Possibility of using GPR Radar to localize human bodies under the rubble caused by an earthquake

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Abstract

Ground penetrating Radar (GPR) is an interesting device that can allow a non-destructive auscultation of the underground without any excavation. It is based on the use of high frequency electromagnetic waves, including reflection or diffraction that allows the detection of buried objects. In this work, we studied the possibility of using GPR for detecting of human targets under the rubble caused by an earthquake. Results were obtained after simulating some models whose dielectric characteristics are those of human tissues. The models studied are assumed to be buried under construction debris. The simulation is performed using GprMax software, whose calculations are based on the finite difference time domain (FDTD). Our results revealed that the use of GPR as a tool to detect human target, existing eventually under rubble containing some level of iron will be very difficult and even impossible. However, in the absence of conductive substances such as iron remains GPR may be useful as a detection tool for buried human bodies under rubble caused by an earthquake for example.

Keywords- *Earthquake Ground Penetrating Radar; Simulation;*

I. INTRODUCTION

The possibility of detecting buried objects, to localize the structures, and to determine the nature of the subsurface has always fascinated the word of research and engineering. However, there is no universal technique able to provide easy answers and accurate information's on the geophysical component of the soil, as well as on their spatial distribution. The existing approaches include seismic methods, methods of electrical resistivity and induced polarization techniques generally referred to imaging of the near surface [1].

Ground penetrating Radar (GPR) is an interesting device that can allow a non-destructive auscultation of the underground without any excavation. It is based on the use of high frequency electromagnetic waves, including reflection or diffraction that allows the detection of buried objects.

Within the context of this work, we are interested in the use of an imaging method based on the propagation of electromagnetic waves emitted and recorded on a sensor. The GPR emits high frequency waves in the direction of the subsoil, whose ratings range from 10 MHz to 2.6 GHz. Detecting and / or location through the soil is highly needed in order to see the content of the soil without destruction or excavation. It will be, then, possible to draw diagrams of the subsoil and to locate searched objects.

II. HISTORICAL AND DESCRIPTION

GPR radar appeared in the beginning of the twentieth century. Since the 70s, it is used for the exploration of the subsoil in several research fields such as the detection of landmines [2], geology [3], civil engineering [4], glaciology [5][6] and archeology [7].

To date, they are several manufacturers selling different types of Radars whose applications depend mainly on their optimizations. These optimizations can be performed on the handling of the device and its accessories. However, the performance of the GPR radar is limited by several parameters of various origins [8].

The objective of this work is to perform some simulations of GPR signals, on body whose characteristics are those of a human tissue, buried in a dielectric medium. These simulations were performed using the software GprMax2D [9], which is based on the finite difference time domain (FDTD)

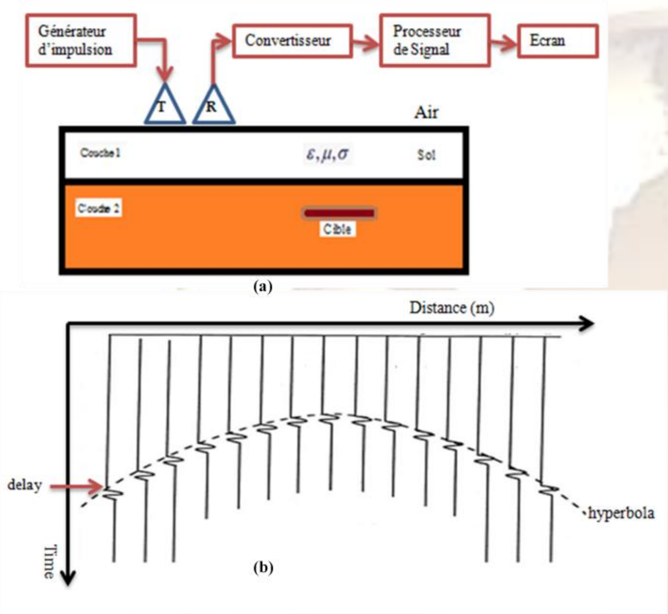
The FDTD stands out for its simplicity of implantation and flexibility of adaptation [10][12]. In 1996, Yee [11] proposed the foundation of this technique and several improvements have been made so far. The FDTD numerical method allows the resolution of Maxwell's equations in a volume of three-dimensional calculation. The code for scientific computing software GprMax, which we used for simulations of GPR signals, is based on this method.

Modeling was an integral part of the interpretation of geophysical data. Early work on numerical modeling for electromagnetic problems, can be attributed to the early 70 [12], several methods have been proposed to simulate the signals received by the GPR. Recently several approaches have been used to solve Maxwell's equations to model the signals captured by the GPR [2]. The results of the simulations used in this work are obtained using the software GprMaxV.20 (cited above) as images called radar-grams.

III. PRINCIPLE OF USE

The operating principles of GPR are as follow: a transmitting antenna sends into the ground pulses of a very short time, at different frequencies ranging, according to the antenna used (from 20 MHz to 2 GHz). These pulses cause a wave front that propagates through the medium investigated. When the waves encounter an obstacle, with different dielectric properties on the initial propagation medium, part of their energy is reflected, while the other continue its spread to the depth of soil. The reflected waves are capted on the surface, by the receiving antenna, and passes into an acquisition system where the signal is sampled and stored as digital data at central processing unit, which is part of the GPR equipment.

