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Editorial to selected papers from the 2019 IMEKO TC4 International Conference on Metrology for Archaeology and Cultural Heritage

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Section: Editorial

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Dear Reader,

This Issue of Acta IMEKO is dedicated to papers that have been selected from those presented at "2019 IMEKO TC4 International Conference on Metrology for Archaeology and Cultural Heritage", MetroArchaeo, held in Florence in December 2019.

Measurements are essential to access knowledge in every field of investigation, from industry to quality of life, science and innovation. As a consequence, metrology plays a crucial role for archaeology and cultural heritage, addressing issues related to the collection, interpretation and validation of the data, to the different physical, chemical, mechanical or electronic methodologies used to collect them and to the associated instruments.

MetroArchaeo brings together researchers and operators in the enhancement, characterization and preservation of archaeological and cultural heritage with the main objective of discussing production, interpretation and reliability of measurements and data. The conference is conceived to foster exchanges of ideas and information, create collaborative networks and update innovations on "measurements" suitable for cultural heritage for archaeologists, conservators and scientists.

Thirty-three selected papers from MetroArchaeo 2019 are presented in three Sections (Part 1, Part 2 and Part 3)

Part 1 – Section Editor: Eulalia Balestrieri

The first Section, edited by Eulalia Balestrieri, includes the following ten scientific contributions.

The first contribution, by Valentino Sangiorgio et al, "*Historical masonry churches diagnosis supported by an analytic-hierarchy-process-based decision support system*" presents a new procedure based on Analytical Hierarchy Processes (AHP) aimed at carrying out rapid on-site measurements and diagnostic of masonry churches through a series of condition assessment indexes. The proposed procedure has been successfully validated by a comparison with a standard diagnostic workflow.

In the second paper, by Sveva Longo et al, "*Clinical computed tomography and surface-enhanced Raman scattering characterisation of ancient pigments*", a systematic and complete chemical-physical characterisation of painted pigments has been carried out using Multi-Slice X-ray Computed Tomography (MSCT) and Surface-Enhanced Raman Scattering (SERS) techniques. Thanks to the proposed approach, the identification and characterization of both inorganic and organic materials present on the wooden tablets have been carried out.

The third contribution, by Simone Tiberti and Gabriele Milani, "*Creating a finite element mesh of non-periodic masonry from the measurement of its geometrical characteristics: a novel automated procedure*", illustrates an automated procedure for the generation of a finite element (FE) mesh directly from the rasterized sketch of a generic masonry element, which is particularly suitable for complex and irregular (non-periodic) masonry bonds that can be observed in heritage buildings or found in archaeological sites. Two procedures are set for the creation of 2D and 3D FE meshes.

In the fourth paper, by Laura Guidorzi et al, "*Age determination and authentication of ceramics: advancements in the thermoluminescence dating laboratory in Torino (Italy)*", the thermoluminescence (TL) laboratory developed at the Physics Department of the

University of Torino is presented. The laboratory was set up in collaboration with TecnArt S.r.l. and is also currently operating within the INFN (National Institute of Nuclear Physics) CHNet network. Some example of dating and authenticating results carried out at the laboratory on archaeological sites and artworks are also discussed and compared, when possible, with radiocarbon dating.

The fifth contribution, by Marialuisa Mongelli et al, "*Comparison and integration of techniques for the study and valorisation of the Corsini Throne in Corsini Gallery in Roma*", presents the investigation of an integrated approach involving non-invasive technologies, photogrammetry and structured light, during the development of the "WeACT3" Project (Acting Together - Technology for Art, Culture, Tourism and Territory) jointly signed by CIVITA Association and the National Barberini and Corsini Galleries. Such technologies have been used to build the 3D model of the Corsini Throne, preserved at the Corsini Gallery in Rome.

