifically developed acquisition system, denoted as Oceanus, the measurements from a differential pressure sensor between the two sides of a sail (windward and leeward sides); experiments have been performed using a light jib sail of a 35 feet cruising-racing yacht. The authors analysed the correlation between such a signal and other standard signals usually present on board such as boat speed, intensity, and direction of apparent or real wind; moreover, data from inertial measurement units are handled. They also considered the target data, which depend on the actual point of sail, and the discrepancy between measured data and the predicted targets is monitored as an error in terms of the true wind angle and boat velocity. In this way, the trimmer/helmsman can monitor the differential sail pressure together with target data and decide to reduce the error with a correction in how sails are trimmed, rather than in how the boat is steered to achieve an improvement of boat performance. The resulting telemetry system represents an effective low-cost solution, which is affordable even for amateur yachtsmen.

The study in [4] focuses on accurate parameters identification for solar cells and photovoltaic module simulation using experimental data. To tackle the challenge of modeling these highly nonlinear systems, the Authors propose the innovative use of the Cheetah Optimizer (CO) algorithm, inspired by cheetah

hunting strategies. The CO algorithm employs mathematical models and randomization parameters to balance exploration and exploitation, avoiding local optima by considering energy limitations. Authors demonstrate the CO algorithm's effectiveness by applying it to the three-diode model in solar photovoltaic systems, specifically the STP6-120/36 and Photowatt-PWP201 PV modules. Impressively, the CO algorithm achieves remarkably low root mean square error values of 0.0145 A and 0.0019 A, outperforming state-of-the-art methods and ensuring high accuracy. Additionally, it delivers the lowest power errors of 0.16054 W and 0.01484 W for the respective modules, highlighting its exceptional performance. The CO algorithm proves to be a promising tool for precise parameter extraction and optimization, leading to improved modelling and performance of solar photovoltaic systems.

According to the standards, decision-making procedures generally consider both a threshold that should not be exceeded and the measurement uncertainty that is associated to the measurement result. However, the general indications given in the Standards, in their examples, refer to the particular case when the measurand distributes according to a normal PDF. But a generalization to other cases is not considered and is not straightforward. The Authors of [5] started from a previously presented decision-making procedure which not only considers the measurement uncertainty and the threshold, but also considers a Maximum Admissible Risk. The proposed procedure leads to decisions taken with a risk of a wrong decision lower than the given Maximum Admissible Risk. In particular, closed-form formulas were derived under specific assumptions for the distributions of the measured values. Hence, in [5] they generalize the proposed decision rule and method for setting acceptance and rejection limits, by applying the Monte-Carlo method. As a consequence, the proposed method can be generally applied, even when the distribution associated to the measurement result is not a priori known in closed form.

A new scheme for the measurement traceability, named the 'Metrological Measurements Network', was proposed in [6]. The main reason is that each laboratory calibrates its own object for measurement using its measurement standard and sends it for calibration to a laboratory-participant and, almost simultaneously, receives a similar object from another laboratory-participant that calibrated it. If each participant, at the same time as the others, makes at least four such calibrations and transfers between laboratories-participants, it will form a common and very precise Metrological Measurement Network in a very short time. It can cover hundreds and even thousands of laboratories in a short period of time. The joint processing of a large number of such measurements will help to define the additive and/or multiplicative biases of each measurement standard. Moreover, the reference conditions are imposed that the sum of additive and, separately, the sum of multiplicative biases for all measurement standards is equal to zero regardless of the number of network participants.

Water temperature in rivers and reservoirs plays a crucial role in aquatic ecology, as inadequate conditions can promote the overgrowth of harmful algae and bacteria, resulting in the production of harmful toxins for human and animal health, and affecting water quality. To effectively manage water resources, continuous monitoring of these bodies is crucial. However, existing technological devices rarely offer continuous and real-time data collection, necessitating an alternative approach. The aim of the study in [7] was to compare the performance of four machine learning models (Linear Regression, Stochastic Model, Extra Tree, and Multilayer Perceptron Neural Network) in estimating water temperature in Pernambuco, Brazil's rivers and reservoirs. Statistical metrics showed that all models achieved a satisfactory capacity, with the Multilayer Perceptron Neural Network demonstrating slightly superior performance in reservoirs and rivers where it obtained the best result with a Mean Squared Error: 0.343, Root Mean Squared Error: 0.585, Mean Absolute Error: 0.445 and Coefficient of Determination: 0.595. Consequently, the MLPNN model was chosen for the development of virtual sensors. In addition the Authors developed an interface that allows users to access a map and obtain estimated water temperature information for various locations, facilitating informed decision-making and resource management.

