RoboCup Rescue 2017 Team Description Paper VRU

Iman Alizadeh, Morteza Alizadeh, Rahman Alizadeh, Mohammad khalooei

Info

Team Name:	VRU Team
Team Institution:	Vali-e-Asr University of Rafsanjan
Team Leader:	Iman Alizadeh
Team URL:	http://vru-robotic.ir

RoboCup Rescue 2016 TDP collection:
https://to-be-announced.org

***Abstract*—In this paper we describe the approaches employed by team VRU from Vali-e-asr Rafsanjan University for participation in RoboCup 2016 rescue robot competition. We participated in IRAN OPEN 2016, IRAN OPEN 2015 and AUTCup[1] 2015 last year. Our focus is on exploration of collapsed areas using our tele-operated robot Hurtash and our flying robot.**
We provide some unique features of Hurtash in order to demonstrate the robot ability to explore disaster sites. It is equipped by four flippers and a flexible manipulator. The robot has ability to climb ramps (less than 50 degrees) and also to move objects up to 0.5 kilograms payload. We describe our hardware and software solution and other topics like localization and mapping, navigation strategies, collision avoidance algorithms, sensor fusions, locomotion, automatic victim detection and mechanical capabilities. Our robots are equipped by cameras, temperature sensor, carbon dioxide and sound detection sensor.

***Index Terms*—RoboCup Rescue, Software and Hardware design, Victim detection, Rescue robot**

I. Introduction

A RESCUE robot is a robot that has been designed to rescue people. The rescue robots are employed in mining accidents, urban disasters, hostage situations, and explosions. They are applied to search for victims and survivors. The benefits of rescue robots for these operations, include reduced personnel requirements, reduced fatigue, and access to unreachable areas. During September 11 disasters, rescue robots were first really examined. They were sent into the rubble to look for survivors and bodies. The robots had trouble working in the rubble of the World Trade Center and were constantly getting stuck or broken. After that, some novel procedures were presented about rescue robots. Engineers and scientists are trying to change the shapes of the robots from wheels to no wheels. Strong government funding and support is required if search and rescued robots are to gain widespread use in fewer than 14 years. In other words, without the support of government, the technology of these devices will cost too much for research terms. Furthermore, that these robots hopefully taking a change for the better.[1] One of the most prominent factors in rescue operation is to find and save victims in time. Besides, a rescue scenario usually takes place in unstructured and unstable environment, requiring the use of a combination of complex mechanical designs and control strategies both in software and hardware levels. Thus, the implementation of high technologies such as robotics can be helpful for search and rescue operations.

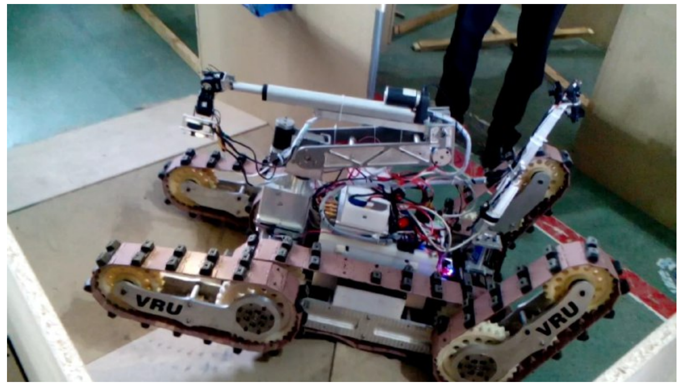

Fig. 1: Photo of Hurtash real rescue robot

VRU rescue robot team was founded in 2014 at Vali-e-Asr University of Rafsanjan robotic research group. The rescue robot is known as Hurtash. It has one powerful dynamic arm to distinguish some feature of environment and victims. The robot is distinctive because of some unique features. Due to four well-designed flippers, it is highly portable. It enables the robot pass through uneven and also bumpy areas which may be dangerous for people. It is easy for Hurtash to go and down using the stairs and sloped ramps fewer than 50 degrees. It is also can move objects up to 150 centimeter height, send photos, about the surrounding conditions and the vital status of injured people. Besides, the robot can be handled easily. Hurtash has one of the most sophisticated arms that includes the considerable 8 degrees of freedom, six linear motors for high performance, two servos with the advanced mechanism, camera, temperature sensor, carbon dioxide, and sound sensor. In the electronics point of view, we have designed a control board which can manipulate controls signals to make a motion in motors and handle the arm as well. Additionally, we also use simple codes with the lowest complexity and overhead. Moreover, the most efficient routing protocols are implemented in our system. The GUI[2] provides a very simple and user-friendly working interface for users. The perspective of robot is depicted in Fig. 1.
As mentioned, we ranked 3th in real rescue league of international IRAN OPEN 2016 and also 7th in IRAN OPEN 2015 tournament, which was held in April 2016 and 2015

[1] Amirkabir University of Technology robotic competition

[2] Graphical User Interface

Fig. 2: Photo of VRU flying robot
(First construction version)

respectively in Tehran. Our team also participated in the fifth robotic competition of Amirkabir University of Technology (AUTCup 2015) which was held in November 2015 in Tehran, and took the third place in the real rescue league.

