

Design and Implementation of a Tank Rescue Robot Controlled with Android Software

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Abstract- The rescue operations are very important in order to save the lives of people in disasters. Especially first hours are very critical for the injured people and the rescue teams have to be careful at their work since it is hard to go through in every hole at destructions. Rescue teams need some auxiliary machines such as robots. In this study, a tank robot is designed and implemented for rescue operations. This robot can climb and continue its way with the help of pallets so that tipping and falling cannot prevent the robot movement. Mechanical, electronics and software systems of the robot are explained in this research. Advantages of this study compared to others in the literature are small, lightweight, flexible design and it is able to continue to move when it overturn with controlled by android phones.

Keywords Tank robot, android, rescue, robotics, mechatronics.

1. Introduction

The rescue teams race with time in order to save the lives of people in major disasters like natural and mining disasters. The first 18-24 hours are very important for rescue operation. For years, the search and rescue operations have been performed without the use of more heavy equipment to save the people under the rubble. It is very difficult to pass through small spaces that are hard to reach for rescue teams and to look and imaging the close places or measuring the coordinates. In such cases, operation distance is extremely important to save lives of people. There are many studies have been made to move on in rugged or harsh places that human face difficulties to reach. In particular, when the search and rescue robots are examined, many robots in different shapes and properties are come across. Kamegawa et.al. performed a robot design named kohga similar to a snake and can easily moves, climbs and passes to narrow spaces [1]. In another study, a single-tracked mechanism has variable geometry was designed for search and rescue operations. Thus, it was aimed to continue its movement forward or backward [2]. Mark J. Micire examined a robot named Inuktun VGTV-Extreme that observes performance in a study for evaluating the robots of other companies as well as made by them. At the same time, properties of rescue operation is examined too [3]. Jumping rescue robots were also designed by other researchers.

A pneumatic cylinder was used on this robot [4]. Birk et al. investigate the software and robot developed by IUB rescue robot team and used them for search and rescue operation since 2001 in their study. This robot attracts attention of scientists with high-level functionalities and intelligent behaviours [5]. In another studies, a search and rescue robot, as well as a disaster rescue robot for mining, communication system, orientation technique, detection technique were investigated [6]. Nagatani et.al. developed a robot to be used at Fukushima Daiichi Nuclear Power Station in Japan as often faced with natural disasters such as earthquakes and tsunami. Then they modified a mobile rescue robot named Quirce for this aim [7]. In another application about human-robot interaction design, Scholtz et al. researched and analysed critical incidents during an urban search and rescue. Researchers collected data about how a task given a robot was performed successfully and then prepared a guideline for human-robot interaction design [8]. Design of another robot to save the survivors was performed in a research and a control system for robotic platform on semi-autonomous navigation with 3D mapping sensor was introduced [9]. Likewise, when examining robots designed for search and rescue, there are some studies emerges to us about a mobile jack robot [10], rescue robot under disaster situation [11] and robot-assisted medical reach back for using medical purpose on rescue works [12]. Suthakom et al. described hardware

components of robot, system architecture and software algorithm in order to provide a general overview of their robot [13]. Tests and studies about autonomous control of Quince highly mobile rescue were performed and to this end, sub-crawlers' autonomous control was integrated to robot [14]. In another study, FUMA: environment information gathering wheeled robot for urban search and rescue missions was explained and wheel-type rescue robot was developed and implemented [15]. A robot designed by S. A. A. Moosavian et.al had 2nd degree in Osaka 2005 Robocup Challenge was designed and practiced for mobile rescue works. The design was carried with some programs like ADAMS, 3D Sketch and Solidworks. Also, mathematical solutions and control algorithms were achieved with using Matlab [16]. In a survey study, Birk and Carpin explained the rescue robots as autonomous robots and described developments in recent years. There are some information about robot development process such as remote control, used algorithms, necessities, telemetry, etc. [17]. A teleoperated mobile robot was developed for 3DMap-building in rubble with Laser range finder. Souryu-IV was given as name to this robot and it developed as snake-like [18]. In another research, a rocker-type coal mine rescue robot was designed to create a mobile platform and motion simulation of the differential function and condition of the robot running on virtual were carried out with Adams and additionally experimentally performed [19]. Karnikawa et al. designed a multi-legged robot and developed a gait control algorithm for limb-mechanism robot on rough terrains and slopes [20]. Another robot developed with a different mechanism was provided with the ability to overcome obstacles. Additionally, it can move autonomous [21]. A conspicuous feature of another robot made for search and rescue of survivors under the remaining mines or in an accident was optimal dexterity of the hybrid head mechanism [22]. In another three case studies [23-25] as autonomous and semi-autonomous rescue robots, multiple robot control, Japan made rescue robots and a survey for describing rescue robots in use we disclosed, respectively.