The article in [8] shows an idealised model of a Jones-type cell with a removable central extension tube. Two main factors leading to the cylindricity distortion of the inner surface of the cell are considered. These are radial displacement and tube diameter inequality. Based on the finite element method (FEM), errors in measuring the resistance of a liquid column caused by the non-uniformity of the current density distribution inside the cell were determined. The methodological error with respect to the idealized model was estimated for each factor separately and in combination. The Authors show that at a radial displacement of 0.6 mm, the error can reach 0.1 %. The same error value occurs when the inequality of the diameters is only 20 μm.

In [9] the lack of intercomparisons in surface tension measurements, and the need to establish the degree of equivalence of such measurements are considered. These needs have led to a comparative study on this subject carried out by 3 National Metrology Institutes (from Poland, Portugal, and Turkey), within the scope of the Project 17RPT02-rhoLiq. For this purpose, the surface tension of 6 liquids, was determined at 20 °C, using force tensiometers, with 2 different measuring probes (Du Noüy ring and Wilhelmy plate), and by applying different correction factors. The results presented in [9] allowed the Authors to conclude on the degree of equivalence of surface tension measurement results, obtained by each NMI, by using different probes and measurement models.

Air quality is an important environmental concern, as it is strictly related to human health risks and adverse effects on it. Monitoring air pollutants and different ancillary parameters is a feasible and crucial approach to address this challenge. This task typically involves high expenses in case measurements are carried out by using conventional measurement instruments and human operators. However, using measurement systems with low-cost sensors can reduce the overall implementation effort. The aim of the paper in [10] is to describe the sensor node architecture applicable to a general monitoring system and based on this structure, review different current low-cost measurement system proposals for outdoor air quality monitoring.

In the presence of natural disasters that increasingly affect urban centers, innovative methodologies that can support all the subjects and bodies involved in the disaster management system are increasingly important. This task can be enhanced in urban settings by automatically assessing at-risk buildings through satellite and aerial imagery. However, creating and implementing models with robust generalization capabilities is crucial to achieving this goal. Based on these premises, the Authors in [11] proposed a deep learning approach utilizing the U-Net model to map buildings within known landslide-prone areas. They trained and validated the U-Net model using the Dubai Satellite Imagery Dataset. The model's prediction accuracy in adapting its results

to urban environments in Italy, different from those involved in the training and validation stages, was tested using natural color orthoimages and diverse geographic information system (GIS) data sources. The outcomes indicate that the model's predictions are better in contexts with denser urban fabric. The level of accuracy in dispersed urban shapes worsens as building footprints cover a small portion of the total image area. Overall, the results demonstrate that the suggested methodology can effectively identify buildings in landslide risk zones, demonstrating noteworthy adaptability, making the proposed platform a tool that can be instrumental for decision-makers and urban planners in pre-disaster and post-disaster stages.

Even though the southeast region of Algeria, especially Ouargla city, enjoys a lot of sunshine all over the year, fixed photovoltaic (PV) solar panels are not sufficient due to two main reasons. Firstly, these panels are unable to capture sunlight during the early morning and late afternoon, and secondly, their efficiency is low, requiring the use of economical methods to enhance their performance. To overcome these limitations, the research proposed in [12] suggests incorporating commercial reflectors to enhance sunlight capture. Furthermore, Authors compare the effects of three types of reflective materials: mirrors, aluminium, and transparent glass, on the performance of the PV module. To achieve this objective, reflectors are installed at the top and bottom of the PV module at their optimal tilt angles. Moreover, the effect of the adjacent module's mirrors was studied by installing two big mirrors (3X). The obtained results show an average improvement of 14.24 %, 11.41 %, and 4.7 % in the electrical energy generated by the PV panel with mirrors, aluminium, and transparent glass, respectively, compared to the module without reflectors. Subsequently, in the large mirror case, the results were positive, with an average 20.84 % increase in the maximal electrical power produced compared to the conventional one.

