Effect on the Difference in Distances between GPR Antennas on Data Quality using Modeling

Gamil Alsharahi, Majid Rochdi, Ahmed Faize, Mohammed Hamdaoui

Abstract: The aim of this work is studying the influence the distance between the antenna of ground penetrating radar (GPR) on quality of the signals and ability to detection the targets buried. We used for the modelling of behavior the signal by development the code on GprMax2d program. The distances different has used in this work and frequencies different. In this work we will simulate the operation of GPR using the common source point mode where the source is fixed and the receiver moved along the inspection profile for three values of the distance between the antennas. The simulations were performed for three different frequencies.

Keywords: Ground Penetrating Radar (GPR), Modeling, monostatic, quality, singlas.

I. INTRODUCTION

The Ground Penetration Radar (GPR) is a very effective tool to detect and identify objects buried under the ground; it is also effective to map structures and features buried in the ground. The GPR works by emitting an electromagnetic wave into the ground and recording the echoes that result from subsurface objects. In the case of monostatic configuration, the GPR use a single antenna to transmit and receive, and for the bistatic configuration, the transmitter and the receivers are separated from each other spatially. The main advantages of the bistatic configuration is the possibility to imagine different scenarios to record the GPR data. [1], [2].

The GPR data are affected by noise and interference caused by various sources. For example, boulders, animal burrows, tree roots, and other phenomena can cause unwanted reflections or scattering phenomena. In the case of urban environment, sources of noise can include reflections from nearby vehicles, buildings, fences, power lines, and trees.

The noise on GPR data can also cause by radiating signals from wireless systems (cell phones…). The effect of this noise GPR images is to blur the details, and complicates reconnaissance of the useful information. [3], [4], [5].

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In this work, we focus on the Electromagnetic coupling between the two antennas in the case of bistatic configuration. Indeed, the radar detects a reflection wave from an object by the receiver antenna, on the other hand the receiver antenna also receives the direct wave from transmitter antenna. In the case if, the distance between the two antennas is comparable to the expected object distance, this direct wave occurs artifact image. In this paper, we study the effect of the distance on the direct coupling on a bistatic configuration [13-14].

II. MATERIEL AND METHOD

A. Methods and theoretical background

FDTD based for GPR modelling and simulation Maxwell's electromagnetic equations that mathematically express the relations between the fundamental electromagnetic field quantities and their dependence on their sources can be used to describe all electromagnetic phenomena. The fundamental equations are [3]: Acquisition methods have to be synchronized and all referred to the same coordinate system in order to integrate the geometric data collected by the different techniques [6], [7], [8-11].

B. GprMax2d

The "GprMax 2D /3D" is a program designed in 1996 by Antonios Giannopolos, University of York Island. Aim to a wave simulator of GPR 2D and 3D as required by using the best adapted version of the desired work. It is based on the numerical method the F.D.T.D. This software is installed on Windows and has been successfully in more cases, where need to understanding, evaluation and comparative with other software tools [9], [12].

III. RESULTS AND DISCUSSION

A. Results obtained for 800 MHz

Distance between antennas is 30cm

In the first case we simulate with a frequency of 800MHz the detection of two different objects one conductor and the other dielectric buried at a depth of 0.5m and the distance between the two antennas is 30cmas shown in figure 1 (a). The radargram obtained in figure 1 (b) shows two hyperboles that indicates the presence of the two objects and lines above at a depth 20cm are caused by the direct wave between the two antennas.

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We can also notice the presence of the direct wave on the time evolution of the GPR waves on figure 1 (c). These results show that this phenomenon can hide an object near to the surface. [11].
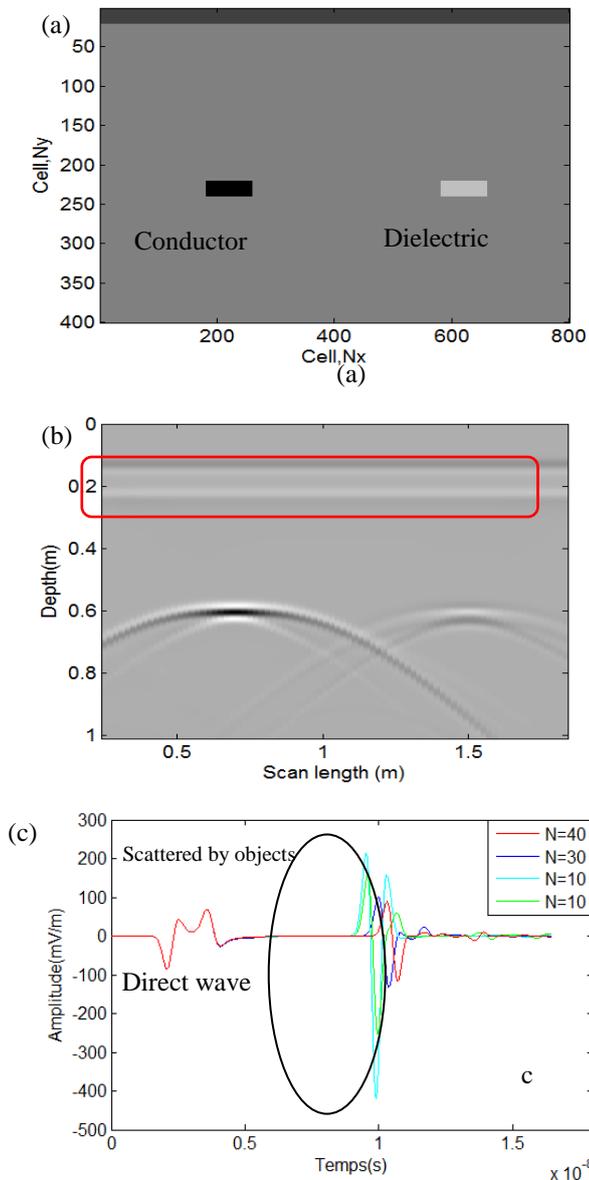