II. System Description

We have described hardware, software, communication, human-robot interface, flying robot overview, and application in the field in the following sections:

A. Hardware

In this subsection we like to describe the hardware components of the system. Fig. 1 demonstrates a photo of our robot. In table I and II in Appendix 1, we have provided sufficient information for introducing our hardware devices. We have depicted out CAD drawings in Fig. 6 up to 14. Furthermore, Fig. 2 illustrates the VRU flying robot that was constructed by our technical team.

1) Sensors for Victim Identification: : In order to identify victims and instruct the robot in an unknown environment, we employ several digital sensors for information gathering of the environment. The robot is equipped with the sensors for sensing and video capturing. The temperature of victim is sensed with the TPA81. Moreover, we use microphones to determining possible sound of victims. Also we have some software identification and processing to identify victims with integerating these data on software system. We also use a camera on some specific position of robot for identifying and localizing victims. The video streams' data are transferred into the operator interface. Furthermore, the microphone, temperature and CO_2 sensors are equipped on the end of the robot arm to gain more information for victim identification.

2) Map generation: A laser scanner is used for production of map, capable of determining walls and other materials on the ground and therefore is able to draw the way map correctly in such a manner that the place of victims would be defined by operator. Application of an accelerometer to assess amount of repositioning, and level difference in the environment would cause better and exact recognition of way-map and injured position.

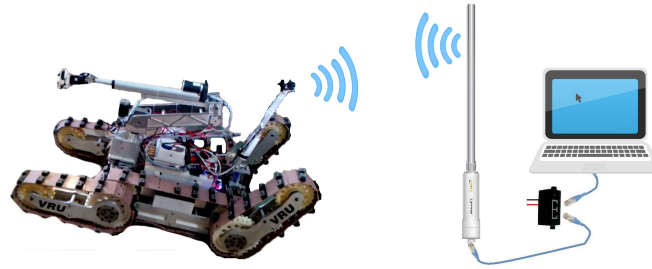

Fig. 3: Simple simulated connection diagram of Hurtash real rescue robot

3) Sensors for navigation and Localization: Following sensors are being used in our application: compass sensor for drawing of map, accelerometer sensor for estimating amount of repositioning, ultrasonic sensor for determining robot distance from walls and victims, and finally laser scanner sensor for specifying way-map.

B. Software

Referring to Table V in the Appendix 1, the software employed in running the Hurtash and flying robot is explained. We have developed our GUI using Qt framework - Qt is a cross platform application framework that is widely used for developing application software that can be run on various software and hardware platforms with little or no change in the underlying codebase, while still being a native application with the capabilities and speed thereof. Also We are doing all real time processing in this framework. Moreover, we use opencv library for image processing and ROS[3] framework for management system.
Our goal was to develop a user friendly GUI system with a minimum operator training requirement. It has straightforward drive and control.

C. Communication

We can control the Hurtash robot, through tele-operated via our custom GUI control interface. By using the GUI, we simply connect to each part of robot and then, we can drive motors, servos, monitoring of sensors, video cameras. Hurtash robot is controlled remotely using gamepad, joystick, or the keyboard. In this case, the operator uses the video-streams to obtain situation cognizance (see Fig. 3). To gain intellectual perception of our communication, the reader is referred to Fig. 4.

D. Human-Robot Interface

In this subsection, we explain how the robot is controlled. Referring to the previous subsection, we introduce the diagram of our connection. As shown, we control our Hurtash robot via XBox 360 - the Xbox 360 controller is the primary controller for the Microsoft Xbox 360 video game console. The GUI gets the signal of operator man, which is pressing

