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# Landmine and IED detection with GPR: Assessing Soil influence through realistic simulations

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GPR is widely being used for clearance operations of landmines and IEDs (improvised explosive devices) as these objects may contain only low amount of metal, potentially rendering metal detectors unsuitable. Sensor performance strongly depends on the individual in situ condition, i.e. the target size, material and depth, the soil type and moisture and the radar system in use. Commonly, experiments are carried out on test sites to investigate these influencing factors, but covering a variety of scenarios is cost expensive. An alternative are numerical simulations of electromagnetic wave propagation to obtain synthetic GPR data of specific scenarios. However, these simulations have the disadvantage of not being able to reproduce all effects. These are e.g. the antenna coupling but also dispersion effects of the ground, which lead to attenuation and distortion effects of the GPR signal. We present 3D FDTD simulations, which include the antenna, the geometry and properties of the target objects, the ground heterogeneity and the intrinsic frequency-dependent dielectric soil properties. The latter was measured by dielectric spectroscopy of soil samples in the lab. We show simulations with two Antenna systems (one-channel and multi-channel) on different soils and with different targets and compare these with real measurements. The results prove that with these software tools realistic data can be generated that include all the relevant properties. As an example, the detection of a canister filled with explosive material in sand with a 600 MHz antenna array proved possible to a depth of up to 50 cm, while a loam soil or gravel reduces this depth considerably due to intrinsic attenuation and scattering, respectively. We are able to produce a comprehensive amount of model data for different clearance scenarios, which can be used to train demining personnel or for evaluating and improving demining techniques. Hereby demining activities of landmines and IEDs can be made safer and more effective.