Measuring a person's cognitive abilities, such as memory and learning, is central in many medical conditions to reliably diagnose, treat and monitor disease progression. Common tests typically include tasks of recalling sequences of blocks, digits or words. Recalling a word list is affected by so-called serial position effects (SPE), meaning that words at the beginning or end of the list are more likely to be recalled. In the recent literature, as part of including ordinal and nominal properties in metrology, compensation for ordinality in the raw test scores has been performed with psychometric Rasch measurement theory. Thereafter, SPE have been successfully explained with construct specification equations (CSE) dominated by information theoretical entropy as candidate reference measurement procedures. In [13], the Authors present how previous German results for explaining memory difficulty in the immediate recalling (IR, trial 1) task of the Rey's Auditory Verbal Learning Test (RAVLT) can be replicated with a Swedish cohort (the Gothenburg Mild Cognitive Impairment study, n = 251). This CSE replicability for RAVLT demonstrates comparability across the two cohorts in a kind of inter-laboratory study. Moreover, RAVLT includes repeated trials and learning through practice is expected. How memory task difficulty changes over the eight trials in RAVLT is studied: SPE are not so prominent for the delayed recalling sequences and there is an overall reduction in the task difficulty CSE intercept with trial number, interpreted as an effect of learning. To conclude, the methodology and evidence provided in [13] can be clinically used not only to measure a person's memory ability but also his or her learning ability, as well as to understand the relationship between learning ability and other cognitive domains.

The paper in [14] describes a video strain measurement solution developed for application in mortar destructive compression testing. Knowledge about the mechanical behaviour of this type of construction material, namely up to its fracture, is still superficial due to the less common use of non-contact measurement methods. The performed research was focused on the determination of image coordinate accuracy, based on the experimental quantification of the identified main uncertainty components, using traceable reference patterns, and validated computational toolboxes dedicated to camera parameterization and digital image processing. The obtained results show the following uncertainty contributions: lens distortion - negligible; re-projection errors - 0.21 pixel; 0.10 pixel - spatial resolution; and digital image processing operations - 0.28 pixel. The combination of these uncertainty components resulted in an image coordinate standard uncertainty equal to 0.36 pixel, which was propagated (in addition to the scale coefficient measurement uncertainty) to the selected camera model – orthographic projection with uniform scaling – which supports the video strain measurement.

In [15] the Authors discuss neural network-based data augmentation to increase the performance of neural networks in classification of datasets with underrepresented defect classes. The performance of deep neural networks suffers from an inhomogeneous class distribution in recognition tasks. In particular, applications of deep neural networks to solve quality assurance tasks in industrial production suffer from such unbalanced class distributions. In order to train deep learning networks, a large amount of data is needed to avoid overfitting and to give the network a good generalisation ability. Therefore, a large amount of defect class objects is needed. However, when it comes to producing defect classes, obtaining a dataset for training can be costly. To reduce this cost, artificial intelligence in the form of Generative Adversarial Networks (GANs) can be used to generate images without producing real objects of defect classes. This allows a cost-effective solution for any kind of underrepresented classes. However, the focus of the work is on defect classes. In the paper a comparison of GANs for data augmentation with classical data augmentation methods for simulating images of defect classes in an industrial context is presented. The results show the positive effect of both, classical and GAN-based data augmentation. By applying both methods parallel the best results for defect-class recognition tasks of datasets with underrepresented classes can be achieved.

Data from the Kering Group's 2018 Environmental Profit and Loss (EP&L) statement were examined for their capacity to meet the demand for meaningful and manageable sustainability metrics. Significant resources were invested in creating the data reported in this EP&L statement, as Kering's operations in 104 countries were evaluated in ways separable into almost 1,500 different indicators. According to the Authors of [16], the data system was not, however, designed as a measurement system. That is, it was not set up as specifically positing the possibility of estimating separable parameters for comparing company location performances across sustainability challenges. Of particular importance is the lack of information in the EP&L on the overall consistency of the data reported, on the uncertainties associated with the metrics given, and on the meaningfulness of comparisons across environmental impacts, processes, and materials. The results reported here showing far from perfect data consistency and large uncertainties comprise an effort at

constructing meaningful measurements that offers important lessons for the redesign of the data and reporting system.

In addition to being used in hospitals, ultrasound systems are used in many other medical settings such as disaster relief and home care. In these types of settings, it is important to be able to perform a large number of examinations easily and efficiently. Portable ultrasound systems can be used to meet such needs. The evaluation of ultrasound systems has been driven by the development of accuracy control methods used in breast examinations. The study in [17] aimed to evaluate the performance of portable ultrasound systems that have not yet been fully investigated. The performance of two ultrasound systems was evaluated using three measures. For physical evaluation, the change in the mean pixel value of the target and the contrast-to-noise ratio were obtained for each ultrasound system. Statistical analyses were performed to compare these measures between the two systems. For visual evaluation, a receiver operating characteristic analysis was performed. The results of the physical and visual evaluations showed no statistically significant differences between the portable ultrasound systems we evaluated and those that are commonly used in clinical practice.

