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COST Action TU1208 – Working Group 3 – Electromagnetic modelling, inversion, imaging and data-processing techniques for Ground Penetrating Radar

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This work aims at presenting the main results achieved by Working Group (WG) 3 “Electromagnetic methods for near-field scattering problems by buried structures; data processing techniques” of the COST (European COoperation in Science and Technology) Action TU1208 “Civil Engineering Applications of Ground Penetrating Radar” (www.GPRadar.eu, www.cost.eu).

The main objective of the Action, started in April 2013 and ending in October 2017, is to exchange and increase scientific-technical knowledge and experience of Ground Penetrating Radar (GPR) techniques in civil engineering, whilst promoting in Europe the effective use of this safe non-destructive technique. The Action involves more than 150 Institutions from 28 COST Countries, a Cooperating State, 6 Near Neighbour Countries and 6 International Partner Countries.

Among the most interesting achievements of WG3, we wish to mention the following ones:

(i) A new open-source version of the finite-difference time-domain simulator gprMax was developed and released. The new gprMax is written in Python and includes many advanced features such as anisotropic and dispersive-material modelling, building of realistic heterogeneous objects with rough surfaces, built-in libraries of antenna models, optimisation of parameters based on Taguchi’s method – and more.

(ii) A new freeware CAD was developed and released, for the construction of two-dimensional gprMax models. This tool also includes scripts easing the execution of gprMax on multi-core machines or network of computers and scripts for a basic plotting of gprMax results.

(iii) A series of interesting freeware codes were developed will be released by the end of the Action, implementing differential and integral forward-scattering methods, for the solution of simple electromagnetic problems by buried objects.

(iv) An open database of synthetic and experimental GPR radargrams was created, in cooperation with WG2. The idea behind this initiative is to give researchers the opportunity of testing and validating, against reliable data, their electromagnetic-modelling, inversion, imaging and processing algorithms. One of the most interesting dataset comes from the IFSTTAR Geophysical Test Site, in Nantes (France): this is an open-air laboratory including a large and deep area, filled with various materials arranged in horizontal compacted slices, separated by vertical interfaces and water-tighted in surface; several objects as pipes, polystyrene hollows, boulders and masonry are embedded in the field. Data were collected by using nine different GPR systems and at different frequencies ranging from 200 MHz to 1 GHz. Moreover, some sections of this test site were modelled by using gprMax and the commercial software CST Microwave Studio. Hence, both experimental and synthetic data are available. Further interesting datasets were collected on roads, bridges, concrete cells, columns – and more.

(v) WG3 contributed to the TU1208 Education Pack, an open educational package conceived to teach GPR in University courses.

(vi) WG3 was very active in offering training activities. The following courses were successfully organised: Training School (TS) “Microwave Imaging and Diagnostics” (in cooperation with the European School of Antennas; 1st edition: Madonna di Campiglio, Italy, March 2014, 2nd edition: Taormina, Italy, October 2016); TS “Numerical modelling of Ground Penetrating Radar using gprMax” (Thessaloniki, Greece, November 2015); TS “Electromagnetic Modelling Techniques for Ground Penetrating Radar” (Split, Croatia, November 2016). Moreover, WG3 organized a workshop on “Electromagnetic modelling with the Finite-Difference Time-Domain technique” (Nantes, France, February 2014) and a workshop on "Electromagnetic modelling and inversion techniques for GPR” (Davos, Switzerland, April 2016) within the 2016 European Conference on Antennas and Propagation (EuCAP).

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