[3]Robot Operation System

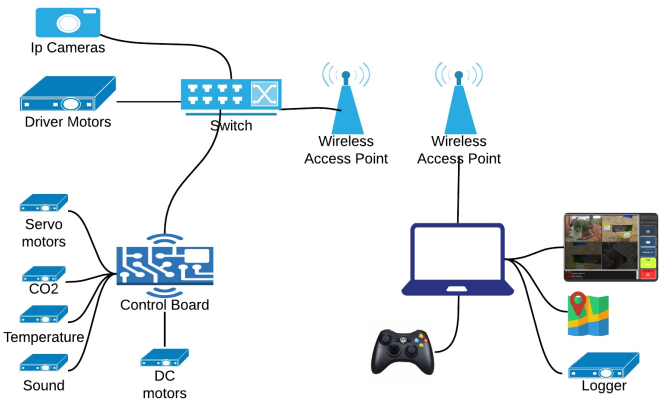

Fig. 4: Hurtash real rescue robot communication diagram

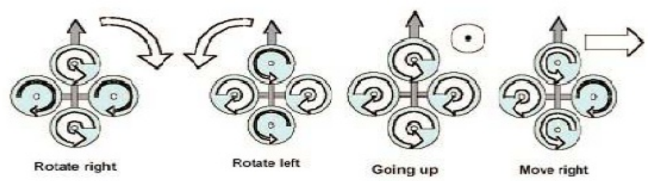

Fig. 5: Quad rotor control and navigation frames

the buttons of XBox 360, via one operator system and then, we make packet of our signal and send them through our robot network. On the other side, robot controller gets the packet and distinguishes the commands and performs what the operator intends. The operator man can follow robot situation and environment via our GUI. As mentioned before, our goal to develop a user friendly GUI system with minimum operator training requirement. It has straightforward drive.

E. Flying Robot Overview

A quad copter, also called a quad rotor helicopter or quad rotor. Quad rotors is an emerging rotorcraft concept for unmanned aerial vehicle (UAV) platforms. The vehicle consists of four rotors in total, with two pairs of counter-rotating, fixed-pitch blades located at the four corners of the aircraft. Having four rotors, the quad rotor can be controlled without using swash plats to change the pitch angle of the blades unlike the helicopters[2]. This simplifies both the design and maintenance of the quad rotor. Moreover, using four rotors enables the quad rotor to remain stable in flight and carry more payload than other flying platforms. This makes the quad rotor a suitable platform for being used as an autonomous robot which can carry equipment like laser scanner, camera, on-board real-time PC, and etc. Dynamic model of quad rotor and its navigation equations are presented in two frames named earth frame and body-frame illustrated in Fig. 5. The first constructed version of the robot is shown in Fig. 2.

III. Application

This section covers the practical aspects of our system.

A. Set-up and Break-Down

Setting up the VRU team operator station is as simple as supplying power to the control console and switching it on. The control console has an integrated voltage converter, antenna, control computer and monitor(s) as well as control device (Xbox controller device). Also, we use only one notebook PC for the operation, so the main devices are only one robot and one notebook PC, therefore the operation is plug and play and the set-up and break-down operation will be quick in a similar way.
In the following steps, we want to explain how we are verifying out the robot system.

B. Hardware

- Connection of battery operation
- View point check of a robot
- Check of wireless connectivity
- Check camera monitoring

C. Software

- Boot notebook of Hurtash robot OS
- Run Hurtash emulator software
- Check connection of wireless communication
- Check of sensor information
- Check of camera monitoring
- Check of movement

D. Application in the Field

In fact, we have yet no practical experience with real disaster sites. As mentioned before, main goal for this activity is used for real disaster situation. Our team design all parts of the robot for real rescue application and they are confident that our robot is very useful to help disaster defender. However this design is not water proved, and we may pursuit some improving steps to make the design for water proved.
In the future, our team may improve and change a lot of the robot parts in order to improve its resistance against water and fire. Also, we want to improve out operator GUI to distinguish and work on efficient movement. For example, we are currently increasing the toughness of some parts of robot, changing the processor of robot to minimize the environment and indoor motors noise, decreasing the robot weight, extending the effective range of WLANs signal and improving quality of video cameras. We also intend to use the robot in real application and situations.

IV. Conclusion

In this paper, we introduced and explained the mechanics, electronics, sensor application and, communication methods between the operator station and the robots in details. Also, we described some special features of Hurtash robot, like our new manipulator that incorporates 8 degrees of freedom and also, robot mobility because of four flipper design. Furthermore, we described some CAD drawing in the paper and also, we explained some hardware and software components in tables. In the future, we would like to improve the performance of

