Remote Sensing of Electromagnetically Penetrable Objects: Landmine and IED Detection

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Abstract

The problem of detection, characterization and classification of harmful environmental hazardous objects [mines, IEDs, pollutants, tunnels, unexploded military hardware] buried in the soil is a worldwide problem that needs urgent attention and solution. Electromagnetic sensor technologies have been applied to identify these underground hazards; the increasing sophistication in the manufacture of landmines acts as major impediment to identify. Also, increasingly low dielectric contrast of buried object, masking effect from clutter from rough ground surfaces, and soil geometric in-homogeneities act as additional barriers.
Subsurface sensing and imaging is the non-invasive recovery of shape and topological characteristics of an object buried underneath or embedded within a dielectric region. The imaging technique involves propagating electromagnetic waves of known frequency and amplitude on the computational geometry, measuring the fields scattered by the dielectric surface and the object, and quantifying the electromagnetic parameters of the scatterer.
The objective of this project is to create a comprehensive template for the development of a computational model for sensing and analyzing subsurface imaging of environmental hazardous objects buried under the soil using the Finite Element Method in the COMSOL Multiphysics® software.
The present study investigates the use of radiation boundary condition in infinite space, different geometric shapes of the environmental hazard, and material properties to model the propagation of electromagnetic wave introduced into the computational domain non-invasively. Three quantities of interest were investigated: depth, terrain, and structure of the buried environmental hazard were analyzed numerically. The depth can be used to quantify whether a buried hazardous object, for example a land mine, can be safely defused without the risk of causing collateral damage on explosion. The structure or material content of the subsurface object can be readily used for identifying the object type prior to being defused or removed.

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Figures used in the abstract

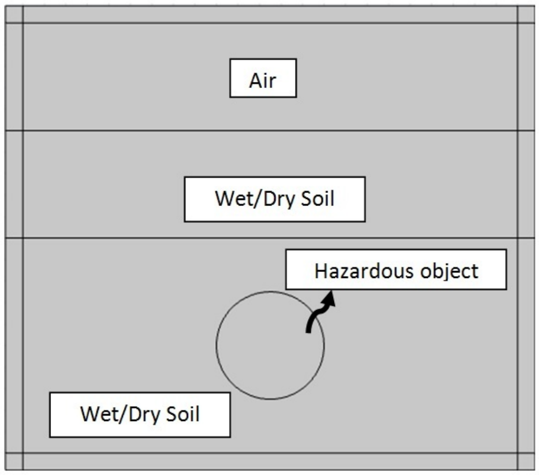

Figure 1: A 2D model used for the computational domain.

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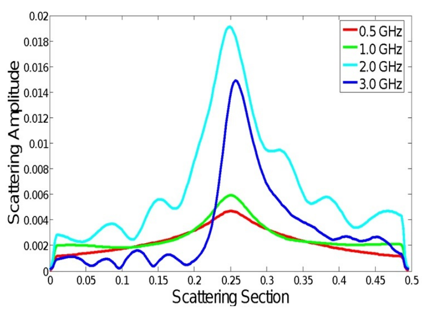

Figure 2: Parametric study at different frequencies directed towards a 5cm circular target for Air/Wet Soil/ Dry soil model.

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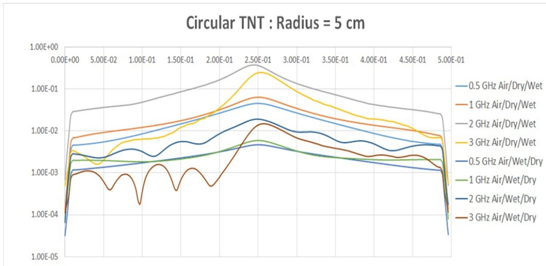

Figure 3 Comparison of scattering profile for Air/Wet/Dry model and Air/Dry/Wet model at different Frequencies.

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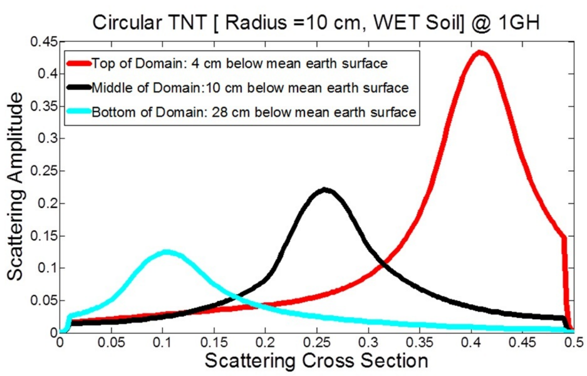

Figure 4: Variation of Hazardous Object Depth for Wet Soil at 1GHz

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