The sixth work, by Carmelo Scuro et al, "*study of an ancient earthquake-proof construction technique monitoring via an innovative structural health monitoring system*", illustrates an innovative method to monitor and obtain in real time the mechanical properties of an anti-seismic construction widespread in southern Calabria and patented by Pasquale Frezza, also minimizing measurement uncertainty. The considered type of anti-seismic construction consists of masonry walls built with bricks and fictile tubules, arranged in staggered and alternating manner, all contained in a timber wooden frame.

The seventh contribution, by Renato S. Olivito et al, "*Inventory and monitoring of historical cultural heritage buildings on a territorial scale: a preliminary study of structural health monitoring based on the CARTIS approach*", presents a preliminary study aimed at defining an integrated methodology for inventory, monitoring, transmission, and data management of heritage buildings to provide important information about their structural integrity.

The eighth paper, by Maria Federica Caso et al, "*Improvement of ENEA laser-induced fluorescence prototypes: an intercalibration between a hyperspectral and a multispectral scanning system*", presents the hyperspectral and multispectral Laser Induced Fluorescence (LIF) scanning systems developed at ENEA Diagnostic and Metrology Laboratory and in particular their intercalibration, along with the data analysis of calibration samples and a software to automatically correct imaging data.

In the ninth contribution, by Alejandro Roda-Buch et al, "*Fault detection and diagnosis of historical vehicle engines using acoustic emission techniques*", the results of the first phase of the ACUME_HV (Acoustic Emission Monitoring of Historical Vehicles) project focused on the development of a protocol for the use of acoustic emission (AE) during cold tests are presented. The project represents the first use of AE as non-invasive technique for the diagnostic of historical vehicles to carry out an objective, human-independent method.

The tenth and last contribution of this part 1, by Sandro Parrinello and Raffaella De Marco, "*Digital surveying and 3D modelling structural shape pipelines for instability monitoring in historical buildings: a strategy of versatile mesh models for ruined and endangered heritage*", illustrates the application of a fast and reliable structural documentation pipeline to Historical Built Heritage, as in the case study of the Church of the Annunciation in Pokcha (Russia), by reviewing the declination of integrated products of 3D survey into Reality-Based Models.

Part 2 – Section Editor: Carlo Carobbi

The second Section, edited by Carlo Carobbi, includes the following ten scientific contributions.

The first contribution, by Valeria Croce et al, "*From survey to semantic representation for cultural heritage: the 3D modelling of recurring architectural elements*", illustrates an approach to be followed in the transition from 3D survey information, derived from laser scanner and photogrammetric techniques, to the creation of semantically enriched 3D models. The proposed approach is based on the recognition -segmentation and classification- of elements on the original raw point cloud, and on the manual mapping of NURBS elements on it.

In the second work, by Francesco Boschin et al, "*Geometric morphometrics reveal relationship between cut-mark morphology and cutting tools*", two groups of slicing cut mark cross-sections were experimentally produced. The resulting sets of striae show different depths and different cross-sectional shapes. It turns out that the difference in shape between the two groups of striations is probably a function of the way in which the tool penetrated the bone.

The third contribution, by Gabriella Caroti et al, "*The use of image and laser scanner survey archives for cultural heritage 3D modelling and change analysis*", elaborates on the methodology used for integration of a metric 3-D model with information present in archive surveys of lost architectural volumes. The presented methodology frames historical plans, representing the survey object, in the reference system of UAV surveys for an open-source GIS environment.

In the fourth work, by Yufan Ding et al, "*Provenance study of the limestone used in the construction and restoration of the Batalha Monastery (Portugal)*", stone samples were investigated, through different methods (Energy-Dispersive X-ray Fluorescence Spectroscopy, Powder X-ray Diffractometry and Thermogravimetric Analysis) obtaining indication of the source of samples collected from different parts the monastery.

The fifth contribution, by Leila Es Sebar et al, "*Raman investigation of corrosion products on Roman copper-based artefacts*", illustrates a case study related to the characterization of corrosion products present on recently excavated artefacts. Results coming from Raman spectroscopy investigation can help in assessing the conservation state of the artefacts and defining the correct restoration strategy.

