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Modelling commercial GPR antennas for the detection of structural features in concrete

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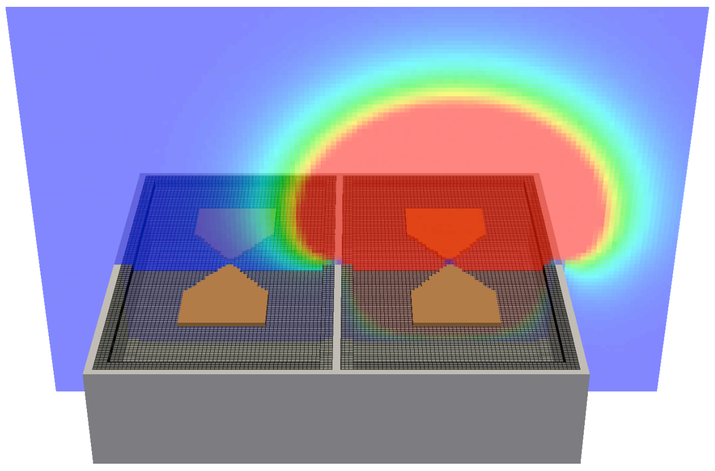
Background and Motivation

- Ground-Penetrating Radar (GPR) is used for a wide range of different applications in engineering and geophysics
- Interpretation of GPR data is still largely experience-based, recognising specific patterns and associating them with specific features
- Evaluation of concrete typically involves the location and identification of features such as *reinforcement, ducts, pipes, voids, and cracking*
- Responses from these types of target have a fast arrival times and are often lost in the direct wave between transmitter and receiver
- Therefore to make a direct comparison between modelled and real data, a model must include a description of the real GPR antenna



GSSI 1.5GHZ ANTENNA MODEL GEOMETRY

Modelled features:

- Shielding and enclosure
- Microwave foam absorber
- Transmitter & receiver bowties
- Printed circuit board
- Polypropylene case
- HDPE skid plate

INVESTIGATING RING SEPARATION IN MASONRY ARCHES

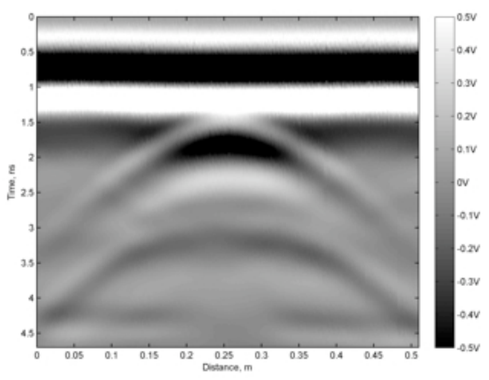
LOCATING REBARS IN CONCRETE

Aim and Objectives

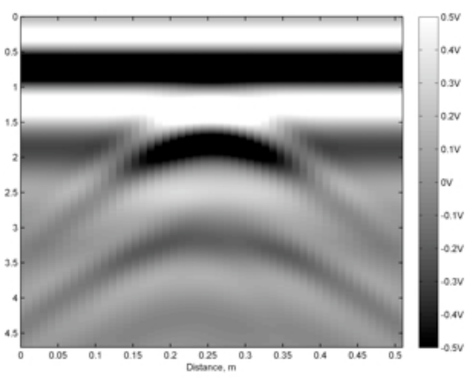
To improve our knowledge and understanding of GPR signals through the development of accurate GPR models. Specifically:

- Create 3D numerical models of commercial GPR antennas [1, 2]
- Validate models by comparing modelled free-space responses with that from real GPR system
- Include antenna models in simulations involving near-surface targets
- Design a series of laboratory experiments using different configurations of typical GPR targets in different homogeneous media
- Further validate the models using data from the laboratory experiments and field surveys

