LOADS AFFECTING UGVs' TECHNICAL STATUS

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Abstract: *There are many new initiatives and scientific research on autonomous ground vehicles (AGV). New applications forecast a new era when autonomous vehicles start to take part in more complex traffic situations, i.e. they are ready to execute their mission although in pick-time, or, in military applications they are ready to execute missions autonomously in their pre-programmed missions. If to combine those two techniques of unmanned aerial vehicle (UAV) and unmanned ground vehicle (UGV) one can get benefits from integrating two platforms into one, supporting for example the border control units answering challenges of the modern epoch. The article provides an overview of the history of robots. The second chapter describes the history of UGVs. This chapter starts with the presentation of the remotely controlled vehicles from the Second World War and finishes the history with the DARPA robot, which used artificial intelligence (AI) in the 1960s. The study also contains information about the autonomous ground vehicles. Authors will derive a set of the loads of the UGVs during their use.*
Keywords: *AGV, UAV, UGV, Robot, Maintenance, Load.*

1. INTRODUCTION

Military and industrial researchers try to use more and more automatic applications in practice. They have lots of reasons why they want to use them. Few times later we can use robots in different types of jobs, and in different missions. These kinds of missions can be very dangerous, boring and/or monotonous. That means users will use robots in the air, on the land, under the water, and also in space both for governmental, and non-governmental applications and purposes.

Nowadays a lot of institutes, factories, hospitals and military facilities use different types of UGVs. These robots are not only used inside the facilities. We can meet them in different areas outside the buildings. This multi-purpose UGVs causes different and unexpected events during their operations.

This paper would like to describe why it is important to use robots in our daily work. The study also incorporates a chapter about the history of the UGVs, and describes a problem about the daily operations of the UGVs.

2. HISTORY OF ROBOTS

First of all, we have to know some information about the word 'robot'. Szabolcsi in his works [1,29] gives a new approach to find the origin of the word 'robot'.

The first robot word was used by Karel Čapek. He used it in his work titled Rossum' Universal Robots (R.U.R.) written in 1920. The word 'robot' came from the Czech word 'robota', meaning unpaid work. [1,2]

We can find the roots of the automation technology in the 18th century. That was the century of the First Industrial Revolution in England. Sir Richard Arkwright invented different types of machines like the automatic weaving and spinning machines, which he used in his own factory. The machines first used water power, and later steam engines. [3,4]

Latter in the 19th century Charles Babbage invented an analytical engine. It was the idea of the first reprogrammable computer in the world. [5,6] This machine can be seen in Figure 1.

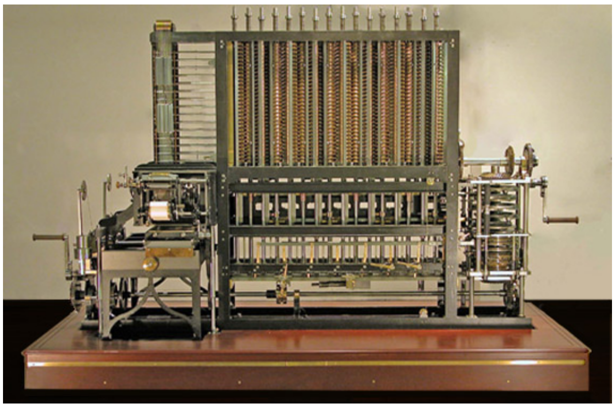

Fig. 1 „The Babbage Engine" [5]

Nikola Tesla, the Croatian-Serbian-American mechanical and electrical engineer who open new dimensions for automation of the technical processes. Tesla invented the first polyphase induction motor and the first electrical motor to run on alternating current. [7]

In the middle of the 20th century the vehicle industry put a lot of energy into robot development. A lot of robot manufacturer companies were born in this period, like FANUC, KUKA, ABB (Asea Brown Boveri). [3,8,9,10] The first robots could work on a known way that they got in their program before the first use. In the early years, robots didn't use any artificial intelligence (AI) technology. Robots were used only for highly precise and/or monotonous operations. Latter robots were used not only by car manufacturers. The developers understood advantages of the application of robot technology. Different kinds of industrial areas started to use them like logistics, or chemical industry. [3,11]

Another important thing about the robots was the costs of the production at the factories. If the companies use robots, they can produce their goods at lower prices in a better quality and, the same time to reduce the amount of losses. If to analyze industrial production supported by robots, or any other kind of activity executed by robots one also have to think about the HR (Human Resources) costs. When companies use robots in the manufacturing, or in the logistic areas one can find lower costs of hiring, training, working clothes, tools and any other personal costs.

