Investigating the Effect of Survey Parameters on the Results of GPR Method Through forward Modeling and Field Studies

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Extended Abstract

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Introduction

Ground-penetrating radar (GPR) is a high-resolution geophysical method which uses electromagnetic waves with high-frequency in order to map structures and objects buried in subsurface without any destruction of the medium. In present research, choice of optimum parameters of real data acquisition for this method has been studied. The governed behavior on the GPR fields can be simulated by solving the Maxwell's equations and the appropriate boundary conditions that form the basis of electromagnetic theory. Among the variety of available numerical methods, the finite-difference time-domain (FDTD) method has paid more attention due to having the simple understanding of the concepts, flexibility, simulation and modeling of complex environments and the acceptability of its responses in the applied cases. The purpose of this study is to identify what reasonable information can be obtained from field data under different environmental conditions and different survey parameters.

Materials and methods

To achieve the goal, first forward modeling of GPR data has been carried out for several synthetic models corresponding to common targets in subsurface installations, using 2-D finite-difference time-domain method by means of GPRMAX, ReflexW and Radexplorer softwares. The main purpose of the simulations is investigation of the effect of survey parameters such as spatial sampling intervals (trace interspacing) and temporal sampling frequency on the GPR response of targets with various physical and geometrical parameters. Also to select and design the most appropriate conditions and survey parameters for real GPR data, numerous field traverses were performed in Isfahan University of Technology campus over the pre-known buried cylindrical targets containing power cable, petro-gas pipe, water pipeline and waste water pipeline with diverse host media. In this operation due to having one monostatic GPR system equipped by shielded antenna with central frequency of 250 MHz, some of the survey parameters containing central frequency, antenna separation and antenna directivity are invariant. The most important investigated survey parameters are temporal sampling frequency, spatial sampling distance (trace intervals), time window and number of stacked traces.

Results and discussion

Regarding carried out investigations through field data acquisition, in only one case the GPR system failed to detect any understated targets which this mode is related to choice a sampling distance of 1 cm and a sampling frequency of 504 MHz. The sampling frequency of 504 MHz is just capable to detect the surface water pipeline (due to its low burial depth). Also only in three cases the GPR system is capable to detect all subsurface targets so that the first mode of the trace interval is 2 cm and the sampling frequency is 1954 MHz, whereas in the latter two, the trace interval is 1 cm and the sampling frequencies have been selected 1563 and 1954 MHz. At the end success or failure of the targets detection was investigated on the basis of selected survey parameters and the probability of successful target detection was determined depending on the temporal and spatial sampling frequency so that the maximum probability of target detection is regarding to temporal sampling frequency of 1954 MHz and trace interval of 1 cm. Regarding GPR field data acquisition, considering the relations between the central frequency of GPR measurement systems, the depth of penetration and resolution, the diversity of materials and various components of the host media of targets and their surface overburdens a range of dierse equipments with a variety of frequencies is needed, which all of them are not generally available.

Conclusion

As a general conclusion of this study, in order to reduce the risk in GPR data acquisition operation, optimal survey parameters are suggested as follows:

The sampling frequency should be about 7 to 8 times the central frequency of the employed system (should not be less than this value in order to avoid aliasing and on the other hand, due to reduction in the amount of data and thus the memory needed for storage and processing), trace interspacing equal to 1 cm (in order to detect all buried targets especially targets with small size), the number of stacked traces equal to 16 (to reduce the amount of computer memory required for processing and storing data) and time window according to the computational-empirical relation (1).

$$W = 1.3\frac{2\times D}{V} \tag{1}$$

Where W is time window, D is the maximum depth and V is the minimum velocity.

The results of this research are not restricted to the investigated case, but in practice are applicable for cases with similar host environments, especially in urban areas (which application of non-destructive methods such as GPR is necessary).

Keywords: Ground-Penetrating Radar (GPR); Forward modeling; Parameters of GPR data acquisition; Sampling frequency; Trace intervals; Radexplorer software.

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