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Introductory notes for the Acta IMEKO second issue in 2025

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Dear Readers,

The second Acta IMEKO issue of 2025 is online. As EiC it is my pleasure introduce the papers belonging to the general track.

In [1], the application of the transposition method in the processing of indirect uncorrelated measurements with different numbers of observations of input quantities is considered. Expressions to estimate of the measurand, as well as the combined standard and expanded uncertainties are obtained. An example of the implementation of the proposed method is also considered.

To meet industry demands, in [2] measurement traceability for the dielectric constant of solid reference materials has been established at audio and radio frequencies. The dielectric constant is determined using capacitance-based contact and non-contact methods, where the dielectric material is sandwiched between the electrodes of a dielectric test fixture. A precision LCR meter measures the capacitance of solid dielectric materials, and results from contact and non-contact methods align well up to 1 MHz. Measurement uncertainty is evaluated according to the Guide to the Expression of Uncertainty in Measurement, with a detailed discussion of contributing factors.

The paper presented in [3] introduces a synthesis study of a switching Linear Parameter Varying (LPV) controller with multiple polytopic subregions, considering separate parameter-dependent Lyapunov functions. The parameter space setup is designed with overlapping subregions in which safe controller switching is ensured by hysteresis switching logic. Robotic manipulators, like any mechatronic systems, are burdened with unmodelled characteristics such as friction phenomena and actuator dynamics, as well as nonlinear dynamics. These effects might be countered by LPV controllers, although they may be too conservative for production. The switching controller can decrease conservatism utilising separate Lyapunov functions while maintaining essential features of a general H_∞ LPV controller, such as global asymptotic stability over the entire parameter space. The suggested method is applied on a real-life 2-DOF SCARA-type robotic manipulator, and extensive testing results are presented along with some of the key challenges that arise when the application is moved from simulation to real-life. Primary considerations with respect to the application of switching control are studied in detail, including the number and shape of subregions, overlapping percentage, switching surface orientation, and scheduling parameter selection.

Landslide activities must be monitored by means of robust sensing and acquisition systems in the spirit of quick intervention in the event of stealth and/or huge subsoil displacements. Acquiring diverse parameters, in order to address this issue, is an important area of research. The paper in [4] illustrates a case-study with a dedicated architecture. The multiparametric acquisition system is developed to acquire in real time data related to linear and rotational displacement parameters. These data are used to prevent prospective ground movement. The principal advantage of the implemented system dwells in its flexibility, efficacity, and its transmission speed, as well as its low implementation cost. The sensor planted on site regularly sends these following parameters: acceleration related to the auscultated site, the sensor rotation velocity and the site ambient temperature. These three parameters essentially allow the monitoring of the site state, the sensor position and the site temperature. In the paper, tests are performed in laboratory simulating two phenomena on which are based our studies: subsidences and collapses.

The aim of the research presented in [5] is to describe the calibration of an unloaded laboratory oven used for drying textiles samples from respiration at (37 ± 2) °C and the detailed associated uncertainty of measurements. The calibration was performed in accordance with the DKD-R 5-7:2018 guidelines. The entire calibration system including the nine calibrated Pt100 temperature probes and the multimeter that reads temperature in °C was interfaced with a PC running a LabVIEW program for data acquisition and analysis. The temperature drift, inhomogeneity, instability and the calibration uncertainty were assessed. This investigation revealed that the calibrated oven

maintains good temperature drift, homogeneity and stability making it suitable for reliable textile testing.

The study in [6] investigates how sand dust accumulation affects the electrical performance of photovoltaic (PV) modules in arid climates. Conducted in southeast Algeria, the research evaluates power output from four identical PV panels exposed to varying dust densities. All panels were mounted with a 30° tilt facing due south, and their power outputs were measured hourly from 09:00 to 17:00. The results revealed that increasing dust levels significantly reduced output.

The article in [7] investigates the integration of the Internet of Things (IoT), digital twin (DT), and augmented reality (AR) technologies to advance digital services in the management, monitoring, and control of agricultural greenhouses, addressing the sector's technological demands. By leveraging advanced technologies, the research aims to enhance efficiency across various fields, including industry, logistics, and commerce. The core objective is to develop a prototype IoT system, incorporating DT and AR, to create a digital transformation environment. This system provides real-time visualization and monitoring of sensor data from physical IoT devices, enabling user interaction and control through microcontroller-based sensor nodes installed in the greenhouse. Data transmission is achieved using the MQTT protocol, while an AR application facilitates greenhouse visualization and control. The findings demonstrate the system's effectiveness in enabling real-time communication between IoT devices and the AR application, with users successfully performing tasks without prior experience, thereby validating the system's usability and efficiency.

