A RETROACTIVE STUDY ON AUTONOMOUS WIRELESS WARFIELD EXPLOSIVES DETECTION SYSTEM

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ABSTRACT

The landmine crisis is globally alarming since there are presently 500 million unexploded, buried mines in about 70 countries. Governments are looking into this situation seriously since landmines are claiming the limbs and lives of civilians every day. So there is urgent need of a system which is capable of finding and diffusing landmines. The method which is used for detection is manually detecting mine by bomb squad or with the help of a trained dog and hence there are no system currently available which are capable of tackling this crises since every method which is used to find the landmines or IEDs involves risk and threat to human life. So, in this paper we are focusing to use a robot prototype which is capable of detecting the land mines beneath the soil and applying counter-measures to avoid its explosion by enabling the operator to control the robot wirelessly from a distance. Many methods which are traditionally used for the detection have been stated. The system typically interfaces with the metal detector circuit in a robot with array of sensors to search the land mines and IEDs. Various other methods for locating landmines and futuristic experimental system have been shown in a comparative way. The purpose of this paper is to provide depth detail of all the available as well as futuristic technologies which can be used to detect the landmines without causing threat to human life.

KEYWORDS: *Semi-Autonomous robot, CMAAD, GPS, Landmine detection*

1. Introduction

There are losses of many soldiers due to landmines. There are many hazardous objects in crowded areas .So there is always a threat of bomb being detected. During disastrous situations, it is difficult to determine the presence of alive humans. As studies says there are more than 500 million live unexploded landmines all over the world. This is a serious issue facing by many countries. Also the well developed countries which spend billions of dollars in military research have developed some expensive system to countermeasure the landmine crises. But these system are so much expensive that many small nations which are facing war like condition cannot deploy them. Therefore there is an urgent need for a system which is of low cost and equally efficient.

There are many technologies available for the detection of landmines like GPR (Ground Penetrating Radar), Thermal Imaging of explosives and advanced metal detector. All of these techniques are widely used but also have some limitations.

In this paper we have given a complete detailing about these technologies in a comparative manner. Thus here we are proposing a model which utilizes the concept of metal detection autonomously using a robot which is also a low cost and highly reliable, so that there would be no harm to human life. The system allows the operator to stay at a safe distance by enabling him to control the robot wirelessly or remotely.

2. Literature Review

Mark F. etal [1] – In this paper the chemical vapor detection technology has been used for the detection of the landmines and IEDs. Every explosives have a different chemical composition and transmit a

unique vapor in the atmosphere. With the help of array of sensor we can collect those vapors and further determine it whether it is an explosive or not. Thus, pinpointing the location of a mine using trace chemical sensors is difficult. However, trace chemical detection could be used to determine whether or not dispersed explosive signatures are present in an area, indicating that mines may be present. To our knowledge, Fido was the first person-portable field sensor to detect the chemical vapor signature of a landmine under field conditions. In blind field tests administered by DARPA at Fort Leonard Wood (FLW), Missouri, the sensor was able to detect TMA5 and PMA1A landmines. Fido uses as sensory materials novel fluorescent polymers developed by collaborators at the Massachusetts Institute of Technology. These polymers were specifically engineered to detect TNT, the explosive found in excess of 85% of mines now deployed. Air that may contain target analytes vapors is drawn through the sampling chamber by a small pump. If the air contains vapors of target analytes, the intensity of the fluorescence registered by the PMT will decrease proportionally to the mass of analytes that binds to the polymer films. The response of the sensor is almost instantaneous upon sample introduction, enabling near real-time analysis of samples. However the results are satisfactory but this technique is so sensitive and difficult that it requires experts for the proper functioning and also it is very expensive and hence can't be deployed by many nations.

R. Furstenberg etal [2] – In this paper the advance imaging technology is used for the detection of explosives. The trace explosives have been detected via resonant infrared photothermal imaging. Here a laser beam is incident on an explosive due to which the explosives commonly (RDX, TNT) absorbs some radiation and a minor conversion of state take place. This change of the state of explosive is observed with the help of thermal camera and an image is being created describing the heat signatures of area. Substances that resonantly absorb this wavelength will absorb light more efficiently than the rest of the surface, and the subsequent IR radiation provides a thermal contrast to the surrounding surface. As an optical technique, it is complementary to, but distinct from, other approaches in the literature. In this letter, the 6.25 µm wavelength has been used. This is more than adequate as modern IR technology has a detection limit of 20 mK. This rapid response enables the photothermal technique to quickly distinguish analytes of interest. This technique is so much expensive and not easy to set up. Also, the thermal response recorded by thermal imaging camera depends on the surrounding of explosives.

