

OVERVIEW AT MODERN MINE DETECTING ROBOTS

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Abstract: In this article, main robotic solutions for mine detection and demining were reviewed using such criterias, as approaches to detection and demining, types of utility tools and mechanical parts. As result, the general view at types of mine detecting robots and distribution of their use case amounts was gathered

Keywords: BOZENA, explosives, GPR, demining, landmine, mine, mine detection, robot.

ОГЛЯД СУЧАСНИХ МІННОПОШУКОВИХ РОБОТІВ

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Анотація: В даній роботі розглянуто різновиди роботів для знаходження та знешкодження мін на основі таких критеріїв, як способи розпізнання мін, їх знешкодження, види допоміжного обладнання, а також види механічних частин. В результаті, було отримано загальне уявлення про види міннопошукових роботів та розподіл кількості їх використання.

Ключові слова: BOZENA, вибухові речовини, радар глибинного дослідження, розмінування, міна, пошук мін, робот.

INTRODUCTION. According to [1], Ukraine is ranked second among the amount of injured by mine explosions. It occurred due to the huge stashes of anti-infantry devices Russian Federation possess in combination with its eagerness to use them without regards to universal practices. Furthermore, it is a common practice to see explosives even far from the places of main battles: explosives can be placed in the toys and left on the streets of Ukrainian cities by infiltrates. As a result, Ukrainians must put their time and efforts in lowering the risk of civilians to be exploded.

The process of mine demolition consists of three steps [2]: detection, neutralization and utilization. Usually, an expert is called to perform each step, however it is anyway dangerous to get into the area with a trap for human: the most attentive can get caught. Moreover, mines can be placed on vast distances, such as corners of crop field, or places inconvenient to reach, like dense forest. In such cases, better to risk a carcass of a machine instead of human being.

But what should the machine be like to perform its task the best? One way is to analyze the existing alternatives to either spot the ways to improve them or find the inspiration for a new one.

TYPES OF EXPLOSIVES. To understand the requirements for demining robots, common explosives to be seen must be observed. According to figure 1, most widespread explosives are in general metal, different in sizes: from aviation bombs to handheld grenades. The proportion between size and explosive power also vary: the devastation from fragmentation mines is bigger in comparison with a grenade of the close sizes.

SENSING. Initially, landmine must be detected before the removal. This process can be done in several ways, depending on the type of the explosive to locate and features of surrounding terrain. The most common approaches are represented on figure 2.

Demining systems like Bozena [3] are most common to be seen among the robotic solutions [4] for demining services due to the efficiency of such machinery for demining vast open areas, such as crop fields. Such machinery possess tillers and flails (figure 3a-b), which both used to intentionally activate the mine, under the cover of hood. Despite their productivity, such robots cannot be used on non-flat areas or one with number of obstacles, like trees or buildings. Also, such systems are typically more expensive because of the required huge sizes and mass.

On the other hand, robots with mine detectors and ground penetrating radars (GRPs) can be both compact enough to pass in areas full of obstacles. Metal detector can find explosives with a help of (electro-)magnets, while GRPs send radio waves, that reflect only from the non-soil object, such as landmine. While metal detectors are usually enough to detect most types of explosives, GRPs can detect plastic one, which can be useful sometimes. Unfortunately, both systems are prone to false positive detections [5], which creates demand for alternative detection methods and advanced classification algorithms.



Figure 1 – Most common explosives, seen on the territory of Ukraine

a) – mortar shells; b) – artillery shells; c) – hand grenades; d) – cluster munitions; e) – anti-tank remote control mines; f) – ballistic missiles; g) – shards of fragmentation grenades; h) – aircraft missiles; i) – anti-tank guided missiles; j) – jet missiles; k) – anti-personnel fragmentation mines; l) – anti-personnel landmines; m) – trap mines; n) – high explosive anti-tank mines ; o) – aircraft bombs [6]

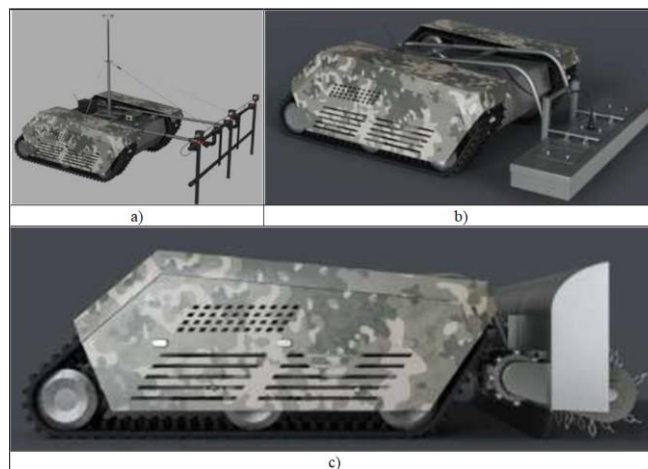


Figure 2 – Main types of landmine detection [7]