(a)

(b)

(c)

Fig. 1.(a) GPR simulation scenario (b) radargram (c) time evolution of GPR waves.

Distance between antennas is 20cm

We repeat the simulation for the same scenario, but in this case, we reduce the distance between the two antennas at 20cm. We can notice that the radargram obtained in figure 2 (a) is very similar to the first one. The only difference is the height of the horizontal lines due to the direct wave. Indeed, in the first case (when the distance is 30cm) the horizontal lines are centered round on 20cm of depth, and in the second case (when the distance is 20cm) the horizontal lines are slightly above the depth of 20cm.
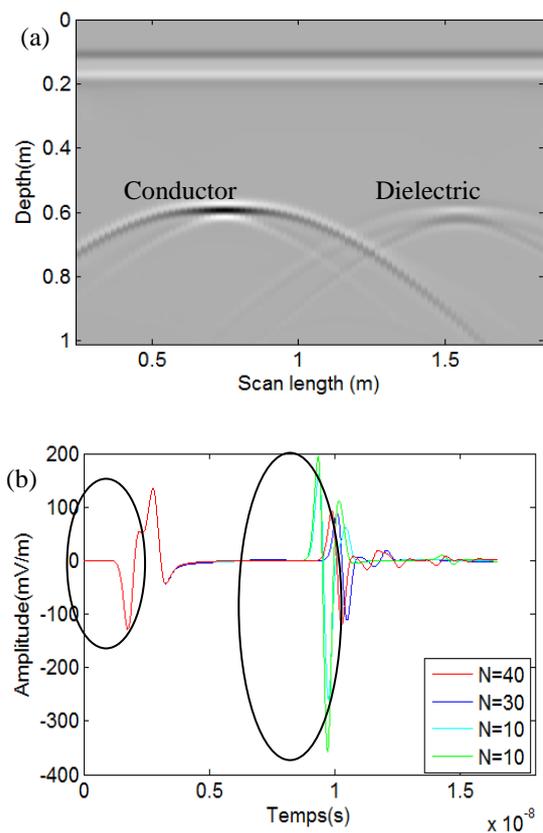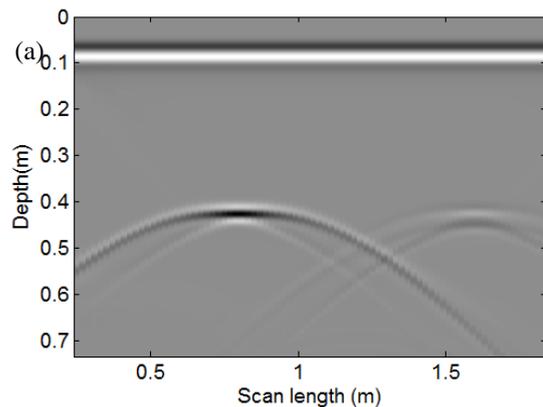

(a)

(b)

Fig. 2.(a) Radargram (b) time evolution of GPR waves.

Distance between antennas is 10cm

For the third scenario, we reduce the distance between the two antennas to 10cm. On the radargram shown in figure 3 (a), we can notice that the amplitude of the direct wave is significantly higher in this case to the two precedents cases. We can also notice that the horizontal lines are slightly above 10cm of depth.
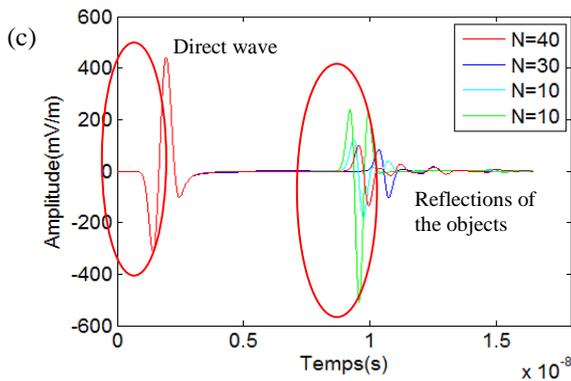

(a)

Fig. 3.(a) Radargram (b) time evolution of GPR waves.