The paper in [8] aims to propose a generic black-box model for converters connected to an electric vehicle. The methodology for identifying the model parameters is presented, as well as the validation of this model. In fact, the control of electromagnetic interference (EMI) in power converters for electric vehicles relies on several approaches, including soft switching and pseudo-random modulation, which aim to reduce voltage variations and spread EMI energy across a wide frequency band, respectively. However, filtering remains the most effective solution to mitigate common-mode and differential-mode noise while ensuring EMC compliance without compromising performance. Moreover, a black-box behavioural modelling approach in the frequency domain enables precise representation of EMI sources and the optimization of EMC filter design, focusing on common-mode and differential-mode impedances without requiring internal circuit details. Finally, a network-based modelling approach has been employed to define and compare theoretical impedances with experimental measurements, validating the EMC model by reconstructing the measured voltages and confirming its ability to accurately represent electromagnetic disturbances.

The study in [9] presents a non-invasive, ultrasonic sensor-based Human Activity Recognition (HAR) system designed to monitor occupant presence and activity in office environments, enhancing indoor comfort measurement. Ten participants performed predefined office tasks in a controlled setting. Raw ultrasonic data were calibrated, denoised, and segmented into 5-second windows, yielding displacement metrics. A two-stage classification approach was applied: first, a support vector machine (SVM) distinguished static from dynamic activities with 93.1% accuracy. Then, a convolutional neural network (CNN) identified specific dynamic actions—writing, typing, talking on the phone, and standing—with 99.3% accuracy. The results demonstrate high effectiveness and reliability, supporting future integration into personalized comfort models and intelligent building systems to optimize indoor resource use and occupant well-being.

In [10], the problem of determining the winding angle in a cylindrical carbon fibre piece, obtained through a filament winding process, is investigated. A polarization camera is used for the measurement, and the winding angle is determined by statistically analysing the angle of linear polarization in each pixel of the region under study. The main influence parameters are considered, like non-planarity and superficial state of the piece, with the aim of reducing the measurement uncertainty. For this purpose, two different types of data processing approaches are tested and compared.

Analog-to-digital converters, as all electronic circuits, are subject to numerous non ideal phenomena. The research activities presented in [11] focus on the effect of phase noise on the standard deviation of the estimation of differential nonlinearity of analogue to digital converters estimated using the code density test. An analytical expression is presented for the use in choosing the number of samples to use to achieve a given bound in the estimation precision or, after a test, to determine the confidence interval associated with a given estimation of differential nonlinearity. A Monte Carlo type analysis is carried out to validate the analytical expressions presented.

In recent years, optical systems operating in the visible spectrum have emerged as the most efficient, low-cost, and environmentally friendly technologies for underwater applications across military, scientific, and economic sectors. While blue and green wavelengths are commonly used due to their lower attenuation in clear water, red light offers distinct advantages in turbid environments. Specifically, red radiation exhibits lower attenuation than blue and green light in such conditions and is non-harmful to marine fauna. The article in [12] explores current and potential future optical technologies that utilize red light. Particular attention is given to underwater wireless optical communication systems employing red wavelengths for data transmission in turbid waters. The proposed systems are applicable in underwater wireless sensor networks, communication buoys, and navigation of autonomous underwater vehicles and remotely operated vehicles. Additionally, the use of red light in underwater photography is discussed, along with two systems designed for fish counting in aquaculture and for monitoring marine fauna behaviour in laboratory settings.

The study in [13] reports on a measurement campaign focused on the elemental characterisation of historic metallic tools and structural elements used in the construction of the Dome of Santa Maria del Fiore in Florence (Italy). The analysed artifacts - such as turnbuckles, pulleys, lewises, and pincers - belong to the Opera di Santa Maria del Fiore collection and are displayed at the Museo dell'Opera del Duomo. This research is the first to examine their alloy composition. Additionally, metallic joints and rods within the Dome were analysed. X-Ray Fluorescence (XRF) was used to identify elemental makeup, and Principal Component Analysis (PCA) revealed compositional patterns. The findings offer valuable insights into Renaissance-era metallurgy and construction techniques, enhancing historical understanding of Brunelleschi's architectural masterpiece.

The study in [14] investigates the indirect estimation of systolic and diastolic blood pressure using electrocardiography and photoplethysmography signals acquired from the fingertip. Two distinct approaches for blood pressure calculation were

evaluated: one based on linear and non-linear models, and another utilising mathematical models to determine diastolic pressure through mean arterial pressure. The research was conducted using the MAX86150 Evaluation System, with algorithm development and analysis performed in MATLAB. Blood pressure calculations were applied to two patients of different ages, and the results were compared. Additionally, the study examined measurement uncertainty and the role of statistical methods in data validation. It was established that the expanded measurement uncertainty does not exceed ± 11.55 mmHg for systolic blood pressure and ± 7.84 mmHg for diastolic blood pressure at a 95 % confidence level, which complies with the clinical accuracy requirements of the British Hypertension Society and the Association for the Advancement of Medical Instrumentation (AAMI/ANSI/ISO 81060-2:2018). The results showed that the approach based on the mathematical model of mean diastolic pressure demonstrated higher accuracy of arterial pressure estimation.

