Development of a Landmine Detection System with Nuclear Sensors and Data Fusion

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The problem of landmines in Egypt and the detection techniques currently used for humanitarian demining are described and discussed. Most of these techniques depend on metal detectors. This makes the demining of vast areas of contaminated lands difficult, dangerous, slow and very costly processes. Although some of these techniques are very effective to locate metal or metal like anomalies, but they suffer from high false alarm rates because they are not capable to identify these anomalies as mines. However, in the last four decades, techniques based on using neutrons of different energies have proved themselves as powerful tools for elemental analysis and are therefore capable to identify explosive materials and to confirm the presence or not of a landmine.

Results of the activities running through the IAEA TC project, EGY.1.024 for developing and adapting the two main promising nuclear techniques based on measuring the density variation of hydrogen by measuring thermal neutrons backscattered from buried object are given and discussed. In addition, the use of two nuclear sensors with other two sensors based on EMI and GPR in an integrated system with data fusion and how to integrate these sensors onto a land vehicle are described and discussed.

1. Introduction

Egypt is the country with millions of landmines result of extensive combat operations between allied and axis forces during World War II that took place between December 1940 to May 1943. UNICEF estimates that about 23 million landmines and unexploded ordinances have been left from the World War Two Campaigns [1]. These hidden killers are scattered over 3902 minefields in the Northern part of the Western Desert of Egypt, left behind by the troops of Germany, Italy and the allied forces led by Britain battling for the control of North Africa in the 1942 Battle of El-Alamein. These abandoned landmines ravaging 270’000 Hectares of pastoral and agricultural lands between El Alamein and the Libyan border. Other 6 million landmines are buried in large number of minefield spread in the Northern and Western parts of Sinai, Suez Gulf and Western Coast of Red Sea. These buried landmines contaminate ~25’000 Hectares of lands in Northern and Western parts of Sinai.

The buried landmines in these vast areas of the Egyptian lands killed and maimed more than 10,000 civilian persons during the last six decades. The effect of these hidden killers on survivors is devastating and the threat is real and lasting. It has a very serious social and economical impact, but it is considered first and foremost as a hu-

Figure 1: Wood sample ($\rho = 0.8$ g/cm$^3$) of $7 \times 6.5 \times 5$ cm$^3$ buried at different depth in the ground.
manitarian problem. Egypt needs to clear the contaminated areas at least $300 million for initiating and starting national projects in agriculture, industry, tourism and for oil and gas exploration. More than $30 million was spent to clear nearly one tenth of the total contaminated areas. The mine clearance should not go slowly as it is now, but requires international efforts and support especially from the countries involved in World War II.

2. Currently used Detection Techniques

In Egypt, the humanitarian de-mining activities, carried-out to remove landmines from the vast contaminated areas are not on the same level of the problem. The conventional methods which are used, such as metal detectors, magnetometers and ground penetrating radar, etc., make the procedure of removing this great numbers of landmines very slow, inefficient, dangerous and costly. In addition, most of these detectors can not distinguish a mine from metallic debris, and in case of metal detectors, the extremely high false alarm rate, only one out of about one thousand alarms turned out to be a landmine. This results in a rather inefficient, costly and slow operation [2–4].

3. Developing and Adopting Nuclear Techniques

Research activities are running to develop the above-mentioned nuclear techniques since the beginning of the IAEA TC project in 2003. In case of detection by thermal and fast neutron analysis, no progress was achieved due to lack of a neutron source with energy high enough to detect Carbon and Oxygen. However, for hydrogen density variation measuring technique the activities running in collaboration with the University of Delft using the DUNBID system have achieved results that are promising for landmine detection in arid countries like Egypt [5,6]. The measured back-scattered thermal neutrons using this system were used to reconstruct 2D images for the tested objects. Some of them are displayed in Figs. 2–3. These 2D images make it possible to recognize the presence of buried objects with different moderating elements. Also the count rates of thermal neutrons back-scattered from plain soil and soil embedded with the tested objects buried at different depths were used to plot the attenuation relations given in Fig. 4. These relations are plotted as net count rate, (count with object – count from plain soil) versus soil depth in cm. It is quite clear from these relations that, the DUNBID system can easily detect and distinguish small AP mines with 100 g explosive buried at depths down to 15 cm. The plotted attenuation relations also show that, the system is capable to distinguish between hydrogen containing objects and others of higher density buried at depths down to 20 cm. However, the main limitation of the system is the un-capability to distinguish between objects of nearly the same hydrogen content.

4. Weighting of Metal and Nuclear Sensors

EMI provides capabilities to detect and allocate all types of landmines very fast but lacks specificity. GPR provides capability for deciding whether anomalies showing low metal content are mines or can be disregarded as metal clutter. NHBS provides capability for identifying plastic land mines of low metal content. PFTNA provides elemental based identification of explosives.
This will be needed to resolve the most difficult cases, namely those in which the decision between landmine and no landmine cannot be made from the information provided by the previous sensors.

If metal clutter is prolific in the region that is being demined, a simple two sensors system consisting of EMI as a location sensor and PFTNAS as a confirmation sensor will probably be inefficient. The low speed response of PFTNA will limit its ability to deal with large numbers of false alarms (due to metal clutter) fed to it by EMI. Incorporating additional sensors in the integrating system can reduce this problem. For example GPR or NHBS can be used to filter out clutter either by imaging by GPR or by identifying plastic land mines with NHBS sensor, among the anomalies detected and localized by the EMI sensor.

5. Conclusions and Recommendations

Thermal neutron back-scattering technique shows reliable results that are encouraging to use a device based on this method as a nuclear sensor for detection of hydrogen containing objects including landmines. Such a device will tend to reduce the number of false alarm rate given by metal detectors.

International co-operation will help Egypt to develop novel detection techniques, not only to overcome the most dangerous problem, but also will make Egypt capable to take the technical lead for assisting regional countries in similar conditions.

REFERENCES

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