Ramakrishna P. etal [3] – In this paper the radar technique is used to detect the landmines. This technique is used for only detecting the landmines. This can't be used for IEDs or any other kind of explosives. The Ground Penetrating Radar (GPR), is an ultra-wide band radar provides centimeter resolution to locate even small targets. There are two distinct types of GPR, time-domain and frequency domain. Time domain or impulse GPR transmits discrete pulses of nanosecond duration and digitizes the returns at GHz sample rates. Frequency domain GPR systems transmit single frequencies either uniquely, as a series of frequency steps, or as a chirp. The amplitude and phase of the return signal is measured. The resulting data is converted to the time domain. GPR operates by detecting the dielectric contrasts in the soils, which allows it to locate even non-metallic mines. The major components of GPR are impulse resonator, antenna system, A/D converter, visual display and some sensors. Although GPR has been shown to be effective on the test track against a variety of land mines in a range of soil conditions, it is technologically complex. The weight and power requirements are not overwhelming, but they make GPR most easily deployed on a vehicular platform. Also, in reality, the signals originating from various types of ground surfaces, like soil or clay, are nearly indistinguishable from those of the genuine landmines. Thus robust and intelligent approaches for the problem are needed.

Doug Few etal [4] – In this paper a highly cutting-edge autonomous system is used for the detection and countermeasure of landmines and IEDs. This effort is commonly named as CMMAD (Countermine, Mobility, Marking, Autonomy and Detection). This project is a part of AMDS (Autonomous Mine Detection System and Risk Reduction Program) which is funded by U.S military. The AMDS program seeks to produce an autonomous mine detection vehicle that achieves the same performance of a handheld mine detector. The primary focus of the AMDS program is on the development of novel sensors and data processing algorithms capable of detecting mines which in future phases of this program can be integrated on existing and future robotic platforms. A secondary focus is the reduction of risk associated with the integration of such sensors on robotic vehicles. The architecture of this system is based on consideration of likely configuration of futuristic systems. Such system will consist of a robotic vehicle equipped with sensors required for navigation and marking, one or more

countermine sensors (likely having both GPR and EMI sensing modalities), a countermine sensor manipulator, and a number of integrated software packages which would provide for real time processing of the countermine sensor data as well as control of the robotic vehicle. This system promises detection of any kind of landmine or IEDs containing explosives and taking countermine measures to diffuse or displace that explosive from remote areas.

Ahmed Ismail etal [5] – In this paper the various strategies has been stated for the detection of landmines using robots. Robots search mines with such a low pressure that mine explosions are not triggered. In order to cover efficiently all mined areas, robots should adapt to accelerated exploration in order to increase efficiency, especially if any surveillance team exists. Using robots in landmines detection provides the ideal sensor for robots due to its low cost, wide availability, high data content and information rate. For highly dynamic adversarial tasks, being able to extract significant information about the world is crucial to operating effectively, making vision an appealing sensor done. The first step is to detect the location of the mines. The second step is to deactivate or destroy the mines. Searching for the location is the process that takes the most amount of time. This is because, every single inch of the land needs to be manually and carefully probed with a mine detector. However, in this method has some drawbacks that the level of false alarms may be made arbitrarily low and the system's complexity.

Hajime Aoyama etal [6] – The authors in this paper successfully developed and tested a mine detection cutting-edge robot. The body of robot had a simple ladder structure consisting of two square pipes as its main frame, and square pipes and channel material as cross members, which requires least number of reinforcements. Axles were penetrated through the main frame, and four independent crawlers were mounted, one for each axle on both sides of front and rear. A hydraulic motor was fitted to each axle via coupling. The weight and size of the robot were limited to within the load capacity and the cargo bed with 3800mm in length and 1900mm in width of a two-ton truck. The robot also consist of two movable sensor arm and the detection of mines is done by SAR-GPR (Synthetic Aperture Radar-Ground Penetrating Radar) system. The mine sensor arm worked at a constant speed with a weight capacity of 35 kg without any problem despite its extension by 400 mm, meeting the specification required for the mine detection sensor.

Iraky Kalifa etal [7] – The authors of this respective paper aims to develop an extremely low-cost mine detection robot. The robot consist of a basic plastic body robotic vehicle consisting four dc motors and a controlling module with a GPS for tracking and marking of landmines. This system can only work for the simple metallic landmine. This system is relied on a smart cellphone based on Android OS and the professional metal detector application for smart cellphones, there is no need to insert a SIM card into this cellphone, it attached to the movable fiber arm for a perfect detecting process and the metal detector application stimulates the magnetic sensor built-in the smart cellphone that based on Android OS to acts as a specialist scanning tool, the smart cellphone scans the surrounding area and sends the data to the controller on a laptop. With the help of GPS the exact location of the mine can be received and the coordinates can be save while going for the clearance of those detected mines. This solution is completely based on using minimum technology and creating a cheap detection system which can be used by poor countries.

3. Comparison

Table 1. Summary of Performance Evaluation of Common Sensors

Sensor Technology	Maturity	Cost & Complexity
Prodder	Available	Low
Metal detector	Near	Low
Infrared IR Imaging	Far	High
Chemical Vapor sensing	Fair	High
Passive MMW	Near	High
GPR	Near	Medium

4. Conclusion

The landmines are the major crises in the world due to which millions of people are in terror of landmines and no faithful systems are practically available to tackle this problem without involving danger to human-life. A complete study has been done about the various technologies and system which are under research and can be used to against terrorism. However more study is needed to determine the range and mechanism of dispersal of landmine signatures in the environment. The sole purpose of our effort to have unmanned autonomous system which can give promising detection without causing threat of explosion to human life can be feasible and deployable in remote areas.

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