In the sixth work by Elisabetta Di Francia et al, "*Characterisation of corrosion products on copper-based artefacts: potential of MA-XRF measurements*", a novel portable MA-XRF scanner prototype has been tested on artificially corroded copper samples to assess its analytical capabilities on corroded metals and yielding information on the spatial distribution of the corrosion products grown on the metal's surface.

In the seventh contribution by Giuseppe Schirripa Spagnolo et al, "*Fringe-projection profilometry for recovering 2.5D shape of ancient coins*", a surface profile measurement system for small objects of cultural heritage, where it is important not only to detect the shape with good accuracy but also to capture and archive the signs due to ageing, is illustrated. The potentiality of the proposed scheme for recovering 2.5D shape of cultural heritage is demonstrated.

In the eighth contribution by Anna Maria Gueli et al, "*Modelling and simulations for signal loss evaluation during sampling phase for thermoluminescence authenticity tests*", the percentage of the intensity signal loss in thermoluminescence emission, due to local temperature increase caused by drilling, is investigated. The

optimal parameters that should be used during sampling phase are identified.

In the ninth work by Zacharias Vangelatos et al, "*Finite element analysis of the Parthenon marble block–steel clamp system response under acceleration*", finite element analysis is employed to provide a tool for the assessment of the conservation potential of the marble blocks, in parts of the monument that require specific attention. Simulation results highlight the importance of intrinsic stresses, the existence of which may lead to fracture of the marble blocks under otherwise harmless loading conditions.

In the tenth and last contribution of this part 2, by Andrea Zanobini, "*Metrological characterisation of a textile temperature sensor in archaeology*", the study of a new generation textile temperature sensor, in two different heated ovens to evaluate temperature and both temperature and humidity, is presented. The results show many metrological characteristics proving that the sensor is a Resistance Temperature Detector.

Part 3 – Section Editor: Ioan Tudosa

The third Section, edited by Ioan Tudosa, includes the following thirteen scientific contributions.

The first contribution, by Sebastiano D'Amico et al, "*A combined 3D surveying, XRF and Raman in-situ investigation of The Conversion of St Paul painting (Mdina, Malta) by Mattia Preti*", presents the results of three different approaches applied to the newly-restored titular painting The Conversion of St Paul, the main altarpiece in the Cathedral of Mdina in Malta. the study was aimed at showing the potentialities of the combined use of 2D/3D photogrammetric surveys and spectroscopy (XRF and Raman techniques) in order to, on one side, get reconstruction, and, on the other side, achieve, at different spatial domains.

In the second work, by Luisa Caneve et al, "*Non-invasive diagnostic investigation at the Bishop's Palace of Frascati: an integrated approach*", a novel methodology aimed to detect and locate materials due to previous restoration actions and to monitor the degradation processes evolution remotely, is proposed. The possibility of a preventive monitoring by the application of the presented approach to reduce the eventual induced damage has been put in light.

In the third contribution, by Sofia Ceccarelli et al, "*Thermographic and reflectographic imaging investigations on Baroque paintings preserved at the Chigi Palace in Ariccia*", two different mid-infrared imaging techniques, operating in the 3-5 μm spectral range, are applied to the study of three paintings on canvas, dating back to the XVII century, preserved at the Chigi Palace in Ariccia (Italy). Presented results allow the evaluation of the conservative status of the support and the detection of graphical and pictorial features hidden beneath the surface layer.

In the fourth work, by Daniele Moro et al, "*Mineral diagnostics: SEM-EDS Monte Carlo strategy for optimised measurements of ultrathin fragments in cultural heritage studies*", a detailed study of the effects related to micro- and nanometric sizes of glass and gold alloys fragments on SEM-EDS microanalysis is presented. Monte Carlo simulations of different kind of elongated glass fragments with square section, from 0.1 to 10 μm thick, and of some gold alloys showed a strong influence of the fragment sizes and operational conditions (beam energy, detector position, etc.). This work can be used to devise the appropriate and optimized measurement strategy.

