Land mines detection, mapping and clearance using Quadcopter in Yemen: A perspective study

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***Abstract*— People who live or work in areas where there have been armed conflicts may face the threat of landmines and explosive hazards, such as unexploded or abandoned ordnance, abandoned military vehicles, and equipment. Therefore, this is a tremendous obstacle to development and construction in such areas, which requires awareness of the threat and appropriate preventive action. This paper aims to facilitate the detection and elimination of planted landmines in Yemen. Two stages are proposed to be implemented in this study for the demining techniques: detection and clearance phases. The first phase uses a Quadcopter with detecting sensors to locate and map the mines' spot, while the second stage uses a Quadcopter to unload a mass on that determined location from a certain height. By employing these two stages, it is expected to quickly and accurately detect the locations of landmines. That will reduce risk, protect human lives, and provide a more efficient and safe way to sweep minefield workers using sample, small, and easy control equipment.**

Keywords—*Land mines, Quadcopter, Detection, Sweeping and Clearance, demining techniques.*

I. Introduction

According to a report by the International Campaign to Ban Landmines (ICBL), there were more than 73,576 casualties caused by mines in 119 different countries between the years 1999 and the end of 2008. Reports estimate that more than 100 million landmines are buried throughout about 3,000 km2 of land worldwide [1], [2]. A negative impact on economic growth is caused by buried landmines [1].

Yemen has encountered great social and political unrest that has brought about contention and resulted in destruction all over the country since 2015 [2]. As a result of this conflict, there have been widespread and urgent humanitarian and developmental crises and significant damage to health and education systems, the economy, service provision, and physical infrastructure [3]. It has also caused hundreds of thousands of deaths, many of which directly result from war violence, mine plantations, and explosions [4], [5]. According to the Landmine and Cluster Munition Monitor, there have been 9,118 known casualties in Yemen as of 2017 [6]. However, the number does not distinguish between those injured and killed by landmines or other explosive remnants of war (ERW). The cumulative number of landmine survivors was undoubtedly much higher. The ongoing conflicts since 2015 may have tremendously contributed to the spread of landmines and ERW [7]. A decision should be taken to enhance the development of a national landmine detection program, and a comprehensive assessment of the mine-affected country will be needed. This assessment will need to be continually updated. Existing programs should also continually assess the country's general mine and ERW situation [8].

The need for trustworthy landmine inspection systems is only expected to increase. The removal of these landmines is complicated by several factors, including the loss of maps or information about the landmine types or their initial areas, the movement of landmines to new locations as a result of environmental and physical factors, the vast number of different types of antitank (AT) and anti-personnel (AP) landmines, and the high cost of locating and removing landmines. These factors all work together to make the removal of landmines difficult. Because landmines are more likely to detonate over time or in response to climatic conditions, they represent a significant threat to persons [9].

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Figure 1: Land mine devices are hidden underground [1], [10].

A landmine is a self-contained explosive device placed on or into the ground to damage or ruin vehicles and wound, kill, or restrict people's activities [11]. These devices are almost always concealed and covered to blend in with their surroundings, making them difficult to identify and locate, as shown in *Figure 1* [12]. The term "demining" refers to the process of locating and removing hidden landmines, and numerous methods have been conceived and created for this purpose. Depending on the type of landmine case, the explosive substance, and the soil, each technique can be useful for landmine detection in some environments and under certain circumstances. A sensor, a signal or image processing unit to arrange the acquired data in a format suitable for detection, and a decision-making unit to decide whether a landmine exists are the three primary components that make up the majority of landmine detection techniques. In general, the majority of landmine detection methods consist of these three primary components.

In addition, post-conflict damage from weapon remnants and land mines is always a concern because it indirectly affects development, causing long-term harm to human and social development [5], [12], [13]. Because mines are manufactured from different types of explosive materials, a landmine detection system should detect them [11]. Several common yet primitive methods for mine detection are used, including simple visual inspection, advanced robots, multi-sensor-equipped vehicles, classical mine prodders, hand-held metal detectors, ultrasound techniques, thermography, biological sniffers, and Ground Penetrating Radars. Many of these methods still need to meet acceptable standards for detecting mines in any area [10], [11], [14]. Lastly, the overall problems can hugely condition the process; settling and using high technology in countries with extremely underdeveloped infrastructure will connect with the stringent time limit and solve a challenging task.

Therefore, in this study, we propose two different stages of mine detection to solve the issues of detection and clearance. These two new demining techniques can surpass the efficiency of the current techniques in this mission with less human potential.

II. Methodology

The nature of the design, structure, and components of landmines is crucial for us to understand so that we can create a device that could fix this problem. Land mine designs utilize as little metal as possible, making it more challenging to search for land mines using a metal detector. Land mines that are primarily comprised of plastic have the additional benefit of being relatively inexpensive [14]. Various stimuli, including pressure, movement, sound, vibration, and magnetism, can set off a land mine. In order to prevent enemy engineers from detonating the mine, the primary trigger on many mines is combined with a touch or tilt trigger. The pressure of a person's foot is typically used as a trigger for anti-personnel mines; however, tripwires are also regularly utilized in this context. Most of today's anti-vehicle mines are equipped with magnetic triggers, allowing them to go off even if the tires or tracks do not contact them. Mines of a higher technological level come equipped with a signature catalogue that enables them to recognize the difference between friendly and hostile types of vehicles. That will, in theory, make it possible for social forces to utilize the mined region while simultaneously restricting access to the enemy.