The study in [15] presents a preliminary prototype of a sensor-based system for assessing cognitive status through finger force modulation. The system integrates strain-gauge load cells within a game-like interface, prompting users to apply and maintain specific force levels using their index finger. The resulting force-time profiles are analysed and compared to a template curve, using Dynamic Time Warping (DTW) and Partial Curve Mapping (PCM), generating a Similarity Index (SI) that quantifies task accuracy. A thresholding system classifies participants into cognitive status levels (High, Medium, Low). The sensing platform was calibrated using standard weights to ensure reliable force measurement. The prototype was tested on 24 participants (16 young adults and 8 seniors) and results showed that PCM outperforms DTW with the 80 % of young adults achieved a "High" cognitive status, while among seniors, 79 % were classified as "Medium" and 6 % as "Low". These findings confirm that age-related motor variability can reflect underlying cognitive differences. The proposed system demonstrates potential for non-invasive, remote cognitive assessment and supports future development of digital tools for aging populations and individuals diagnosed with Mild Cognitive Impairment (MCI) or dementia (PwD).

Urban growth has accelerated land use transformations, underscoring the need for accurate and scalable methods to monitor changes over time. The study in [16] presents a GeoAI-based methodology to classify and quantify urban fabric transformations over a 24-year period (2000–2024). The methodological framework is applied to the medium-sized municipality of Ravenna, in northern Italy, to evaluate its effectiveness. Landsat 5 and Landsat 9 multispectral images were classified into six Land Use and Land Cover categories using Random Forest (RF) and Support Vector Machine (SVM) algorithms within the Google Earth Engine platform. RF consistently outperformed SVM in both reference years, achieving overall accuracies of 83.8 % (2000) and 86.2 % (2024), with F1-scores exceeding 0.90 for key classes including built-up areas. McNemar's test confirmed the statistical significance of RF's performance advantage. Geospatial analysis revealed a 21.6% increase in built-up surfaces (+7.8 km²), a 28.6 % increase in grassland/shrubland (+50.4 km²), and a 66.3 % reduction in bareland (−35.0 km²). Urban Density (UD) increased from 4.49% to 5.73 %, indicating a moderate shift toward more compact urban growth. The results demonstrate the methodology's reliability and transferability, particularly in data-scarce contexts, and provide actionable insights for evidence-based urban planning and sustainable land management.

This collection of research papers addresses diverse scientific and engineering challenges aligned with the United Nations Sustainable Development Goals (SDGs), showcasing innovative solutions for a more sustainable and technologically advanced society. In [1] and [2], advancements in measurement traceability and uncertainty quantification (SDG 9: Industry, Innovation, and Infrastructure) underpin accuracy in scientific processes. Paper [3] enhances robotic control systems for improved efficiency (SDG 9), while [4] develops a real-time landslide monitoring system to mitigate natural hazards (SDG 11: Sustainable Cities and Communities). Calibration techniques for textile testing ovens in [5] support industrial standardization (SDG 12: Responsible Consumption and Production).

Environmental monitoring and renewable energy performance, vital for SDG 7 (Affordable and Clean Energy), are addressed in [6], which examines the impact of sand dust on photovoltaic systems. Digital transformation in agriculture through IoT and AR integration in [7] promotes SDG 2 (Zero Hunger) and SDG 9. Paper [8] focuses on electromagnetic interference control in electric vehicles, contributing to cleaner transport (SDG 11 and SDG 13: Climate Action). In [9], a non-invasive Human Activity Recognition system enhances indoor environmental quality and user well-being (SDG 3: Good Health and Well-being).

Paper [10] explores precision manufacturing using polarization imaging (SDG 9), while [11] enhances precision in ADC testing, which is foundational for reliable electronic systems used in industrial automation, telecommunications, and medical imaging (SDG 9). The work [12] highlights the ecological and technical advantages of red-light optical systems for underwater applications (SDG 14: Life Below Water). The historical materials study in [13] enriches cultural heritage preservation using modern analytics (SDG 11). Medical innovations are demonstrated in [14], where non-invasive blood pressure estimation aligns with SDG 3. In [15], a force-based cognitive assessment tool supports aging populations (SDG 3), and finally, [16] applies GeoAI to urban development monitoring for improved land management and resilience (SDG 11 and SDG 13)

Together, these works exemplify interdisciplinary contributions to sustainable development through digital innovation, health technologies, environmental stewardship, and urban planning and at the same time highlight the role of metrology as basis for sharing ideas and create wider cooperation among different research fields.

I hope you will enjoy your reading.

Francesco Lamonaca
Editor in Chief

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