a) – radiolocation; b) – magnetism; c) – detonation

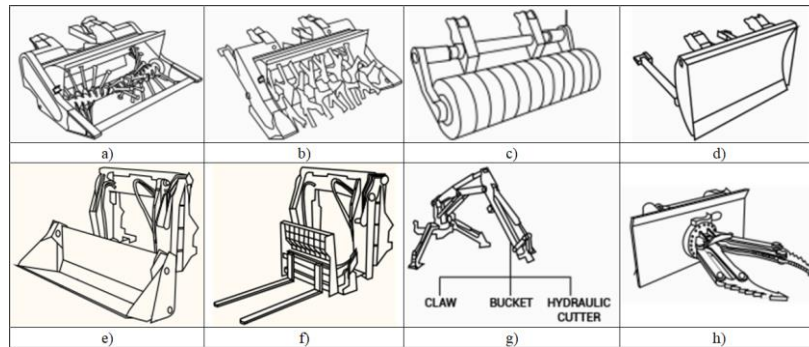


Figure 3 – Equipment of DOK-ING MV-4 demining system

a) – flail; b) – tiller; c) – segmented roller; d) – dozer blade; e) – rear shovel; f) – rear forklift; g) – EOD arm; h) – rotational gripper [8]

According to [5], there are also other detection methods, however most of them are either analog to the mentioned systems (nuclear quadrupole resonance systems send radio waves to detect specifically ^{14}N nuclei, X-ray backscatter systems send X-ray waves instead of radio ones, acoustic systems send out sound waves instead of electromagnetic, etc) or too specific to use in general cases (vapor sensors detect the mine only if a vapor of explosives gets to the sensor).

Despite sensing the landmine itself, robot should also get the data for movement planning. To do this, demining robots are usually equipped with cameras [5, 9] and LIDAR system.

ACTUATION. As it was shown on figure 3, demining robots can have parts of actuation, which are used either for landmine-based operations or area preparation activities. If robot is dedicated to demining in addition to mine detection, then it is usually equipped with flail or tiler for direct detonation (figure 3a-b) or manipulator (figure 3g) [10].

Other actuators are mainly used for terrain preparation: dozer blades are used for earth moving, rotational gripper – for obstacle removal, etc.

According to [11], most of demining robots are wheeled, either with tracks or without them (figure 4a)

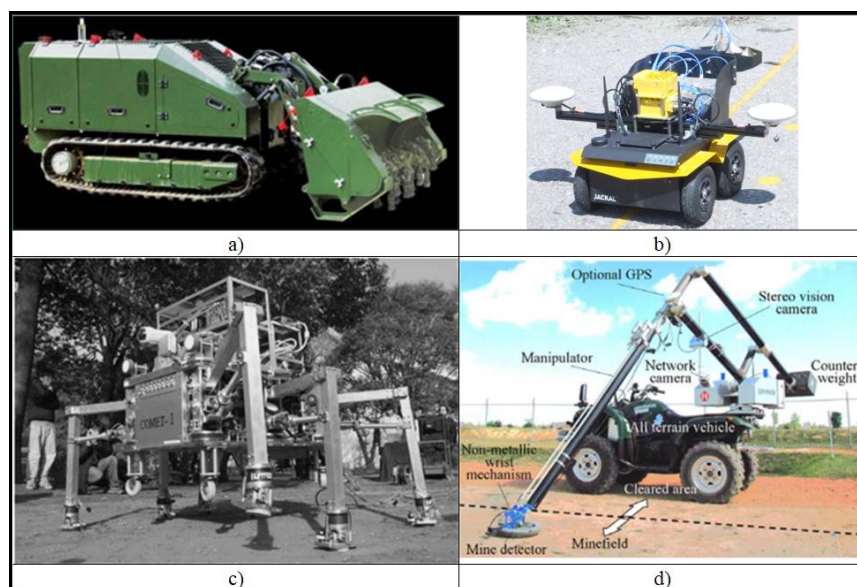


Figure 4 – Some types of demining robot structures

a) – DOK-ING MV-2 [12]; b) – JACKAL by clearpath robotics [13]; c) COMET I [14]; d) – Gryphon [15]

Some other types of robots exist, but they either have significant drawbacks, that do not allow for them to be used on daily base (COMETs are huge and heavy), or just were not polished enough in comparison with competitors.

CONCLUSION. In the scientific realm, there are numbers of solutions for mine detection and disposal, however practically only some solutions are applied on a regular basis. Such robots are usually track wheeled devices, either of human height sizes, armed with direct detonation devices and utility tools for landscape modifications, or of compact dimensions, armed with mine detector like magnetic one or GRP, and sometimes with manipulator for demining. Even though other structures exist, they are implied seldom, if not only on the territory of the research field.

However, the first sappers were unlikely to imagine the ways their instruments would develop in decades, and so we can not to imagine completely the demining devices of future. Thus, new land clearance solutions should be tried, notwithstanding the amount and types of solutions, widespread nowadays.

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