All these costs are often called for hidden ones because they are often forgotten while calculating the return costs of robot investments. [3,12,13]

First definition of the industrial robot is available in ISO 8373 standard, accepted worldwide by users. [14]

3. SHORT HISTORY OF THE UGVS

The UGV is a vehicle which operates on the ground without human presence on its board. These kinds of robots can be used for many applications which may be D3-ones (Dirty-Dull-Dangerous) for the Human (assault, defense, minesweeper etc.). The UGVs use different types of sensors and cameras which send signals to its control stations. The new generation of UGVs uses artificial intelligence (AI) technologies during their work. Figure 2 presents a TALON UGV, which is a type of military UGVs. [15]

Fig. 2 Talon UGV [16]

The first UGVs were built in the 1930s and the early 1940s by the USSR (Soviet Union). The name of this UGV was Teletank. It was a series of wireless remotely controlled unmanned tanks. This tank was used in the Winter War during the Second World War (1939-1941). [17]

Worth mentioning that not only the Soviet Union has used remotely controlled machines. The British army used a radio controlled prototype of MATILDA II (Figure 3.) in 1941. This kind of tank got the Black Prince code name. [18]

Fig. 3 MATILDA II [18]

During the Second World War not only the allies tried to use remote controlled weapons. In 1942 the Nazis developed a new small remote controlled tank. The tank's name was GOLIATH. (Figure 4) [3,19]

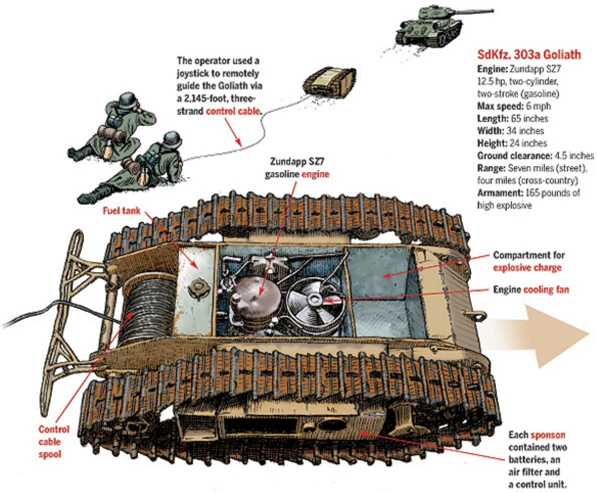

Fig. 4 GOLIATH [19]

The GOLIATH was controlled by cable and it carried approximately 60 kg explosive material. The Nazis had more weapons which are the ancestors of the modern ballistic rockets. They were the V1 and V2 rockets. [3,19]

As we can see, these kinds of robots were controlled by humans with cable or with using radio technology. The focus of mobile robotic research was moving towards the discipline of artificial intelligence (AI). The first „modern" mobile robot was SHAKEY, which was developed in the late 1960s. It was a prototype robot made by DARPA. (Figure 5) [20]

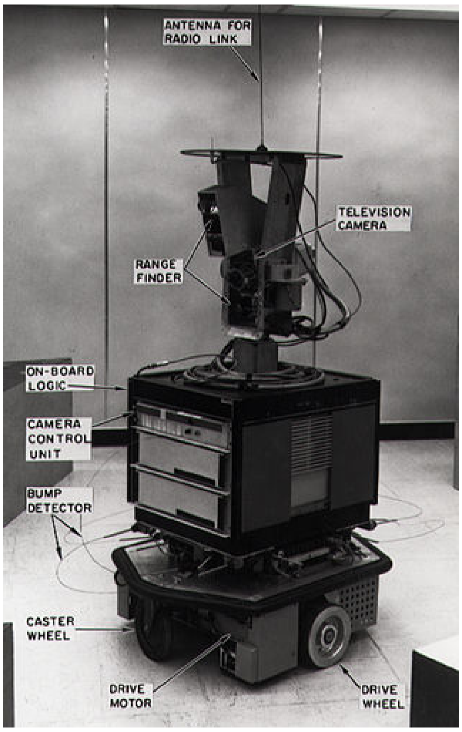

Fig. 5 SHAKEY [21]

Nowadays we can meet different types of UGVs which are operated by human control or with AI. References [22,23] and [24] describe different types of UGVs. These articles discussing high mobility robots and one can also read about big robots with diesel engines which are used for any dirty or dangerous (D3) applications.

