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Mine Clearance Techniques and Technologies for Effective Humanitarian Demining

By Maki K. Habib, School of Engineering and Science, Monash University, Bandar Sunway, Selangor, Malaysia

Introduction

The removal and the destruction of all forms of dangerous battlefield debris—particularly landmines—are vital prerequisites for any region to recover from their impact. These tasks involve a great deal of effort and time, and high risk, all of which result in high clearance cost per unit area. Many conditions have to be observed, such as soil, topol­ogy and type of contamination [1-7, 10, 11].

The major effect of mines is to deny access to land and its resources, causing deprivation and social problems among the affected populations. In addition, the medical, social, economic and environ­mental consequences are immense. The United Nations Department of Human Affairs (UNDHA) assesses that there are more than 100 million mines that pose significant hazards in more than 60 coun­tries around the world. Many types of mines exist around the world, including more than 650 types of AP landmines (1,2,5). AP mines are harmful because of their unknown position and because they are often difficult to detect.

Humanitarian Mine Clearing “Demining” Phases

The landmine clearance process can be divided into the following basic phases:

1. Locating and identifying a mine field in 10 to 20 minutes.

2. Preparing the mine field for the clearance operation, which can include cutting vegetation, collecting metal frag­ments from the surface, etc.

3. Locating and marking individual mines within the identified area.

4. Using different types of detection of the de­tected mines by neutralization (either re­moval or detonation).

5. Enforcing quality control measures.

There is a need to verify that the cleared area is free from mines with a high level of confidence.

A clearance priority rating should be given to each mapped mine field by taking into consideration factors of a social and economical nature, as well as those related to weather and ground conditions. It is necessary to associate this step with a mine awareness program, which aims at reducing civilian casualties caused by mines and other explosive devices. Locating the contaminated land will help to separate the danger from people and to make the unminanted land available for use immediately.

Solutions and Priorities

Current demining technology is slow, expensive and dangerous, and it can only cover a few hundred square meters per day. It becomes urgent to develop detection (individual and area), identifi­cation and removal techniques to increase the efficiency of demining operations by several orders of magnitude to achieve a substantial reduction to the threat of AP mines in a reasonable time frame and at an affordable cost.

The priorities for research and de­velopment in the humanitarian demining field require strategies that should start with the following needs:

• To develop reliable and accurate techniques that can enhance the performance of the demining process and al­low efficient area detection of landmines. There is an urgent need to recognize and reliably locate mine fields and isolate them by defining proper signs and limits to make the public aware and to avoid further accidents.

• To have quality training programs that fit the needs of local environments. Such training programs need to integrate cultural, environmental and operational considerations when developing.

• To enhance the safety of deminers by providing them with suitable cloth­ing and equipment and by isolating them from direct physical contact with mines.

• To enhance the performance of the sensor and the deminer.

• To have light, reliable, easy-to-use handheld multi-sensor systems to support clearance in difficult and narrow environ­ments (woods, uneven terrain, residen­tial, etc.) and vehicle-based systems to support mine clearance in open areas.

• To use information and commu­nication technologies to enhance contact, experience, research, data sharing results and data among all parties and personnel within the demining community.

• To have mechanized mine clearing, however, it would be better to find a technology that can detect and mark mines without having to cut vegetation.

• To speed up the mine detection process with an array of sensors that can be integrated to cover wider areas.

• To automate/mechanize detection and removal of mines and to improve deminer safety through the use of ef­ficient, reliable and cost effective humani­tarian mine action equipment (such as robots, flexible mechanisms, etc.) with minimum environmental impact.

• To have efficient quality control methods that are reliable and accurate in ensuring that an area is clear of mines.

Demining Approaches and Techniques

The demining methods currently being used are not safe for those clearing the mines or for those who must occupy the land after it has been cleared. The methods are neither cost effective nor ef­ficient. Mine clearance itself can be ac­complished through different methods with varying levels of technology, but the most laborious way is still the most reli­able. We should favor technologies that can be manufactured in mined countries, that are transferable and that provide employment and economic infrastructure where it is most urgently required.

Manual Demining

Manual Demining is a procedure in which mines are manually detected and neutralized by a human deminer [1-5]. The deminer first scours the ground with a metal detector. Then the deminer uses a prodger in order to feel, locate and iden­tify the object causing the signal, after which the deminer carefully uncovers it. When operating in this way, the detection phase still relies heavily on metal detectors, whereby each alarm needs to be carefully checked until it has been fully understood and/or its source removed.

Most mines contain enough metal to be detected by this method, however, only about one in every 10 000 signals detected belongs to a mine or UXO. In general, the ground being cleared is often satu­rated with metal fragments, scrap and cars, making manual demining methods slow, extremely dangerous and expensive. Complicating matters more, about one third of all AP landmines currently deployed are metal free. The accuracy of metal de­tection depends heavily on the level of mineralization and debris in the ground.

The type of mine used and the time needed to clear land varies enormously, depending on local conditions.

The Use of Animals, Insects and Bacteria

So far, dogs are considered the best detectors of explosives. Their sensitivity to this kind of substance is estimated to be 10,000 times higher than that of a man-made detector. Specially trained dogs are used to detect the characteristic smell of explosive residue that emanates from mines regardless of their composi­tion or how long they have been implanted. This enables the dogs to detect mines with low metal content that are undetect­able by metal detectors. In addition, be­cause dogs do not respond to metal, soil or non-explosive objects, they eliminate much of the time-consuming shortcom­ings of manual detection techniques.

