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Material characterization via in-situ GPR survey

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Ground Penetrating Radar (GPR) represents a feasible and friendly tool to gain information about the presence, location and geometry of targets embedded in opaque media. This is due to its advantages in terms of portability, easiness of use, fastness of the survey (it is possible to perform measurements over large areas in reduced time) and flexibility of employ. In this framework, it is largely employed in cultural heritage diagnostics with the aim of detecting hidden objects that can be representative of defects, voids or indicative of the constructive typology of the heritages. Despite of the widespread exploitation of the GPR as data acquisition system, the use of GPR reveals of limited usefulness in the case of complex scenarios as the case of masonries where the absence of any a priori information about them make difficult to obtain images reliable and easily interpretable by the end-users.

Therefore, in order to gain information useful for a cultural heritage stakeholder, novel data processing approaches based on inverse scattering have been recently developed [1] These approaches are based on accurate electromagnetic scattering models and thanks to them, it is possible to gain accurate and reliable "images" of the investigated structure in order to detect, localize and possibly determine the extent and the geometrical features of the embedded objects.

A crucial step to build up reliable inverse scattering models concerns with the determination of the background scenario with respect to the "defects" have to be detected and localised. From the electromagnetic point of view, it is necessary to have the maximum available information about the geometry of the structure (this can be also performed by historical sources) and about the materials employed in the construction of the structure. In fact, the knowledge of the materials permits to have an estimate of the electromagnetic properties of the materials that is necessary to build up reliable inverse scattering model.

This knowledge can be achieved in two ways. The first one entails the measures on samples in laboratory experiments, for example via free-space configurations [2].However, it is not always to perform this kind of measurements, since the availability of the sample entails the necessity of an intrusive action on the structure and also the "environmental" conditions can change from the structure to the laboratory thus changing the materials properties (water content).
To overcome this difficulty, here we present a novel strategy based on in situ measurements, which is based on an electromagnetic model of the reflection/refraction at the structure/air interface and exploits the more advanced concepts of the inverse problems [3].
The other topic of the work regards the effect of the inaccurate knowledge of the electromagnetic properties on the retrieved image under the multimonostatic configuration, which is the simpler and more used in GPR survey. Some numerical examples with synthetic and experimental data will be presented.

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[3] R. Solimene, G. Prisco, and F. Soldovieri, “GPR based soil electromagnetic parameters determination for subsurface imaging”, Advances in Geosciences, Geophysical monitoring of the near-surface by electromagnetic and other geophysical methods, vol. 19, pp. 39-44 , Nov. 2008.