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Integration of infrared thermography and high-frequency electromagnetic methods in archaeological surveys

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An integration of high-resolution non-destructive techniques is presented for the inspection and evaluation of ancient architectonic structures.
Infrared thermography (IRT) represents a valuable tool for nondestructive evaluation of architectonic structures and artworks because it is capable of giving indications about most of the degradation sources of artworks and buildings of both historical interest and civil use. In particular, it is possible to detect cracks, disbondings, alteration of material consistency, etc. Indeed, by choosing the most adequate thermographic technique, it is possible to monitor the conservation state of artworks in time and to detect the presence of many types of defects (e.g., voids, cracks, disbondings, etc.) in different types of materials (e.g., concrete, masonry structures, bronze, etc.). The main advantages of infrared thermography when dealing with precious artworks may be summarized with three words: non-contact, non-invasive, and two-dimensionality. It is possible to inspect either a large surface such as the facade of a palace, or a very small surface of only few square millimetres. Conversely, the inspection depth is quite small; generally, of the order of centimetres. However, as demonstrated in previous work, IRT well matches with electric-and electromagnetic-type geophysical methods to characterize the overlapping zone from low-to-high depth in masonry structures. In particular, the use of high-frequency electromagnetic techniques, such as the ground penetrating radar (GPR), permits to reach investigation depths of some ten of centimetres by choosing appropriate frequencies of the transmitted electromagnetic signal. In the last decade a large utilisation of the GPR methodology to non-destructive analysis of engineering and architectural materials and structures has been experienced. This includes diverse features, such as definition of layer thickness, characterisation of different constructive materials, identification of voids and/or degraded zones, water content mapping, location of reinforcing bars and metal elements in concrete structures.
The attention of this work is focused on the integration of both techniques for inspection of architectonic structures. First, an integration of techniques is performed in laboratory by considering an ad hoc specimen with insertion of anomalies. Then, the techniques are used for the inspection in situ of some important Italian archaeological sites, such as Pompei (Naples) and Nora (Cagliari). In the first site, the exploration is devoted to the analysis of wall decoration of the architectonical complex of Villa Imperiale with the aim to support the hypothesis that attributes the Villa to Imperial property as well as to evaluate the state of conservation of frescoes and underneath structure. As main findings, the applied techniques allows for detection of hidden previous decorative layers and for discrimination of different types of paint used as well as for identification of areas damaged by ingression in-depth of moisture and/or by disaggregation of the constituent materials. In the archaeological area of Nora, instead, the prospecting is devised to the evaluation of the state of degradation of two significant buildings of the ancient site: the temple and the theatre. Due to the very high horizontal and vertical resolution of the performed surveys, detailed physical anomaly maps of the investigated structures are obtained. Large portions of the masonry walls appear interested by decomposition of the mortar binding the stone blocks, which sometimes propagates along the whole stone wall. The information coming from a joint interpretation of IRT and GPR data allows detailed 3D images of the two investigated buildings, which are useful for future restoration planning.