Surveys in Geophysics (2018) 39:1035–1038
https://doi.org/10.1007/s10712-018-9500-4

New Perspectives on Geophysics for Archaeology: A Special Issue

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Received: 30 August 2018 / Accepted: 10 September 2018 / Published online: 22 September 2018

This Special Issue hosts a selection of papers presented at the Third International Conference on Metrology for Archaeology and Cultural Heritage (Lecce, Italy, 23–25 October 2017), related to the new perspectives on geophysics for archaeology. In recent years, archaeological prospecting has seen major advances through a variety of remote sensing and computing technologies. Geophysical instrumentation continues to improve in sensitivity and acquisition speed, and new multi-sensor arrays, e.g., drawn by carts over land, now permit vast areas to be rapidly covered. On the other hand, the availability of high-resolution remote sensing techniques provides multiscale and multi-temporal approaches to the study of ancient settlements and landscapes, and proves fundamental in the reconstruction of their development over centuries. Nowadays, research in landscape archaeology needs the integration of different high-resolution remote sensing techniques such as satellite (optical and radar data), aerial (photographic, infrared and lidar data from aircraft and unmanned aerial vehicles), but also land acquisitions (integration of different geophysical techniques, field walking, and differential GPS topographical surveys). All these investigations are based on a geoarchaeological approach, with several aims ranging from historical reconstruction to preventive archaeology and from the preservation of archaeological and monumental heritage to noninvasive diagnosis through micro-geophysical techniques.

Several geophysical methods have often been applied successfully for archaeological purposes. Among them, the most frequently used are certainly ground penetrating radar (GPR) (Leucci et al. 2016), magnetic (Eppelbaum et al. 2001), electrical resistivity

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tomography (ERT) (Griffiths and Barker 1994; Fiandaca et al. 2010), induced polarization (IP) (Slater et al. 2000), and self-potential (SP) (Drahor 2004). In recent years, much attention has also been given to the integration of different geophysical techniques in order to limit the equivalence uncertainties of individual inverse models, in order to obtain a more robust interpretation for a combined characterization of archaeological constructions and artefacts (Capizzi et al. 2007; Leucci et al. 2014; Malfitana et al. 2015). In many cases, instrumentation and acquisition techniques have been adapted for indoor (Capizzi et al. 2012) and/or small surface applications (Cosentino et al. 2009, 2011). Furthermore, interdisciplinary studies, understood as collaborations between the humanities and scientific disciplines, are extremely useful for the investigation of archaeological sites, with a growing interest in broadening their usage in the understanding of past landscapes (Bottari et al. 2017; De Giorgi and Leucci 2017).

The 16 papers published in this Special Issue and briefly presented below are focused on the application of different surface remote sensing techniques. They introduce novel instrumentation and new data processing approaches oriented towards cultural heritage conservation and, in particular, to archaeological target characterization.

The increasing use of ground penetrating radar (GPR) is discussed by Gizzi and Leucci, by means of a statistical comparison of the most authoritative bibliographic databases, identifying the main fields of application, that are essentially physical–mathematical, sedimentological–stratigraphical, civil engineering/engineering geology/cultural heritage, hydrological, and glaciological. Persico et al. propose a strategy, called “shifting zoom”, that allows them to mitigate the effects of the limited view angle in the linear tomographic inversion applied on GPR data. The integrated use of electrical resistivity tomography (ERT) and ground penetrating radar (GPR) measurements, and in particular the joint analysis of 2D and 3D data, can represent a valid solution for target identification at complex archaeological sites. An example is presented by Deiana et al.; this shows how the joint analysis of 2D data in a 3D view can help in the difficult interpretation of the spatial distribution of buried archaeological remains.

Different approaches of indoor geophysics for monumental heritage are proposed. Casas et al. discuss an exemplary case of indoor geophysics for archaeological investigation, in which special devices and electrodes are used to investigate the subsoil of the Cathedral of Tarragona using 2D and 3D electrical resistivity tomography and ground penetrating radar, thus avoiding damage to the floor. In particular, in this case study, a specific 3D array is designed to minimize the current injection. Fontul et al. show that GPR, when combined with other nondestructive tests (NDTs), can make a valuable contribution to the evaluation of floor and geometry materials in historic buildings, when it is not possible to carry out visual inspections. In the São Carlos Theater in Lisbon, the shape and position of the beams are identified, distinguishing between wooden beams and metal beams. The results of the GPR have allowed the ideal positions for subsequent drilling tests for further investigations to be identified.