The factories use another type of UGVs which we call – Automated/Automatic Guided Vehicle (AGV) (Figure 6). This kind of vehicle follows markers or wires on/in the floor or uses magnets or laser beams for navigation. This kind of robots is most often used in industrial environments to carry materials, finish goods or tools around the manufacturing facilities and warehouses. In the late 20th century they were given increased importance. [25,26,27]

Fig. 6 AGV in work [28]

The first AGV was made by Barrett Electronics of Northbrook, Illinois, USA in 1953. This kind of robots has a professional system management system where the user can check where the vehicles are in the facility, the status of the AGV, battery voltage etc. [25,26,27]

4. UGV GROUPS FROM MAINTENANCE SIDE

Regarding fields of the possible UGV applications they can be classified into four groups [3]:

- Reconnaissance robots;
- Prevention robots;
- Logistic robots;
- Assault robots.

These groups perfectly describe the four main categories of UGVs. But this classification and segmentation can't be used to evaluate maintenance and operations of the robots.

The basic maintenance steps at the UGVs are the same as in the maintenance of a normal machine. The large scale diversity of the UGVs allows users use robots in different situations, environments and in more and more dangerous projects (e.g. reconnaissance missions at Fukushima nuclear power plant's radiation, monitoring volcano eruptions etc.). This is the reason why one could find uncertainty in the maintenance and operation methods. There are many different types of the loads affecting robot application, and their behaviour. The most important of those loads being considered for evaluation of the robot operation could be the followings:

- high temperature loads;
- loads from changing humidity;
- surface roughness loads;
- weather conditions;
- extra loads on the UGVs chassis;
- damages of the UGVs' mechanical or electrical components.

High temperature loads can lead to irreversible degradation of the technical status of the UGV. There are many missions famous for that kind of external loads, e.g. monitoring volcano eruptions.

The climate itself can change the technical parameters of the dynamical systems, e.g. resistances and conductances are in high dependence of the temperature and humidity, as well. The surface roughness determines the quality of the robot navigation and, derives energy consumption of the electrical servo actuators applied on-board. Besides extra needs in relation of the electrical energy consumption of the robots if there is a meaningful surface roughness the robot movement itself can generate mechanical extra loads on robot frame (chassis) being considered during robot design phase.

We can call these kinds of loads external loads. They can appear both during robot operations and when robot is out of the operation. Most of these loads intensively influence the batteries' technical status applied on the board of the UGV. The battery's electrical loads can be divided into two main groups (Figure 7.)

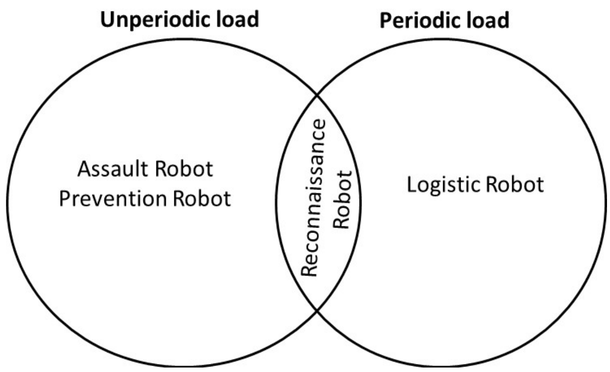

Fig. 7 Load set

Figure 7 shows two groups of loads. Logistic robots which are used mostly in the same environment with the same loads get a periodic load. Assault and Prevention robots are used in different types of environment and they always work in different missions.

Reconnaissance robots can be part of both groups. Users can use them in war theatre applications generating aperiodic loads on the robot, or they can be used in facility guarding operations generating mostly the periodic loads. The main load factors were determined and defined. The aperiodic loads of the electrical batteries can lead to failures, shortfalls in electrical energy supply system during robot operation.

The modern UGVs are mostly supplied with on-board diagnostics of the batteries responsible for management of the energy supply process.

CONCLUSION

The paper gives a short summary of the history of robots. In the second part the reader can get information about the evolution of the UGVs and AGVs. The article also describes a possible classification of UGVs. The authors used these four groups and made new sets of UGVs from the operation side. This classification helps to determine a new operations method for the UGV systems. The aperiodic loads may cause damage while the users work with the UGVs, which mean the life time of the UGVs can be worse than the previously predicted one.

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