Archaeology, historical site risk assessment and monitoring by UAV: approaches and case studies

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Non-invasive methods for archaeological research, like geophysical prospecting, aerial and satellite remote sensing, integrated with field survey activity, can make a large quantity of data essential for both operational uses and scientific purposes: from the detection of buried remains to risk assessment and monitoring (Lasaponara & Masini 2012; 2013; Lasaponara et al. 2016). Among the latest non-invasive methods there are the unmanned air vehicle (UAV) platforms, a real innovation, which proved to be capable for a variety of fields of applications, from the topographic survey to the monitoring of infrastructures. In the field of cultural heritage, for purposes ranging from the documentation to the detection of archaeological features, the use of UAVs is extremely functional, efficient and low-cost. Moreover, UAV flight requires much less time than that required by an Aircraft. A traditional aircraft must take off from an airport, sometimes far from the work area, while a drone, particularly rotary wing, can be transported in the area of interest and take off directly from there in a few minutes. The reason of the success of UAV are also the innovative vision, the very high-resolution of the obtainable products (orthophoto, digital elevations models) and the availability of easy tools of image processing based on Structure from Motion (SfM). (Neitzel & Klonowski 2011; Nex & Remondino 2013). SfM is a range imaging technique which allows to estimate three-dimensional objects from two-dimensional image sequences which may be coupled with local motion signals. Respect to conventional photogrammetry which requires a single stereo-pair, SfM needs multiple, overlapping photographs as input to feature extraction and 3-D reconstruction algorithms. In SfM the geometry of the scene, camera positions and orientation are solved simultaneously using a highly redundant, iterative bundle adjustment procedure, based on a database of features automatically extracted from a set of multiple overlapping images. The usefulness of UAV-based investigations has been given by its integrability with other methods of remote sensing including geophysics, optical and SAR satellite remote sensing. The presentation deals with the methodological approaches and the results in three historical sites for different applications such as: 1) archaeological site discovery, 2) the study and observation of archaeological looting and 3) the 3d reconstruction of building and sites.

In the case 1) UAV has been used for the creation of orthophotos and digital elevation models (DEMs) as well as the identification of archaeological marks and microrelief, as proxy indicators of the presence of archaeological buried remains. The obtained information have been compared and integrated with those provided by georadar and geomagnetic prospections. The investigated site is a medieval settlement, including a benedectine monastery, dated to 12-15th century. It is San Pietro a Cellaria, located in the territory of Calvello, in Basilicata (Southern Italy). The multisensor integrated approach allowed to identify several features referable to buried structures of the monastery (Leucci et al. 2015; Roubis et al. 2015). In the case 2) UAVs have been used for the identification and analysis of traces of grave robbers, in the territory of Anzi (Basilicata). Since the end of the 18th century to the first half of the 20th century, hundreds of tombs of the Archaic, Lucan and Roman age have been destroyed and stolen. The case 3) is related to the ceremonial centre of Pachacamac in Peru, which was investigated for several years by the international mission ITACA (Italian scientific mission for heritage Conservation and Archaeogeophysics) of IBAM/IMAA CNR of Potenza (Italy) (Lasaponara et al. 2016b). For more than 2,000 years, Pachacamac was one of the main centers of religious cult keeping this role unchanged in different historical periods and for different cultures such as Chavin, Lima, Huari, Ychma and Inca. A test site has been selected to assess the capability of SAR satellite data for the identification of earthen archaeological features. UAV surveys have been performed to provide a very detail DEM enabling us to analyze and interpret the radar signal backscattering behaviour of archaeological microrelief and structures. In all the three applications UAV proved to be an effective, user-friendly, less time consuming, flexible tool for a number of applications and aims ranging from from the site detection to the risk evaluation of archaeological interest areas.

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