Mine detection dogs can work in almost all types of terrain. They are also easy to transport and highly reliable, and they can screen land up to five times faster than manual deminers. South Africa and Af­ghanistan have reported successes, but it was more in locating the edges of mine fields than in finding individual mines. Dogs can be overwhelmed in areas with dense landmine contamination. Mor­eover, they can only work for short peri­ods each day (about a couple of hours a day). Dogs can become confused if they can smell explosive coming from several sources at once. The effectiveness of the dogs depends entirely on their level of training, the skill of their handlers and on their correct use.

Trained rats may be the best and cheapest detectors of landmines, but they do have certain advantages over dogs. They have a better sense of smell, are cheaper to keep and maintain and they are more...
In small parks or thick bush, such machines simply cannot maneuver. These systems are employed for mine verification and area reduction tasks. Mechanical probes (e.g., inductive detectors, mechanical scrapers) have been suggested as mine detectors, and some are effective in finding mines. So far, no large literature has been seen describing any tests or trials. An additional technology for getting rid of landmines is the remote controlled vehicle (RCV or its current batch of robots). This batch of robots, which is now under field study at Oak Ridge National Laboratories (ORNL) may take advantage of the same concepts: genetically engineered bacteria that are also being used in waste management technologies. These bacteria can be genetically engineered to glow in the presence of certain compounds, including explosives.

Mechanical Demining

Mechanical approaches rely on the use of motorized mine-cleaners whose designs is influenced by military demining requirements. Mine-cleaning devices are designed to clear not only a navigable path through a field rather than remove all the mines in the area. A number of mechanical mine-cleaners have been constructed or adapted from military vehicles or armored vehicles of the same or similar type, with the same or reduced size. These are designed to operate in mine-clearance systems (such as armored vehicles, plows and rakes) near mines or force them to move along a path of heavy machinery. Mechanical clearance may be used in large areas (agricultural areas, for instance) and favorable terrain such as flat, sandy areas with no dense vegetation.

Robots and Humanitarian Demining

Most people in the mine clearance community would be delighted if their work could be done remotely or, even better, robotically. The benefits of remote-controlled mine detection, removal, or neutralization are clear. Clearly, it is difficult to design a universal robot/machine that is applicable to different types of terrains and works at different environmental conditions to meet demining requirements. The high cost and sophisticated technology used in robots need to be balanced against the added cost and possible reduction in efficiency. A cost analysis should be conducted to determine if the cost of remotely controlled vehicles is justified.

Properly sized robotic solutions with a suitable modularization and structuring of tasks that are well adapted to local conditions of mine fields can greatly improve the safety of personnel as well as the efficiency, precision, productivity, and success of the work. Solving this problem presents challenges in robotics and mechanical and structural design. There are many robots being designed by researchers worldwide. The use of many robots coordinating their tasks over the landscape will improve the productivity of overall mine detection processes through the use of team cooperation and coordination (7, 8, 14). One benefit would be increased safety by removing the operator from the hazardous area. There are still some doubts whether such equipment will operate as effectively when the operator is at a distance or has been removed altogether. There is little value in a system that makes life safer for the operators but fails to protect the environment and the deminers. In addition, there is a need to have simple, flexible and user-friendly interaction that allows safe operation without the need for extensive training. Furthermore, careful study of the limitations of any tool with regard to the location, environment, and soil composition is critical for the development of such tools. Technical operation and maintenance skills is important, as is remembering that not all high-tech solutions may be workable in different soil and environmental conditions. The development phase of new technologies requires a well-established technical infrastructure to develop and test the new technologies under actual field conditions to specify benefits and limitations of different methods. The work must be verified in cooperation with multiple organizations and the users of the equipment, and the real deminers should carry out the test at a real site. This will ensure that the developments are compatible and that there are no obstacles in the context of humanitarian demining and that the technology is fulfilling user requirements. Also, there is a need to have a reliable set of global standards for assessing the availability, suitability and affordability of technology with common information tools that allow for these assessments and evaluations. This can be enhanced by benchmarking the performance levels to develop equipment, systems and algorithms. (5, 11-13)

The idea of developing multi-sensor systems involving two or more sensor links to computer-based decision support systems with advanced signal processing techniques is attractive and is advocated by many as a fruitful line of development. In addition, there is a need to complementary sensor technologies that and have an appropriate sensor data fusion. A critical need is the ability to distinguish fragments or stones from the target material in real time.

Conclusions

Due to the complexity of the landmine problem and poor coordination of new technologies, development and field requirements, a well-coordinated plan needs to be developed in international, regional, national and organizational levels to address the issue of humanitarian mine clearance. Any single development in technology should be viewed as yet another tool available for use in the demining process, but we must be aware that the tool may be appropriate under all conditions. All of the above-mentioned approaches of humanitarian mine clearance are effective and practical in specific circumstances. A Tool Box approach has to be adopted, and different procedures and technologies have to be used for the clearance of different types of landmines. If the international community must act to foster and further these research programs and coordinate their efforts in order to provide mine clearance personnel in the field with technologies, real deminers, policies and standards that can enhance the effectiveness, cost efficiency, reliability and safety of humanitarian mine clearance.

References


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