B. Results obtained for 400 MHz

In this section, we will use a frequency of 400MHz for the same conditions (same objects at the same depth). The figure 4 shows the simulated results for the three distances between the two antennas. For the case when the distance between the antennas is 30cm we can notice that the horizontal lines due to the direct wave appears slightly below 20cm (slightly deeper that for the f=800MHz).
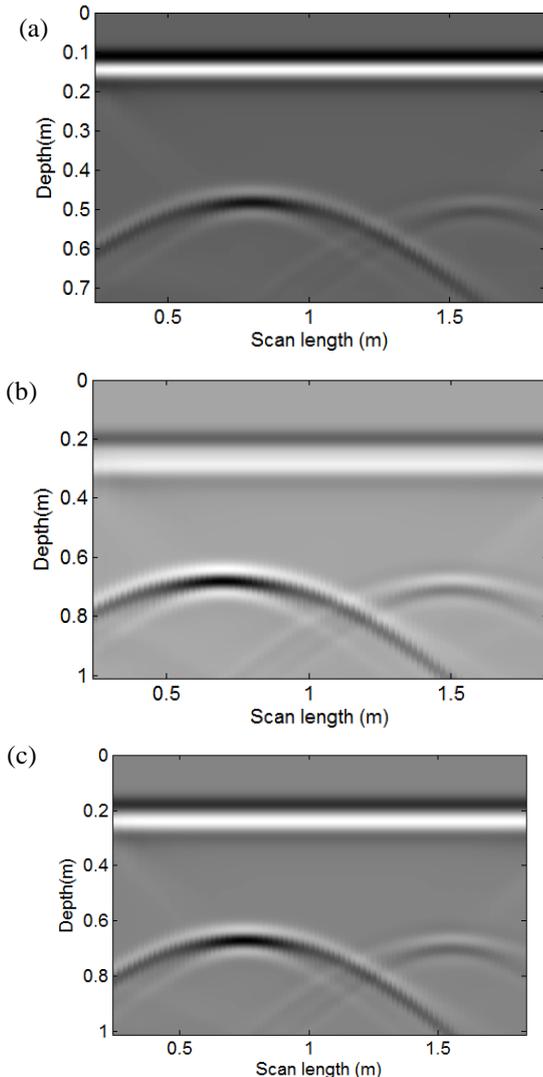

Fig. 4.(a) Radargram distance between antennas is 30cm, (b) distance between antennas is 20cm, (c) distance between antennas is 10cm..

C. Results obtained for 200 MHz

For the third case we simulate the same scenario but this time at 200MHz. We can observe on the results shown on figure 5 that the horizontal lines are deeper and most marked than the others two frequency.
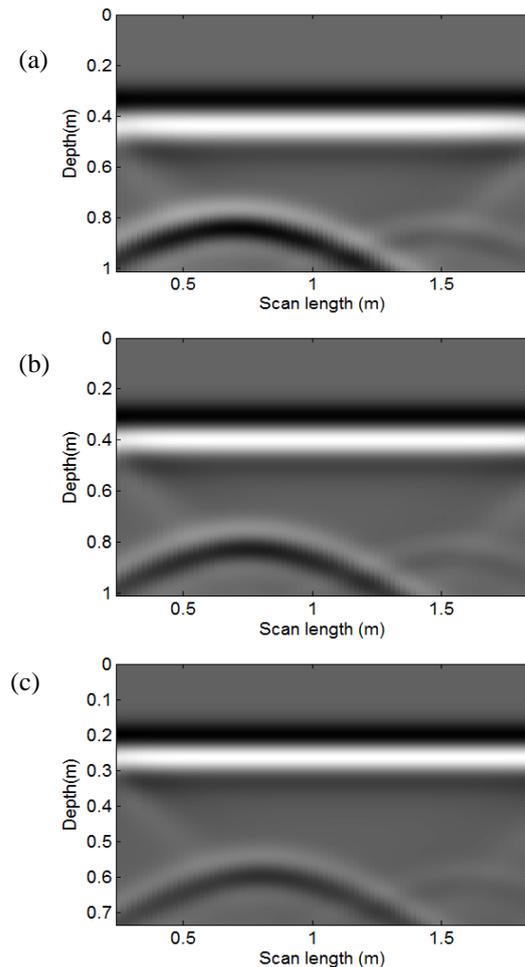

Fig. 5.Radargram (a), distance between antennas is 30cm (b), distance between antennas is 20cm and (c) distance between antennas is 10cm.

IV. CONCLUSION

In this paper we focused on electromagnetic coupling between the two antennas in bistatic configuration. The simulated results show the effect of the direct wave traveling from the transmitting antenna toward to the receiving antenna. Indeed, for three different distance between antennas (30cm, 20cm, 10cm) we have noticed that the effect of the direct wave appears as horizontal lines in the radargram, and the depth of this lines change with distance between the antennas and it's also depend on the frequency. The simulated results show that it's important de take account the direct coupling between transmitting antenna and the receiving antenna, because it can hide objects near to the surface.

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