In this study, starting with palette and design phases of Android-controlled tank, mechanical parts, electronic parts and software are mentioned. Also, performance of the robot under different conditions such as straight road, bumpy road, overturning is evaluated. This robot controlled with a written android program from smart phone or tablet can continue the path anyway even if it turns reverse or overturned to any side because of its small size, palettes and symmetrical design. Parts of palettes are designed for moving on rough terrains.

2. Design and Implementation

The robot has mainly three sub-systems as mechanical, electronics and software systems. Main body, gear systems, pallets, motors, motor drivers and microcontroller, Bluetooth connection module are explained in this section.

2.1. Design of The Mechanical System

Tank Robot has been investigated with three sections as mechanics, electronics and software. Main body, gear systems, pallets and the other mechanical parts are explained in this section. Tank Robot is composed of seventeen different parts. Two cover panels for sides, two gear holders that transfer the power to the pallets are available at this robot. Fig.1 and Fig. 2 show these parts, respectively.

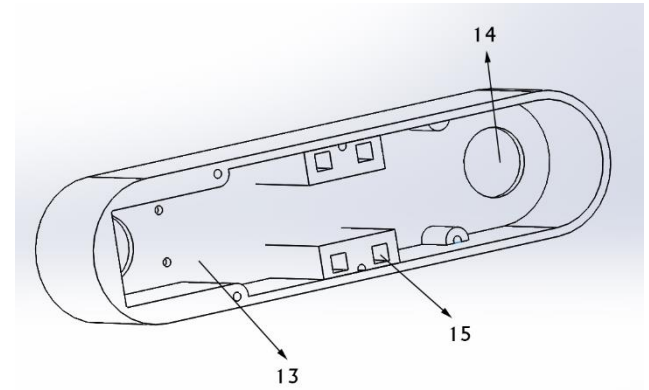


Fig. 1. Cover panel

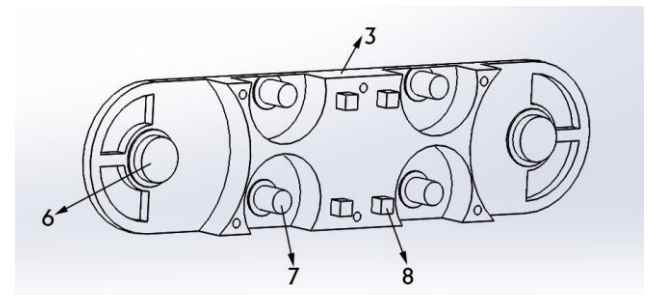


Fig. 2. Gear holder

Other parts are two gear holder mounts, nine gears, a microcontroller cover, two cover panels for sides, two gear holders and top cover. The gears designed for power transfer are depicted in Fig. 3.

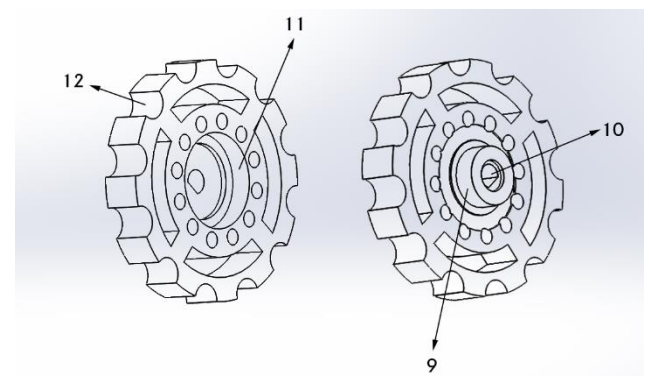


Fig. 3. Main gears

In Fig.4, the installed gear system with gears, side covers and gear holder mounts is illustrated. Four small gears, two main gears are available on both parts of the robot. Tank robot without pallets and top cover is shown in Fig.5.

