Geophysical Research Abstracts
Vol. 15, EGU2013-13941, 2013
EGU General Assembly 2013

Civil Engineering Applications of Ground Penetrating Radar: Research Perspectives in COST Action TU1208

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Ground Penetrating Radar (GPR) is a safe, non-destructive and non-invasive imaging technique that can be effectively used for advanced inspection of composite structures and for diagnostics affecting the whole life-cycle of civil engineering works.
GPR provides high resolution images of structures and subsurface through wide-band electromagnetic waves. It can be employed for the surveying of roads, pavements, bridges, tunnels, for detecting underground cavities and voids, for utility sensing, for the inspection of buildings, reinforced concrete and pre-cast concrete structures, for geotechnical investigation, in foundation design, as well as for several other purposes.
Penetration and resolution of GPR depend primarily on the transmitting frequency of the equipment, the antenna characteristics, the electrical properties of the ground or of the surveyed material, and the contrasting electrical properties of the targets with respect to the surrounding medium. Generally there is a direct relationship between the transmitter frequency and the resolution that can be obtained; conversely there is an inverse relationship between frequency and penetration depth. GPR works best in dry ground environments, but can also give good results in wet, saturated materials; it does not work well in saline conditions, in high-conductivity media and through dense clays which limit signal penetration.
Different approaches can be employed in the processing of collected GPR data. Once data have been processed, they still have to be analysed. This is a challenging problem, since interpretation of GPR radargrams is typically non-intuitive and considerable expertise is needed. In the presence of a complex scenario, an accurate electromagnetic forward solver is a fundamental tool for the validation of data interpretation. It can be employed for the characterization of scenarios, as a preliminary step that precedes a survey, or to gain a posteriori a better understanding of measured data. It can be used by GPR operators to identify the signatures generated by uncommon targets or by composite structures. Repeated evaluations of the electromagnetic field scattered by known targets can be performed by a forward solver, in order to estimate – through comparison with measured data – the physics and geometry of the region investigated by the GPR.
It is possible to identify three main areas, in the GPR field, that have to be addressed in order to promote the use of this technology in the civil engineering. These are: a) increase of the system sensitivity to enable the usability in a wider range of conditions; b) research novel data processing algorithms/analysis tools for the interpretation of GPR results; c) contribute to the development of new standards and guidelines and to training of end users, that will also help to increase the awareness of operators.
In this framework, the COST Action TU1208 "Civil Engineering Applications of Ground Penetrating Radar", proposed by Lara Pajewski, "Roma Tre" University, Rome, Italy, has been approved in November 2012 and is going to start in April 2013. It is a 4-years ambitious project already involving 17 European Countries (AT, BE, CH, CZ, DE, EL, ES, FI, FR, HR, IT, NL, NO, PL, PT, TR, UK), as well as Australia and U.S.A. The project will be developed within the frame of a unique approach based on the integrated contribution of University researchers, software developers, geophysics experts, Non-Destructive Testing equipment designers and producers, end users from private companies and public agencies.
The main objective of the COST Action TU1208 is to exchange and increase scientific-technical knowledge and experience of GPR techniques in civil engineering, whilst promoting the effective use of this safe and non-destructive technique in the monitoring of systems. In this interdisciplinary Action, advantages and limitations of GPR will be highlighted, leading to the identification of gaps in knowledge and technology. Protocols and guidelines for European Standards will be developed, for an effective application of GPR in civil engineering. A novel GPR will be designed and realized: a multi-static system, with dedicated software and calibration procedures, able to construct real-time lane three-dimensional high resolution images of investigated areas. Advanced electromagnetic-scattering and data-processing techniques will be developed. The understanding of relationships between geophysical parameters and civil-engineering needs will be improved. Freeware software

will be released, for inspection and monitoring of structures and infrastructures, buried-object localization, shape reconstruction and estimation of useful parameters. A high level training program will be organized. Mobility of early career researchers will be encouraged.
The scientific work-plan of the Action is open, to ensure that experts all over the world, who did not participate in the preparation of the proposal but are interested in the project, may join the Action and participate in its activities. More information about the project can be found at http://www.cost.eu/domains_actions/tud/Actions/TU1208.