This study proposes the application of the advancements in Quadcopter technology in the field of minesweeping. To meet this task's requirements, the Quadcopter needs to be equipped with extra proximity sensors and enhanced by Simultaneous Localization and Mapping (SLAM) technology [15]. The proposed scheme can initiate the search task and plan the entire process and autonomously search large suspected fields. The Quadcopter will be guided by a compass, gyroscope, and accelerometer onboard to a specific area of the target field. As a result, the Quadcopter will be able to follow the lawn-mower path generated by the onboard navigation equipment.
The working procedures can be divided into two main phases; the detection phase and the sweeping or clearance phase.

A. Detection phase

This mine detector combines an electromagnetic induction sensor and ground-penetrating radar (GPR) to detect landmines. The detection device will be mounted at the end of an arm that extends from the Quadcopter's bottom surface, see *Figure 2*. In the detection phase, the Quadcopter will fly near the ground according to the predefined height to provide the necessary distance for the sensing device to detect underground mines. Adding the GPR reduces the detector's false alarm rate and the amount of time the operator spends analyzing clutter, boosting the operator's speed and efficacy.

Once it detects a mine, it will mark that spot by releasing coloured marking powder or save the coordinates of that spot on the local map to be handled later in the next stage. When sweeping the suspected field, the Quadcopter will follow a lawn-mower path to ensure the searching process covers every spot on that field [16], [17].

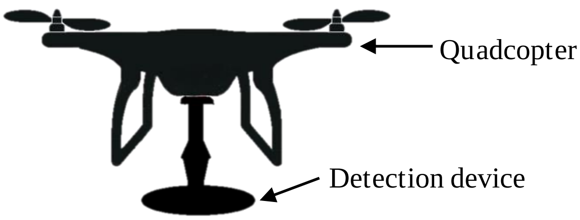

Figure 1: Landmine's detection phase design

B. Sweeping and clearance phase

For the land mines clearance phase, the Quadcopter will be loaded by a mass of a certain weight and hover over the marked spot before it unloads the carried weight on the detected mines. By dropping this weight on the mines, the decreased weight will provide the required mechanical contact for the mines to explode. For convenience, the load can be spherical and made of rubber to ensure it hits (presses) and releases the targeted mines. *Figure 3* shows the mechanism sketch and the operation scenario.

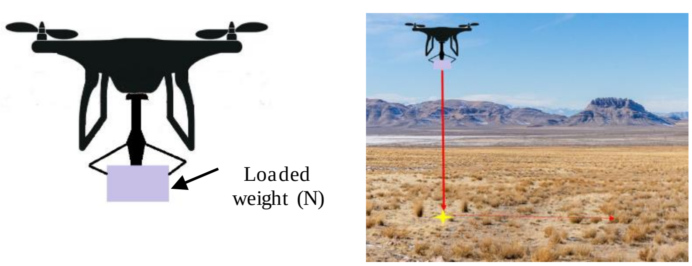

Figure 3: Landmines sweeping and clearance phase design

III. Expected Results

This proposed approach uses state-of-the-art technology and up-to-date equipment to deal with the current devastating issue in Yemen due to the ongoing conflicts. Implementing and developing this technique is expected to save many human lives and protect the sweeping minefield workers from any potential harm and injury from the explosion of these remnant weapons.

The main contributions of this work are:

1) Applying the Quadcopter technology in the field of minesweeping;

2) Proposing the proper technical modification and adjusting the current features to meet the new working environment and achieve the required tasks;

3) Proposing a new, convenient, safe approach to handle the randomly widespread landmines.

The removal of landmines around the world necessitates a course of action that is imperative and of paramount importance. Yemen is one of the countries whose death toll has risen exponentially as a result of the unaccounted-for use of more than a million landmines. According to the findings of various studies, annual land mine deaths are estimated to be more than 4800 [18], [19]. Land mines can also threaten the transportation of large vehicles on public roads [18].

We have developed a prototype to detect landmines using an unmanned drone, considering the various implications. The prototype incorporates the following concepts: A quadcopter is a multi-rotor helicopter powered by four motors that can fly at high speeds. In contrast to most helicopters, Quadcopters are constructed from two pairs of identical propellers, two of which rotate clockwise and two of which rotate counterclockwise. This work presents a working paper for landmines sweeping and clearance projects for post-war Yemen, expecting to be applied everywhere with its surpass features, including the capability of detecting and sweeping a larger and hard-to-navigate environment within high speed in less time.

IV. Conclusion

Traditional demining techniques suffer from various problems, the most notable of which are the risks posed to the deminer, the slow speed, and the high unit cost. The only way to advance the demining process considerably is to develop detection devices that can rapidly and precisely locate hidden landmines. The interpretation of sensor data for landmine detection is a difficult task. That is because of a low signal-to-noise ratio, changing environmental conditions that influence measurements (humidity, temperature, the composition of the soil, etc.), and the existence of other natural or artificial objects that give sensor readings similar to the landmine. In addition, the task is complicated by the existence of other natural or artificial objects that give sensor readings identical to the landmine.

Landmine detection is a complex problem because it requires developing effective techniques and adapting them to specific local conditions. Therefore, developing a new approach that meets this requirement is necessary. Therefore, this paper presents a perspective idea of the proposed two phases of mines detection and clearance. The proposed method is a recent and advanced technology believed to achieve remarkable outcomes and outperform other classical techniques.

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VI. Conflict of Interests:

None

VII. References

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