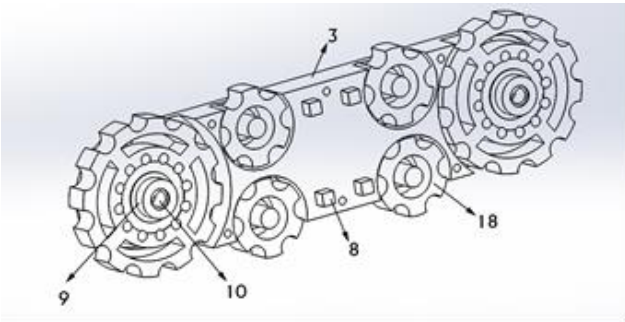


Fig. 4. Installed gear system

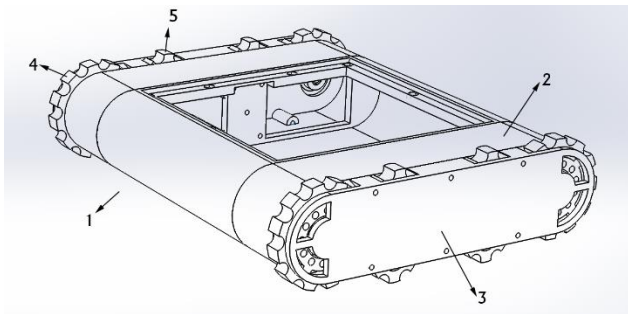


Fig. 5. Tank without pallets and top cover

There are 66 components of pallets and 66 pins used to combine the pallets. Pallet and pin number varies depend on the length of the robot body and it is designed with sharp peace in order to move all kinds of lands and created by using 3D printer. The pallet and robot tank is shown in Fig. 6.



Fig. 6. Pallet and the robot tank

Pallets are designed for minimum wear and maximum grip. Final version of the robot is shown in Fig.7.



Fig. 7. Final version of the robot tank

2.2. Design of Electronic System

There are two 12 V, 300 rpm DC motors used in this robot and 4s Li-po battery is preferred to support enough voltage to these motors. List of the electronic materials used in the tank is given in Table 1.

Table 1. List of the electronic materials used in the tank

Battery	Li-po 4s battery 14.8V (nominal voltage)
Motor	12V 300 rpm DC motor
Motor driver	L298N
Microcontroller	Arduino Uno
Wireless shield	HC-06 Bluetooth module

L298N circuit is used as the DC motor driver with upper limits 24 V and 2 A.

2.3. Design of Software

An android program is prepared to move the tank robot on desired directions. There are six buttons placed on interface of program and it is shown in Fig. 8. For connecting to the robot tank with Bluetooth, Bluetooth button at the top side of interface has to be clicked. After the synchronization, the robot can be moved using android software by clicking on the directions buttons. At this time, it has continuing autonomous to its way by the help of gyroscope and the algorithm. When the robot rolls forward or reverse, it does not affect the movement.