The monitoring and analysis of the conservation status of frescoes is addressed by Danese et al. They propose a protocol based on spatial analysis for the interpretation of data coming from the application of noninvasive techniques such as structure-from-motion (SfM) photogrammetry, ground penetrating radar and multi-temporal infrared thermography. The protocol is tested on frescoes of the Gymnasium in Pompeii.

Urban areas are a difficult context for archaeo-geophysics. Lazzari et al. propose a procedure related to GPR prospecting performed in the Roman archaeological site of Aquinum (central Italy). The use of geophysical methods in metrology is a significant tool within the wide research topic of landscape archaeology context. Scudero et al. discuss an integrated geophysical approach (including ground magnetic and GPR measurements) linked to photographic and thermographic surveys carried out using an unmanned aerial vehicle (UAV). The results derived from the different geophysical techniques proposed here have been combined by means of a cluster analysis, allowing the authors to identify a series of buried archaeological features.

The integration of geophysical data with an archaeological infra-site analysis is proposed by Rizzo et al. The overlap between archaeological datasets and geophysical surveys leads to investigations of the area of Masseria Grasso (Campania region, Italy). This approach can be used in general for studies at other archaeological sites. Starting from an integrated geophysical approach to study the necropolis of Porta Nocera in Pompeii using ground penetrating radar (GPR), self-potential (SP) and electrical resistivity tomography (ERT), Malfitana et al. propose a 3D model of the necropolis, combining laser scanning with surface land and aerial ortho-photogrammetry data, thus offering a very useful dataset for a possible intervention of restoration in this area.

The use of geophysics for archaeological prospection only started at the end of the first decade of the 2000s in Southern America. In the paper by Masini et al., a brief overview is given, and preliminary results obtained from the investigations conducted in Chachabamba (Peru) are shown. The results demonstrate the effectiveness of the applied methods used in the complex geological conditions of the surveyed site. Bottari et al. apply different geophysical techniques for archaeo-seismological studies. The hypothesis of the existence of a fault zone that caused co-seismic damage at an archaeological site is supported by the results from electrical resistivity tomography, seismic refraction tomography, ground penetrating radar, and magnetic surveys. A geophysical method with great potential in archaeology, but not yet in widespread use, is the multi-frequency electromagnetic induction (EMI) discussed by Tang et al. This method, tested on archaeological remains and tombs, proves capable of identifying shallow subsurface relics by getting information about both their electrical conductivity and magnetic susceptibility.

Lasaponara et al. present the state of the art in the use of declassified Corona satellite images for detecting ancient hidden cultural relics that may be completely lost in the modern landscape, being veiled by current land uses and land covers. Adopting a geospatial analysis, the authors propose how to extract and map the subtle archaeological features and cultural landscape using historical archives of Corona satellite and aerial photographs. In another paper, Lasaponara and Masini propose an automated Archaeological Looting Feature Extraction Approach (ALFEA) in desert areas for the identification and quantification of disturbances at archaeological sites, as an alternative to the usual approach based on visual inspection of optical aerial or satellite images. These techniques are applied on free of charge images, such as those available from Google Earth. The authors also show the results from two test sites in Syria and Peru that demonstrate the effectiveness of this approach. Elfadaly et al. discuss remote sensing technologies for sustainable management and exploitation policies as well as suitable conservation and mitigation strategies that are mandatory to preserve cultural heritage, to reduce threats, weathering phenomena, and human actions that may produce significant deterioration and alteration of the cultural heritage and “its environment”. The new approach is applied in the archaeological Theban area (Egypt).

We believe that the research papers presented here will be interesting for readers coming from different disciplines in the field of the cultural heritage sciences, thus attracting new contributors to the important topics of archaeological target recognition, cultural heritage monitoring and diagnostics. Our thanks go to all authors for their presentations and fruitful

discussions at the conference and for preparing the papers in this Special Issue, and to the Editor in Chief, Michael Rycroft, for his assistance in its publication.

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