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Introductory notes for the Acta IMEKO second issue General Track

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Dear Readers,

As Editor in Chief of Acta IMEKO, I am pleased to share with you a further success of Acta IMEKO that in the last ranking of Scimago increases its position to the third quartile also in Instrumentation (*https://www.scimagojr.com/journalsearch.php?q=21100407601&tip=sid&clean=0*). I would like to thank all the Editorial Staff, the Reviewers, the Authors, and each of you for choosing Acta IMEKO as a valuable source to find knowledge and inspiration and an effective media to share your research and results with the Scientific Community.

This General Track collects several contributions that do not relate to a specific event. As Editor in Chief, it is my pleasure to give to you an overview of these papers.

Accurate, continuous and reliable data gathering and recording about crop growth and state of health, by means of a network of autonomous sensor nodes that require minimal management by the farmer will be essential in future Precision Agriculture. In [1], a low-cost multi-channel sensor-node architecture is proposed for the distributed monitoring of fruit growth throughout the entire ripening season. The prototype presented is equipped with five independent sensing elements that can be attached each to a sample fruit at the beginning of the season and are capable of estimating the fruit diameter from the first formation up to the harvest. The sensor-node is provided with a LoRa transceiver for wireless communication with the decision making central, is energetically autonomous thanks to a dedicated energy harvester and an accurate design of power consumption, and each measuring channel provides resolution of a few tenths of a millimeter with a full-scale range of 12 cm. The accurate calibration procedure of the sensor-node and its elements is described in the paper, which allows for the compensation of temperature dispersion, noise and non-linearities. The prototype was tested on field in real application, in the framework of the research activity for next-generation Precision Farming performed at the experimental farm of the Department of Agricultural and Food Science of the University of Bologna, Cadriano, Italy.

The paper in [2] belongs to a line of research known as aerial archaeology and compares some specific visualizations of LIDAR data (hill-shading, openness, and sky view factor) to understand which of them can provide the best approach to suitably identify and unveil some archaeological permanences as function of different boundary conditions. In the case presented by the Authors, such permanences belong to the very special material heritage consisting of the "physical traces" of the Great War, although latent, they persist in the present landscapes at different states of preservation and visibility, waiting to be unearthed to express their cultural potential. They represent an indispensable palimpsest of "minor signs" such as, for example, fragments of entrenchments, gun emplacements, shelters, bomb craters, and temporary shelters. Such elements made the war machine work at that time while, nowadays, if properly recognized and enhanced, could foster the historical and cultural revitalization of the territories where they are placed.

In [3] the results of measurements of atmospheric absorption and the amount of precipitated water on the Suffa Plateau for the period from January, 2015 to November, 2020, are presented. The measurements of atmospheric parameters in the 2 and 3 mm range of the radio waves spectrum were carried out using the MIAP-2 radiometer. The results of more than six years of measurements have shown that on the Suffa Plateau, atmospheric parameters in the above range remain fairly stable.

In [4], the analysis of measuring channels of angular velocity with an encoder is given. This analysis has made it possible to obtain an equation for estimating the quantization and sampling error for an exponential mathematical model describing the transient process of operation of electrical machines. The components of the mathematical model of this dynamic error are the sampling step and the derivative, which characterizes the rate of change of the measured value over time. It was found that the errors of quantization and sampling significantly depend on the

value of the resolution z of the encoder. Moreover, an increase in z leads to a decrease in the sampling error, but the relative quantization error increases. A proposal to reconcile these components of errors is also given.

The monitoring and management of Postprandial Glucose Response (PGR), by administering an insulin bolus before meals, is a crucial issue in Type 1 Diabetes (T1D) patients. Artificial Pancreas (AP), which combines autonomous insulin delivery and blood glucose sensor, is a promising solution; nevertheless, it still requires input from patients about meal carbohydrate intake for bolus administration. This is due to the limited knowledge of the factors that influence PGR. Even though meal carbohydrates are regarded as the major factor influencing PGR, medical experience suggests that other nutritional should be considered. To address this issue, in [5], the Authors propose a Machine Learning (ML)-based approach for a more comprehensive analysis of the impact of nutritional factors (i.e., carbohydrates, protein, lipids, fiber, and energy intake) on the blood glucose levels (BGLs). In particular, the proposed ML-model takes into account BGLs, insulin doses, and nutritional factors in T1D patients to predict BGLs in 60-minute time windows after a meal. A Feed-Forward Neural Network was fed with different combinations of BGLs, insulin, and nutritional factors, providing a predicted glycaemia curve as output. The validity of the proposed system was demonstrated through tests on public data and on self-produced data, adopting intra- and inter-subject approach. Results anticipate that patient-specific data about nutritional factors of a meal have a major role in the prediction of postprandial BGLs.

