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GPR FOR DETECTION AND MEASUREMENT OF FILLED UP EXCAVATIONS FOR FORENSIC APPLICATIONS

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ABSTRACT

The General Procurator Office of Russia jointly with the Central Research Institute of Radio & Electronic Systems (TsNIIRES JSC) has undertaken a series of tests to determine effectiveness of the ground penetrating radar (GPR) for detecting filled up excavations and buried objects. In the criminalistic investigation practice critically important clues are customarily found buried under ground. Different methods are used to detect buried objects: metal detectors and magnetometers for discovering metal objects and methane gas detectors - for corpses. GPR opens up new possibilities for discovering buried objects.

Key words: buried objects, forensic applications, ground penetrating radar.

INTRODUCTION

The idea of using GPR for forensic investigations is not new. There are some cases of using GPR to detect dead bodies (Strongman, 1992; Daniels, 1996).

Buried objects represent areas of different permittivity that reflect electromagnetic pulses emitted by the radar. However in many cases reflection from buried objects prove to be too weak to be discriminated. As for filled up excavations around buried objects their reflection can be more detectable. This is due to increased porosity of soil at the excavation spot, which leads to adsorbing more water. As the result of the tests conducted we have found that special processing of radar record permits to detect such spots. The objective of the tests was to measure reflection from a filled up excavation and background dependent on season, weather and how long ago had the excavation and fill-in been performed.

System

The data were collected with LS-3 system (Russia). It is the time-domain impulse ground penetrating radar design. The design has impulse duration equal to 1 ns. The maximal penetration depth is about 2…4 m at this pulse length. This is sufficient for the majority of forensic applications.

Experiment

The tests were conducted in an urban area in Moscow. A hole measuring 0.5 by 0.7 m and 0.6 m deep was dug and then filled in. Measurements were taken before digging and periodically after it. Each measurement gives full three-dimensional picture of the hole and the surrounding area. The general view of test site and LS-3 radar are presented on Figure 1.

Figure 1. General view of test site and LS-3 radar.

The scheme of experimental site on the earth surface is shown in Figure 2. Two metallic stakes in the corners designated borders of the experimental platform. On the scheme black circlets mark them. Step of the net on both axises is 10 cm. Measurements were conducted at each knot of the net.

Initial position of the radar is brought on the scheme in the upper left corner. The radar moves on 10 cm on axis ***X*** after registrations of the first signal and so on. Then radar moves on 10 cm on axis ***Y*** and so on.

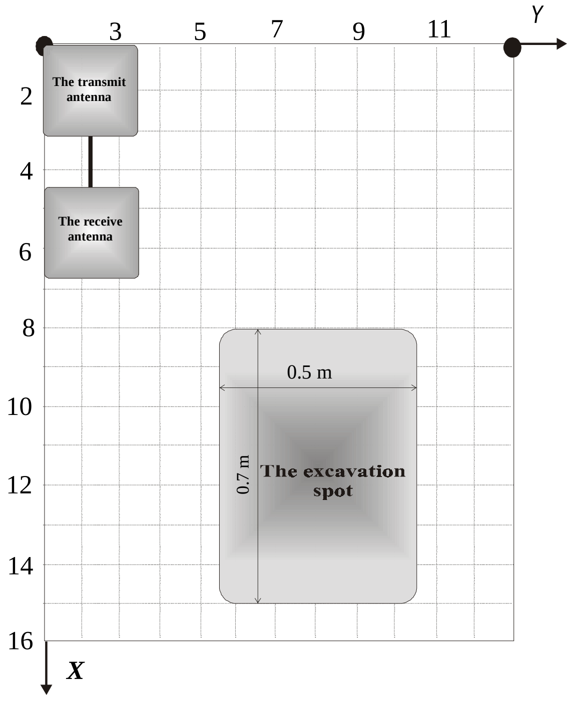


Figure 2. The scheme of experimental site.

The received signals were recorded in each knot and designated as $f_{i,j}(t)$, where i - serial number of the knot on axis $\boldsymbol{X}$ and j - serial number of the knot on axis $\boldsymbol{Y}$. The third axis is a signal time t.

3-D visualization and data processing

Using by following algorithm performed the three-dimensional visualization of GPR data. It was calculated medium wavelet $f^*(t)$ as

$$f^*(t) = \frac{1}{i \cdot j} \cdot \sum_{i=1}^{I} \sum_{j=1}^{J} f_{i,j}(t)$$

where $\boldsymbol{I}$ – common number of the knot on axis $\boldsymbol{X}$;

$\boldsymbol{J}$ – common number of the knot on axis $\boldsymbol{Y}$.

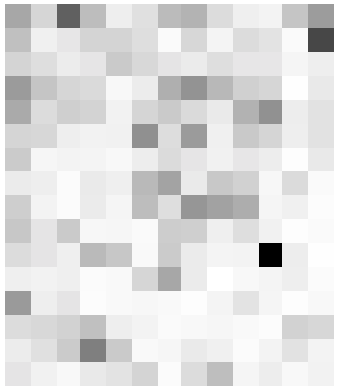
Then it was calculated a signal changing in the time window from t to $t+\Delta t$ as

$$f_{i,j}(t, \Delta t) = \int_{t}^{t+\Delta t} \left[f_{i,j}(\tau) - f^*(\tau) \right]^2 d\tau$$

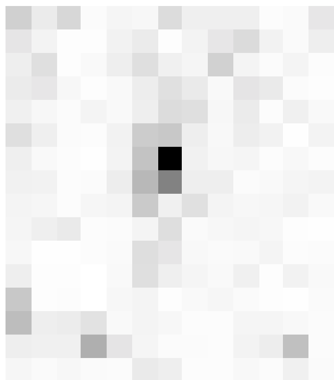
Hence we can select reflections from different depths. Calculations were performed for different time windows and results were displayed in black and white pictures.

The experimental results are shown in Figure 3. Experiments were conducted the next day after rain. Time window of Section A corresponds to the breakthrough signal from transmit to receive antenna. As one can see from this picture, there are no details of excavation spot in this picture.

Section A



Section B



Section C

Section D

Figure 3. The experimental results for different time window.

Time window of Section B corresponds to the signals from earth near the surface. There are no details also. On Section C we see response from bottom of excavation where moisture is maximal. Next picture (Section D) shows reflection under bottom of excavation.

As we see from this pictures, wetter soils has lager permittivities and hence more reflection capacity. As water accumulates at bottom of excavation spot, its contrast is maximal.

CONCLUSION

GPR has far-reaching capabilities in forensic applications. Many types of radars are on market now, but GPR using restrains by absence proved technique. It is necessary further efforts for elaboration of methods of the radar's using on different types of soils and climatic areas.

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