REAL B-SCAN



MODELLED B-SCAN

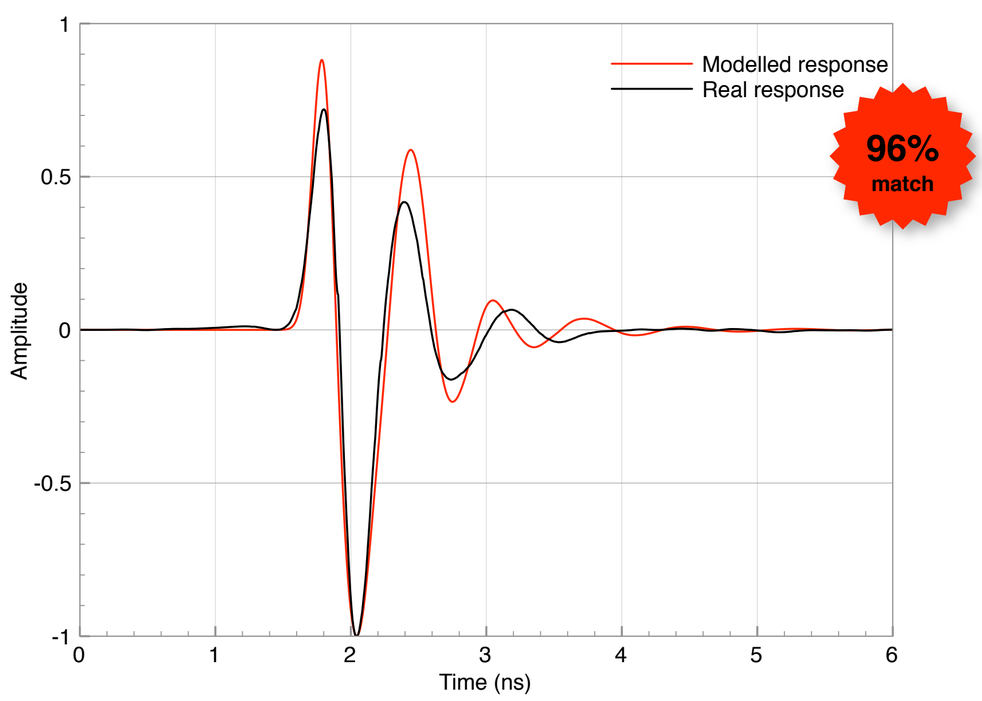


15MM COPPER PIPE ABOVE 34MM PLASTIC PIPE

Research Outcomes

- Developed a set of software tools [3, 4] to create, visualise and validate detailed 3D models of GPR antennas
- Built Finite-Difference Time-Domain models of commercial GPR antennas from leading manufacturers: GSSI and MÅLA
- Improved accuracy of models by optimising unknown parameters using Taguchi's method [5]
- Initial validation of models by cross-correlation of real and modelled free-space responses has shown excellent agreement
- Conducted a series of laboratory experiments to simulate different targets in different media using oil-in-water emulsions [6, 7]
- Comprehensive validation of models by comparison with data from the laboratory experiments

GSSI 1.5GHZ ANTENNA: FREE-SPACE RESPONSE



References

[1] Geophysical Survey Systems, Inc. (GSSI) - Ground-Penetrating Radar Equipment [http://www.geophysical.com/] (2008).
[2] MÅLA GeoScience - Ground-Penetrating Radar Equipment [http://www.malags.com/] (2008).
[3] A. Giannopoulos. Gprmax - Suite of electromagnetic wave simulators for GPR modelling based on the FDTD method [http://www.gprmax.org/] (2008).
[4] Kitware Inc. Paraview - Parallel Visualisation Application [http://www.paraview.org/] (2008).
[5] W.-C. Weng, F. Yang, A. Z. Elsherbeni, Electromagnetics and Antenna Optimization Using Taguchi's Method, Morgan and Claypool Publishers, 2007.
[6] J. Bungey, S. Millard, M. Shaw, Simulation tank to aid interpretation of radar results on concrete, Magazine of Concrete Research 45 (164) (1993) 187–195.
[7] G. Smith, W. Scott, The use of emulsions to represent dielectric materials in electromagnetic scale models, IEEE Transactions on Antennas and Propagation 38 (3) (1990) 323–334.

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