The fifth contribution, by Luisa Spairani, "*Measure by measure, they touched heaven*", illustrates a case study in photography of the law of Leavitt.

In the sixth work by Giacomo Fiocco et al, "*Chemometrics tools for investigating complex synchrotron radiation FTIR micro-spectra: focus on historical bowed musical instruments*", a method describing how the Synchrotron Radiation (SR) micro-FTIR spectroscopy in reflection geometry and chemometrics were combined to investigate six cross-sectioned micro-samples detached from four bowed string instruments, is presented.

In the seventh contribution by M. Faifer et al, "*Laboratory measurement system for pre-corroded sensors devoted to metallic artwork monitoring*", a measurement system for the development and testing of sensor for atmospheric corrosivity monitoring is presented. The developed system allows to monitor metal corrosion higher than 3 nm in the temperature range from 23 °C to 39 °C. The performed analysis allows to state that the system is an efficient laboratory setup for the development and characterization of sensor for metal corrosion monitoring.

The eighth contribution by Maria Legut-Pintal et al, "*Methodological issues of metrological analysis of planned medieval towns and villages*", proposes the usage of cosine quantogram, which has rarely been used to study of urban layout, for the identification of units of measurement in medieval regular towns.

In the ninth work by Roberta Spallone et al, "*Digital strategies for the valorisation of archival heritage*", a study that aims at creating a sort of digital model-museum, in which to insert all the historical information useful to tell the story of the evolution of the artefact over time, and allowing users, through the use of personal devices, to live interactive and immersive experiences, through Virtual and Augmented Reality, is presented.

In the tenth paper by Tilde de Caro et al, "*Application of μ-Raman spectroscopy to the study of the corrosion products of archaeological coins*", a study case of the corrosion products formed on archaeological bronze artefacts excavated in Tharros (Sardinia, Italy) is presented. The experimental findings allow to acquire, through micro-Raman spectroscopy, a better knowledge on the environmental factors that may cause the degradation of archaeological bronzes in soil.

The eleventh contribution, by Leila Es Sebar et al, "*In-situ multi-analytical study of ongoing corrosion processes on bronze artworks exposed outdoors*", presents a long-term in-situ monitoring campaign of contemporary bronze statuary exposed outdoor. The Authors demonstrate the importance of the use of portable instruments offering the possibility to perform in situ measurements, thus avoiding any sampling and assessing of the degradation of the material directly in contact with the environment to which the artwork is always exposed to.

The twelfth contribution by Máté Sepsi et al, "*Non-destructive pole-figure measurements on workshop-made silver reference models of archaic objects*", reports the non-destructive pole figure method as a sufficient way to distinguish between metal objects formed in different ways. The specific forming modes result in specific pole figures, and therefore, by producing and examining a sufficient number of reference materials, the mode of production of archaic objects can also be reconstructed. The Authors state that the obtained pole figures by the robot diffractometer are completely identical to the figures of the previously validated G3R diffractometer.

The thirteenth and last contribution of this part 3, by Maria Grazia D'Urso, "*A combination of terrestrial laser-scanning point clouds*

and the thrust network analysis approach for structural modelling of masonry vaults", presents how the geometric and geo-referenced 3D models are obtained by processing laser-scanning measurements. A model built on a coherent geometric basis, which contemplates the methodological complexities of the detected objects is reported. A semi-automated method that allows one to switch from point cloud to an advanced three-dimensional model, able to contain all the geometrical and mechanical characteristics of the built object, is proposed in the paper.

It was a great honour for us to act as Guest Editors for this issue of Acta IMEKO, a high-profile scientific journal devoted to the enhancement of academic activities of IMEKO and a wider dissemination of scientific output from IMEKO TC events. We would like to sincerely thank all the authors for their valuable contributions, and we hope the readers will be inspired by the themes and proposals that have been selected and included in this Special Section related to innovations in metrology for archaeological and cultural heritage.

Eulalia Balestrieri, Carlo Carobbi, Ioan Tudosa
Guest Editors