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Development of SAP-DoA techniques for GPR data processing within COST Action TU1208

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This work focuses on the use of Sub-Array Processing (SAP) and Direction of Arrival (DoA) approaches for the processing of Ground-Penetrating Radar data, with the purpose of locating metal scatterers embedded in concrete or buried in the ground. Research activities have been carried out during two Short-Term Scientific Missions (STSMs) funded by the COST (European COoperation in Science and Technology) Action TU1208 "Civil Engineering Applications of Ground Penetrating Radar" in May 2015 and January 2016.

In applications involving smart antennas and in the presence of several transmitters operating simultaneously, it is important for a receiving array to be able to estimate the Direction of Arrival (DoA) of the incoming signals, in order to decipher how many emitters are present and predict their positions. A number of methods have been devised for DoA estimation: the MUltiple SIgnal Classification (MUSIC) and Estimation of Signal Parameters via Rotational Invariance Technique (ESPRIT) are amongst the most popular ones [1]. In the scenario considered by us, the electromagnetic sources are the currents induced on metal elements embedded in concrete or buried in the ground. GPR radargrams are processed, to estimate the DoAs of the electric field back-scattered by the sought targets. In order to work in near-field conditions, a sub-array processing (SAP) approach is adopted: the radargram is partitioned in sub-radargrams composed of few A-scans each, the dominant DoA is predicted for each sub-radargram. The estimated angles are triangulated, obtaining a set of crossings with intersections condensed around object locations. This pattern is filtered, in order to remove a noisy background of unwanted crossings, and is processed by applying the statistical procedure described in [2].

We tested our approach on synthetic GPR radargrams, obtained by using the freeware simulator gprMax implementing the Finite-Difference Time-Domain method [3]. In particular, we worked with the reference data of TU1208 Concrete Cells 1.1-1.3 [4]. Preliminary results and a description of the method have been presented in [5]. Further results have been obtained by processing radargrams obtained in the presence of modified versions of the TU1208 Concrete Cells, where we changed the positions of the reinforcing elements. As expected, we achieved better results when the distance between the scatterers was larger and their interaction weaker. By analysing in depth the results obtained for the enlarged versions of Cells 1.1-1.3, we could assess in a comprehensive way the accuracy and limits of our approach in the presence of multiple scatterers, versus their relative distance.

During future STSMs, we look forward to testing our approach on experimental data. We also plan to improve the method, in order to exploit in a more advanced way the multi-frequency information enclosed in the GPR data. A final STSM will be devoted to implementing a graphical-user interface and writing a user manual, as we intend to release our codes for free public download by the end of the Action.

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