An example of 2D acquisition is shown schematically in Figure 1. The radar system, represented by two antennas (T: transmitter and R : receiver), is deployed on the surface along a horizontal profile (Figure 1a). Figure 1b shows the registration of the propagation time of electromagnetic waves according to the position of the GPR device used. The hyperbola which is observed in this figure is an extremely important index, because it gives, in general, information on the location of buried objects.



IV. SIMULATIONS

The medium used for our simulation corresponds to a homogeneous medium; which is dry sand with dielectric properties($\varepsilon_r = 3$ et $\sigma = 0.0001\, S/m$). This medium contains a simulated model of human being tissues with dielectric characteristics($\varepsilon_r = 53, \sigma = 1.43\, S/m$). The signals refracted by this model were simulated and analyzed using the software GprMax2D, for central frequency of 500 MHz. This frequency corresponds to wave length directed in the simulated medium: $\lambda = \frac{c}{3f\sqrt{\varepsilon_r}} = \frac{3.10^8}{3.500.10^6.\sqrt{3}} = 0.115$ m.

An example of the geometrical model used for modeling of the radar signal refracted from human body buried at 0.4 m depth. Each signal emission and signal reflection is recorded during a time-period of 45 ns with a spatial increment $\Delta x = \Delta y = \Delta l = \frac{\lambda}{10} = 0.0115$ m. The total simulated length is 3.3 m x 2.0 m, which corresponds to 300 x 182 cells ((3.3/Δx) x (2.0/Δx)).

V. INTERPRETATION AND CONCLUSION

The simulations carried out on a body, with dielectric characteristics' of a human tissue, are presented in Figure 2. Figure 2 (a) shows buried human body under the sand, which is considered as a homogenous medium. Its radargram (presented right side) show hyperbolas, which reveal its existence in this area. Figure 2 (b) shows the same body buried under rubble composed with a mixture of sand, stones and wall (en brick), which covered completely the considered body. On its radar-gram, in the same figure and at the same location, the hyperbola are still visible. However, when the body is buried under a mixture of sand, stones and iron bar, the hyperbolas disappear (Figure 2 (c)).

As a conclusion, the use of GPR as a tool to detect human target, existing eventually under rubble composed of reinforced concrete (high percentage of iron) will be very difficult and even impossible. However, in the absence of conductive substances such as iron remains GPR may be useful as a detection tool for buried human bodies under rubble caused by an earthquake for example.

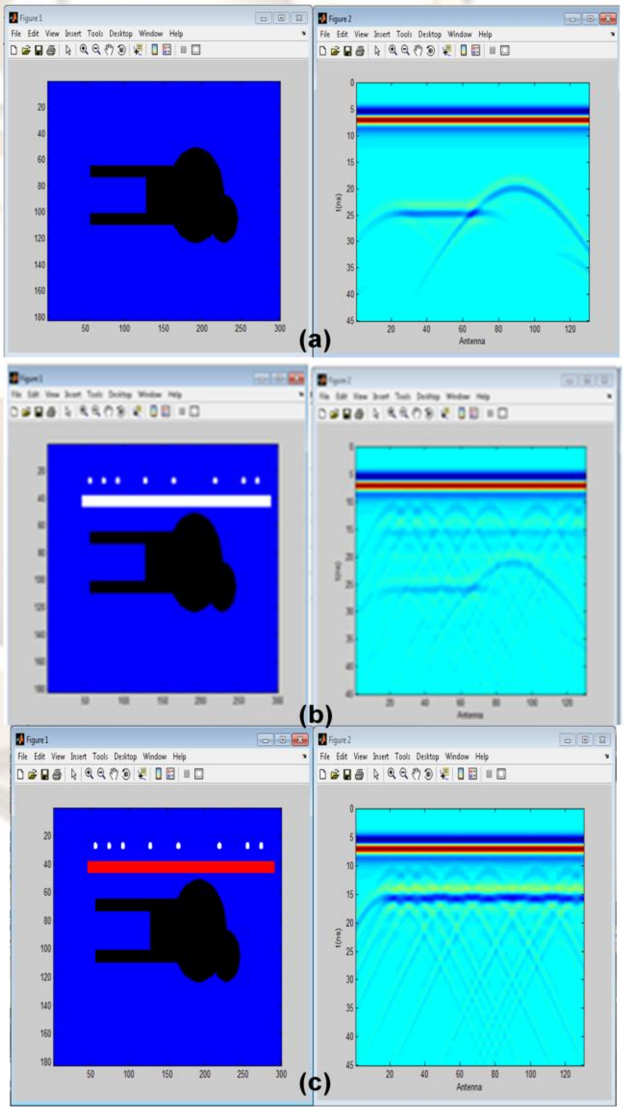


Figure 2. B scan of GPR signals obtained using GprMax2D for model composed of human tissues ($\varepsilon_r = 53, \sigma = 1.43\ S/m$). Simulated human body buried (a) under sand; (b) under a mixture of sand, wall and stones and (c) under a mixture of iron still, sand and stones.

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