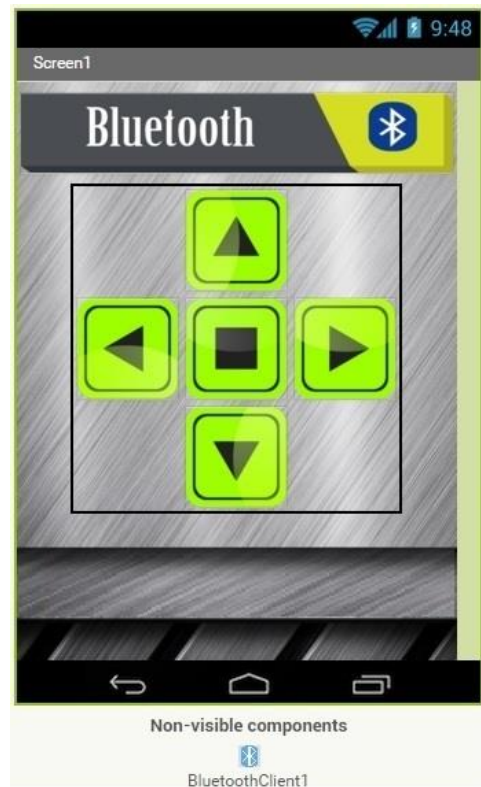


Fig. 8. Interface of Tank Robot Android Application



Fig. 9. Flowchart of Tank Robot Android Application

3. Results

The robot has a narrow and thin body fed by a Li-Po battery. Nominal voltage value of the battery is 14.8 volt (3.7 V per cell). However, its nominal value is 14.8 V, it can be charged to 16.8 V (4.2 V per cell). The charge and discharge characteristics of Li-po battery cell under room temperature is illustrated in Fig. 10.

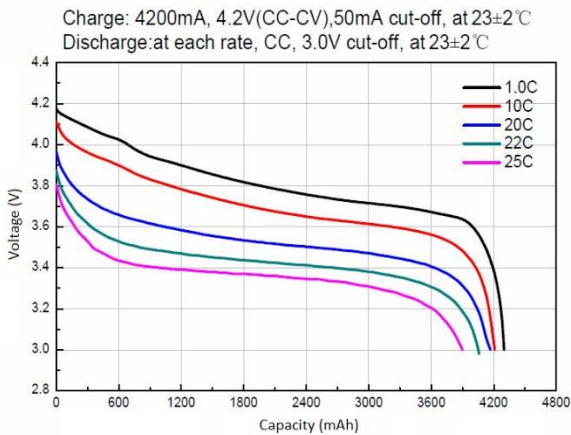


Fig. 10. Discharge characteristic of Li-po battery cell

The tank robot can operate for nearly two hours with a 4s Li-po battery (4400 mAh) but this limit can be changed depending on the road conditions. The ramp or unstable roads change the battery life. At this time, it can be fed by 3s Li-po battery because the voltage of the battery is 11.1 V (nominal value) and it can be charged up to 12.6 V (max. value). The nominal speed of DC motor is 300 rpm due to reductor. The change in speed and torque of the motor is shown in Fig.11.

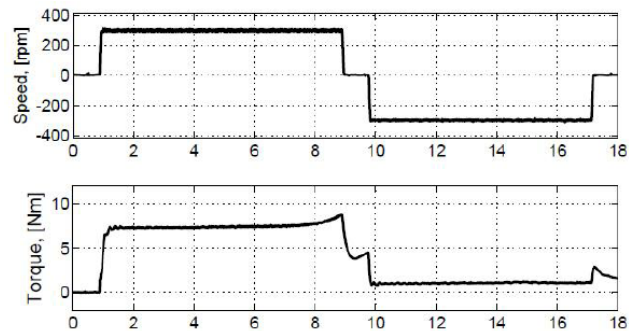


Fig. 11. Change of the speed and torque of the motor

In table 2, the current and voltage values depend on different li-po batteries (2s, 3s and 4s) are shown. Idle current values are same all the situations but under load current values are changing due to the voltage values of batteries. The power of the batteries is increasing depend on the voltage levels and it affects the battery life.

Table 2. Current and voltage values depend on different batteries and under load

Cell number of Battery (Li-Po)	Nominal voltage (V)	Idle Current (A)	Current under load (A)	Full charge voltage (V)	Idle Current (A)	Current under load (A)
2s	7.4	0.06	1.2	8.4	0.06	1.37
3s	11.1	0.06	1.19	12.6	0.06	2.1
4s	14.8	0.06	2.52	16.8	0.06	2.81

4. Conclusion

In this paper, design and implementation of a tank rescue robot is explained. This tank robot design enables continuous, vibration-free, and strong attachment to wide range of smooth and rough surfaces, relatively fast and smooth motion, and improved capability to traverse obstacles and to carry high payloads. Robot has lightweight and can climb on different slope degrees on smooth surfaces. Moreover, it can continue on its way even if it rolls forward or reverse thanks to the pallets, gyroscopes and program. The robot can move into narrow spaces and as long as its pallets touch the floor.

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