The dew point temperature can be generated by saturating air with water vapor through several methods, one of which is by creating small-sized air bubbles passed through water in an enclosed space known as a saturator. In practical terms, the dew point temperature produced by this system can be determined by measuring it using a dew point meter. However, the prediction of the dew point temperature generated through theoretical approaches has not been presented before. Thus, in [18], a simulation has been conducted to determine the dew point temperature. The result is then compared to the experimental data. The experiment follows the single pressure humidity generator principle, where a saturator containing a bubble aerator is immersed in a stirred liquid bath. The bath temperature is set to 25 °C, and the gas flow rate is adjusted from 0.1 lpm to 0.4 lpm. The dew point temperature is measured using a 373 LHX chilled mirror dew point meter. On the other hand, the simulation is performed using the Monte Carlo method, and the physical model involves a heat balance between convection and the change in bubble energy. The convection heat transfer coefficient is determined by the behavior of bubble dynamics, which is related to the bubble size and bubble velocity. The dew point temperature obtained from the simulation is assumed to be the same as the bubble temperature. As a result, the simulation data align well with the experimental data.

In [19], the Author proposes the digitised voltage and current waveforms to estimate active power by processing the obtained samples through two methods: Discrete Integration and Spectral Analysis. The former involves computing the average of the sample-by-sample product of the two waveforms, while the latter uses sine fitting algorithms to estimate the amplitude and initial phase of each waveform. Precision expressions for both estimators are derived as a function of the number of samples acquired and the amount of additive random noise present, which is useful for determining the confidence interval for measurements. The two estimators are compared, and it is concluded that the second method, using sine fitting, is sometimes superior.

In [20], the dynamic behaviour of an airless wheel made by additive manufacturing is investigated. A lattice geometry is chosen as the cyclic pattern from which the wheel is built. Initially, a linear numerical model is used to preliminarily assess the resonance frequency and mode shapes of the wheel. Afterwards, specimens were tested twice, in August 2020 and after six months, highlighting a relevant frequency and damping shift in the vibrational response. To better understand the reason behind the change over time in the wheel dynamic behaviour, dedicated structural dynamics tests at varying temperature and humidity set points were performed in an environmental chamber, consisting in measuring the wheel vibrational response when subjected to temperature and humidity variation.

Creative design methods should allow the extraction of novel wisdom and favor their integration into many technological domains, thus leading to an innovative product. The research presented in [21] reports some technical considerations on the role of generative design as a "collaborative partner" in supporting the ideation process through the development of design alternatives in agreement with the designer's criteria. A specific case study was considered and the role of the generative design method was stressed, also focusing on technical features and differences in terms of solutions for the given design problem. The possibility of selecting well-defined manufacturing methods (e.g., traditional or advanced – additive manufacturing) was highlighted.

The design of scaffolds for multi-tissue regeneration is very complex in terms of material and structure, as a direct consequence of hierarchical and organizational features. TRIZ represents the Russian acronym for the "Theory of Inventive Problem Solving" (TIPS). TRIZ is able to identify and codify such principles, using them to make the creative process more predictable. It is a methodology for the identification of the system conflicts and contradictions to solve inventive problems. Its multidisciplinary features and the general approach to product design can make TRIZ as an intriguing starting point for the biomimetic approach in a systematic and organized way. Biomimetics aims at a complete integration between nature and technology. In this scenario, BioTRIZ shares the contradiction resolution method of the Altshuller's theory, representing a systematic biomimetic approach towards the product design. In [22], BioTRIZ was considered to systematize the process of bio-inspired design of 3D-optimized scaffolds for the regeneration of complex tissue defects. A device for the regeneration of osteochondral tissue defects was considered as a case study. The technical solutions involved the design of a two-compartment, hybrid and functionally graded scaffold.

I would like to thank all the Section Editors of this issue and of all issues for the great contribution they gave collecting papers from different matters but all tied by the *fil rouge* of measurements and instrumentation.

Finally, let me formulate my Best Wishes for the new year.

We hope you will enjoy your reading.

Francesco Lamonaca
Editor in Chief

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