The cyber-security of an embedded device is a crucial issue especially in the Internet of Things (IoT) paradigm, since the physical accessibility to the smart transducers eases an attacker to eavesdrop the exchanged messages. In [6], the role of metrology in improving the characterization and security testing of embedded devices is discussed in terms of vulnerability testing and robustness evaluation. The presented methods ensure an accurate assessment of the device's security by relying on statistical analysis and design of experiments. A particular focus is given on power analysis by means of a scatter attack. In this context, the metrological approach contributes to guaranteeing the confidentiality and integrity of the data exchanged by IoT transducers.

An electroencephalography (EEG)-based classification system of three levels of fear of heights is proposed in [7]. A virtual reality (VR) scenario representing a canyon was exploited to gradually expose the subjects to fear inducing stimuli with increasing intensity. An elevating platform allowed the subjects to reach three different height levels. Psychometric tools were employed to initially assess the severity of fear of heights and to assess the effectiveness of fear induction. A feasibility study was conducted on eight subjects who underwent three experimental sessions. The EEG signals were acquired through a 32-channel headset during the exposure to the eliciting VR scenario. The main EEG bands and scalp regions were explored in order to identify which are the most affected by the fear of heights. As a result, the gamma band, followed by the high-beta band, and the frontal area of the scalp resulted the most significant. The average accuracies in the within-subject case for the three-classes fear classification task, were computed. The frontal region of the scalp resulted particularly relevant and an average accuracy of (68.20 ± 11.60) % was achieved using as features the absolute powers in the five EEG bands. Considering the frontal region only, the most significant EEG bands resulted to be the high-beta and gamma bands achieving accuracies of (57.90 ± 10.10) % and of (61.30 ± 8.43) %, respectively. The Sequential Feature Selection (SFS) confirmed those results by selecting for the whole set of channels, in the 48.26 % of the cases the gamma band and in the 22.92 % the high-beta band and by achieving an average accuracy of (86.10 ± 8.29) %.

In [8], a feasibility study on electroencephalographic monitoring of executive functions during dual (motor and cognitive) task execution is presented. Electroencephalographic (EEG) signals are acquired by means of a wearable device with few channels and dry electrodes. The light weight and wireless device allow for walking in a natural way. The most significant EEG features are investigated to classify different levels of activation for two fundamental Executive Functions (EF) both in sitting and walking conditions. Power spectral density in the gamma band resulted in the most relevant feature in discriminating low and high levels of Inhibition. Power spectral density in the beta and gamma bands resulted the most discriminating the level of activation of Working Memory. The study poses the basis for (i) monitoring the activation levels of EF during Gait allowing loss prevention in the elderly and (ii) specific cognitive rehabilitation aimed at the most relevant executive functions during walking.

The paper in [9] deals with the extraction of the fetal electrocardiography (ECG) signal from the raw ECG signals of the mother by the beamforming based algorithms. The foetal ECG sensors bring out signals containing information from the pregnant mother and the infant. Detailed and separate signals are already provided by the foetal ECG instruments; but for some specific studies related to the infant conditions, it is necessary to improve the quality of the signal with a dedicated processing. In this paper, four techniques, with some enhancements, are proposed to perform the processing; we have applied the following techniques: Least Mean Square (LMS) with adaptive noise cancellation technique, Discrete Wavelet Transform (DWT)-based technique, Empirical Wavelet Transform (EWT) technique, and Multiple Signal Classification (MUSIC). The LMS and the MUSIC pertain to beamforming approach. The techniques were used to decompose and identify the different elements constituting the source signal (mother's signal) and noise cancellation by Multivariate Empirical Mode Decomposition (MEMD) technique. The signal was adaptively decomposed by LMS, DWT and MUSIC according to optimised parameters to extract some hidden components of the source signal, such as the foetal features, QRS, heartbeat etc. The results have showed that LMS, with enhancements, is more effective in identifying and removing useless noise. The techniques were applied to the ECG signal of a 30-year-old healthy pregnant woman, which allowed to verify their applicability. The present research leads to the below main contributions among others: separation of the ECG signal of the foetus from the mother, highlighting the functional state of the foetal heart rhythm (heart rate and heartbeat,) and this can show us if the foetal ECG has malfunctions.

