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Microwave tomography for GPR data processing in archaeology and cultural heritages diagnostics

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Ground Penetrating Radar (GPR) is one of the most feasible and friendly instrumentation to detect buried remains and perform diagnostics of archaeological structures with the aim of detecting hidden objects (defects, voids, constructive typology; etc..). In fact, GPR technique allows to perform measurements over large areas in a very fast way thanks to a portable instrumentation.

Despite of the widespread exploitation of the GPR as data acquisition system, many difficulties arise in processing GPR data so to obtain images reliable and easily interpretable by the end-users. This difficulty is exacerbated when no a priori information is available as for example arises in the case of historical heritages for which the knowledge of the constructive modalities and materials of the structure might be completely missed.

A possible answer to the above cited difficulties resides in the development and the exploitation of microwave tomography algorithms [1, 2], based on more refined electromagnetic scattering model with respect to the ones usually adopted in the classic radaristic approach.

By exploitation of the microwave tomographic approach, 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.

In this framework, the adoption of simplified models of the electromagnetic scattering appears very convenient for practical and theoretical reasons. First, the linear inversion algorithms are numerically efficient thus allowing to investigate domains large in terms of the probing wavelength in a quasi real- time also in the case of 3D case also by adopting schemes based on the combination of 2D reconstruction [3]. In addition, the solution approaches are very robust against the uncertainties in the parameters of the measurement configuration and on the investigated scenario.

From a theoretical point of view, the linear models allow further advantages such as: the absence of the false solutions (a question to be arisen in non linear inverse problems); the exploitation of well known regularization tools for achieving a stable solution of the problem; the possibility to analyze the reconstruction performances of the algorithm once the measurement configuration and the properties of the host medium are known.

Here, we will present the main features and the reconstruction results of a linear inversion algorithm based on the Born approximation in realistic applications in archaeology and cultural heritage diagnostics. Born model is useful when penetrable objects are under investigations. As well known, the Born Approximation is used to solve the forward problem, that is the determination of the scattered field from a known object under the hypothesis of weak scatterer, i.e. an object whose dielectric permittivity is slightly different from the one of the host medium and whose extent is small in term of probing wavelength. Differently, for the inverse scattering problem, the above hypotheses can be relaxed at the cost to renounce to a "quantitative reconstruction" of the object. In fact, as already shown by results in realistic conditions [4, 5], the adoption of a Born model inversion scheme allows to detect, to localize and to determine the geometry of the object also in the case of not weak scattering objects.

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