Mine Detection Under Rough Ground Surfaces Using 2-D FDTD Modeling and Hypothesis Testing

He Zhan, Carey Rappaport, Magda El-Shenawee and Eric Miler
Northeastern University, 235 Forsyth Building, Boston MA 02115
(617) 373-4874
hzhan@ece.neu.edu

ABSTRACT

This paper attempts to investigate hypothesis test performance in mine detection, based on numerically simulating the wideband scattering of experimentally measured GPR signals by realistic, dispersive soil interfaces. We employ a 2D finite difference time domain (FDTD) method to analyze the delay and amplitude characteristics of ground-scattered waves as a function of roughness parameters. In addition, we apply binary hypothesis tests to the signals obtained using physics-based signal processing techniques to investigate the presence of the target at certain depth. We quantify the detection performance in terms of the spatial distribution of transmitter and receiver.

INTRODUCTION

Detecting buried dielectric targets—such as nonmetallic antipersonnel mines—with ground penetrating radar (GPR) is important and difficult, because the dielectric constant of nonmetallic mine targets are similar to those of the surrounding soil, and because their size is comparable to the thickness of soil layer above it. In addition, the soil dielectric constant may not be well characterized, and the ground surface will usually be rough, often with roughness of the order of the target burial depth. We simulate the effects of random rough ground surface on the GPR signal using multiple Monte Carlo runs of 2D TM FDTD calculations. A typical bistatic geometry (Fig. 1a) is used along with a measured excitation signal generated by the Geo-Centers TEMR GPR antenna (Fig. 1b).

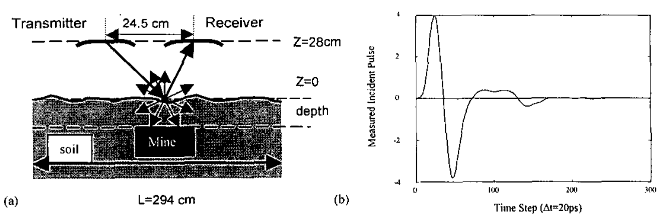

Figure 1: (a) Rough surface computational geometry; (b) incident measured waveform

In the FDTD code, the time step is Δt = 20ps and Δ = 1.22cm. Simulations are done for 500 surface realizations with and without a mine target at various depths below the nominal surface level for a variety of roughness statistics. The probability density function for the height and the surface profiles spectrum are both assumed Gaussian [1,2]. The soil model is Puerto Rican clay loam with 10% moisture and 1.4g/cc density, with average dielectric constant $\varepsilon' = 6.2$ [3].

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