A STUDY OF ACOUSTIC METHODS FOR COMPLIANT LANDMINES DETECTION BY USING THE SURFACE ACCELERATION PARAMETER

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1. INTRODUCTION

This work presents the results of our research on acoustic methods for the detection of buried compliant objects like landmines. The relevant parameter to detect the objects was the ground surface acceleration, which was produced by means of MEMS silicon micro machined sensors [1][2]. These provide analog voltage signals proportional to the acceleration components along the coordinated reference system (x, y, z directions) of the devices. As the orientation of the accelerometer can be adjusted using gravity for reference, we could distinguish the acceleration component normal to the ground surface with respect to the in-plane components.

2. SOIL-MINE SYSTEM MODEL

The authors studied and developed a laboratory model of a compliant mine simulant where mechanical parameters were defined by design [3] and carried out the first experiments to validate the soil-mine system model. More recently [2] they presented the results obtained in laboratory, where the mine simulant and other buried objects were put in a sand-box. This set-up aimed to collect a data set of signals from compliant and non compliant objects for signal elaborations in the time and frequency domain. In this paper we present and describe a new set-up which allowed tri-axial accelerometer signal acquisition in outdoor experiments to study the significance of the most significant parameters useful to detect compliant and non compliant subsurface objects. The real-time signal processing capability was exploited also to generate an audio output channel which was considered an important step toward the development of new portable handheld landmine detectors.

3. OUTDOOR SET-UPS

An example of an experimental set-up for measurements in-field on homogeneous sandy soil will be described. This set-up was very useful to develop signal processing and visualization methods for landmines detection in real time and investigate instrumental and experimental factors influencing the acceleration measurements. Moreover we will report a time domain simulation of the soil-mine system. The output of this simulation was used to select the acoustic probing frequency range where resonance can be expected (about 130 Hz for target depth of 4 cm in sand). Finally, experiments with different test-beds were carried out. In the first experiment, that was performed with a compliant metal case positioned at different distances from the acoustic source, we analyzed the maximum operating distance and spatial sampling requirements for scanning the surface. In the second experiment, a set of compliant and rigid targets were used. These were embedded at short distances (from 20 cm to 50 cm) to test the detection method in a situation similar to one that can be met in real operational fields.

4. REFERENCES

[1] G. K. Fedder, J. Chae, H. Kulah, K. Najafi, T. Denison, J. Kuang, S. R. Lewis "CMOS Based Inertial Sensors," Advanced Micro & Nanosystems, vol. 2, 2005

[2] A. Bulletti, S. Valentini, F. Cioria, G. Borgioli, M. Calzolai, L. Capineri and L. Masotti, "Silicon micromachined accelerometers for the detection of compliant anti-personnel landmines," in Proc. IEEE Sensors, Lecce, Italy, pp. 1159-1162, Oct. 2008

[3] G. Borgioli, A. Bulletti, M. Calzolai, L. Capineri, P. Falorni, L. Masotti, S. Valentini, C. Windsor, "Theoretical and experimental analysis of an equivalent model for the investigation of shallow landmines with acoustic methods," in Proc. SPIE, vol. 6739, 2007