The random noise test of analog to digital converters recommended by the IEEE 1057 Standard for digitizing waveform recorders is studied in [10]. The heuristically derived expression presented for the estimation of the random noise standard deviation is experimentally validated. The standard suggests a triangular stimulus signal. The Authors show how to use a sinusoidal stimulus signal to carry out the test. The influence of stimulus signal offset and amplitude on the estimation error is also analysed and an expression is presented

to compute the minimum amplitude value that guarantees an upper bound on the estimator bias.

The paper in [11] presents a theoretical analysis of uncertainty sources in measurement techniques used to determine vibrations of turbomachinery blades using stationary sensors mounted on the casing of the turbomachine. A mathematical model based on fundamental physical principles is proposed, and two different measurement set-ups are evaluated. One set-up uses a reference sensor to measure the passage of an undeformed part of the blades (blade base), while the other set-up does not involve the use of a reference sensor, with both sensors facing the blades tip (deformed part). The intrinsic uncertainty of these methods and the performance of the complete measurement chain are defined. The analysis of the measurement technique leads to conclusions about the practical set-up and possible performances of these measurement techniques.

Measurement uncertainty plays a very important role ensuring validity of decision-making procedures, since it is the main source of incorrect decisions in conformity assessment. The guidelines given by the actual Standards allow one to take a decision of conformity or non-conformity, according to the given limit and measurement uncertainty associated to the measured value. Due to measurement uncertainty, a risk of a wrong decision is always present, and the Standards also give indications on how to evaluate this risk, although they mostly refer to a normal probability density function to represent the distribution of values that can be reasonably attributed to the measurand. Since such a function is not always the one that best represents this distribution of values, the paper in [12] considers some of the most-often used probability density functions and derives simple formulas to set the acceptance (or rejection) limits in such a way that a pre-defined maximum admissible risk is not exceeded.

Accurate and reliable results in orthodontics heavily depend on selecting the right impression materials. With the rise of digital technology and additive manufacturing techniques, it has become necessary to characterize experimentally the materials used to design prosthetic bases. In the study presented in [13], the mechanical properties of Polyetheretherketone, Nylon6, Nylon12, and Polypropylene are analysed, as impression materials commonly used in dentistry applications. Specifically, the effect on their flexural elastic modulus of the exposure to working environment conditions is also investigated by means of 3-point bending test performed on virgin materials and samples immersed in saliva for 72 hours. The proposed approach revealed significant behaviour in terms of loss in mechanical performances. These findings have significant implications for the proper selection and use of AM materials in dental applications.

Structural health monitoring (SHM) is an essential aspect to ensure the safety and longevity of civil infrastructure. In recent years, there has been a growing interest in developing SHM systems based on Micro-Electro-Mechanical Systems (MEMS) technology. MEMS-based sensors are small, low-power, and cost-effective, making them ideal for large-scale deployment in structural monitoring systems. However, the use of MEMS-based sensors in SHM systems can be challenging due to their inherent errors, such as drift, noise, and bias instability; these errors can affect the accuracy and reliability of the measured data, leading to false alarms or missed detections. Therefore, several methods have been proposed to compensate for these errors and improve the performance of MEMS-based SHM systems. For this purpose, the Authors in [14] propose the combined of a redundant configuration of cost-effective MEMS accelerometers and a Kalman Filter approach to compensate MEMS inertial sensor errors and data filtering; the performance of the method was preliminarily assessed by means of a custom-controlled oscillation generator and compared with that granted by a high-cost, high-performance MEMS reference system where amplitude differences of 0.02 m/s² have been experienced. Finally, a sensor node for real-time monitoring has been proposed that exploits LoRaWAN and NFC protocols to access the structure information to be monitored.

Electromagnetic Tracking Systems (EMTSs) are widely used in surgical navigation, allowing to improve the outcome of diagnosis and surgical interventions, by providing the surgeon with real-time position of surgical instruments during medical procedures. The main goal is to improve the limited range of current commercial systems, which strongly affects the freedom of movement of the medical team. Studies are currently being conducted to optimize the magnetic field generator (FG) configuration (both geometrical arrangements and electrical properties) since it affects tracking accuracy. In [15], Authors discuss experimental data from an EMTS based on a developed 5-coils FG prototype, and they show the correlation between position tracking accuracy and the gradients of the magnetic field. Therefore, they optimize the configuration of the FG by employing two different metrics based on i) the maximization of the amplitude of the magnetic field as reported in literature, and ii) the maximization of its gradients. The two optimized configurations are compared in terms of position tracking accuracy, showing that choosing the magnetic field gradients as objective function for optimization leads to higher position tracking accuracy than maximizing the magnetic field amplitude.

I hope you will enjoy your readings.

Francesco Lamonaca
Editor in Chief

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