TABLE I: Manipulation System

Attribute	Value
Name	Hurtash
Locomotion	tracked
System Weight	47kg
Weight including transportation case	56kg
Transportation size	1.3 x 0.57 x 0.7 m
Typical operation size	1.3 x 0.57 x 0.4 m
Unpack and assembly time	120 min
Startup time (off to full operation)	10 min
Power consumption (idle/ typical/ max)	120 / 200 / 400 W
Battery endurance (idle/ normal/ heavy load)	60 / 40 / 20 min
Maximum speed (flat/ outdoor/ rubble pile)	1.5 / 0.8 / 0.1 / - m/s
Payload (typical, maximum)	2/ 8 kg
Arm: maximum operation height	150 cm
Arm: payload at full extend	1.5kg
Support: set of bat. chargers total weight	2kg
Support: set of bat. chargers power	100W (100-240V AC)
Support: Charge time batteries (80%/ 100%)	60 / 90 min
Support: Additional set of batteries weight	1.5kg
Cost	9808 USD

our robot with some programming methods. We also are going to develop data processing methods like image and sound processing in order to improve autonomous capabilities of our robots. Thereupon, if we implement these methods on Hurtash, we would have powerful and intelligence system to identify victims. Our goal is to develop a rescue robot to use in real applications.

Appendix A
Team members and Their Contributions

In this section, we want to recognize all team members and their technical contributions.

- Iman Alizadeh Mechanical design
- Morteza Alizadeh Electronical design
- Rahman Alizadeh Mechanical Advisor
- Mohammad khalooei Artificial intelligence programmer
- Dr.Hassan Fatehi Marj Electrical Advisor
- Vali-e-Asr University of Rafsanjan Team Supporter

Appendix B
CAD Drawings

In this section, we put some CAD drawing to introduce some aspect of our Hurtash robot - see Figure 6 up to 14

Appendix C
Lists

A. Systems List

Hurtash robot incl. support, operator station and so on. Our technical member answered the following items in one table per system (see table I up to III).

B. Hardware Components List

In this section we listed all interesting components of our Hurtash robot and Operator stations (see table IV).

C. Software List

In this section we listed all relevant used software packages (see table V).

TABLE II: Aerial Vehicle

Attribute	Value
Name	VRUFLY
Locomotion	quad copter
System Weight	1.3kg
Weight including transportation case	2.9kg
Transportation size	0.32 x 0.32 x 0.2 m
Typical operation size	0.32 x 0.32 x 0.1 m
Unpack and assembly time	15 min
Startup time (off to full operation)	2 min
Power consumption (idle/ typical/ max)	11 / 66 / 106 W
Battery endurance (idle/ normal/ heavy load)	20 / 15 / 12 min
Maximum speed	10 m/s
Payload	0.2 kg
Cost	1856 USD

TABLE III: Operator Station

Attribute	Value
Name	Hurtash Op
System Weight	2kg
Weight including transportation case	3kg
Transportation size	0.4 x 0.3 x 0.3 m
Typical operation size	0.4 x 0.3 x 0.5 m
Unpack and assembly time	5 min
Startup time (off to full operation)	5 min
Power consumption (idle/ typical/ max)	60 / 80 / 90 W
Battery endurance (idle/ normal/ heavy load)	4 / 2 / 1 h
Cost	1199 USD

References

[1] https://en.wikipedia.org/wiki/Rescue_robot

[2] Gabriel M. Hoffmann, Haomiao Huang, Steven L. Waslander, and Claire J. Tomlin. *Quadrotor Helicopter Flight Dynamics and Control:Theory and Experiment*. American Institute of Aeronautics and Astronautics, 2007.

TABLE IV: Hardware Components List

Part	Brand & Model	Unit Price	Num.
Drive motors	Maxon Motor200w	1471	2
Drive gears	Planetary Gearhead GP 52	490	2
Drive encoder	Encoder HEDS 5540	190	2
Motor drivers	BS25	380	2
DC/DC	-	-	-
Battery Management	-	-	-
Batteries	6Cell Lipo 5500mAh	771	2
Micro controller	Dspic30f6014a	11	2
Computing Unit	.002 MIPS	-	-
Wi-Fi Adapter	BULLET M5	214	2
IMU	ArdoIMU+V3 (DIYDrounes)	330	1
Cameras	MINI DIGITAL	9	4
CO_2 Sensor	MQ-9	85	4
Thermal Sensor	TPA 81 1*8	85	4
Hokuyo Sensor	URG-04LX-UG01	10900	1
Battery Chargers	IMAX B6AC	33	4
6-axis Robot Arm	8DOF	2285	1
Rugged Operator Laptop	Lenovo ideapad	714	1

TABLE V: Software List

Name	Version	License	Usage
Ubuntu	14.04	open	OS
ROS	jade	open	Robot Operation System
Qt	5.4	open	programming
iSpy	6.5	open	Digital Servers (camera,...)

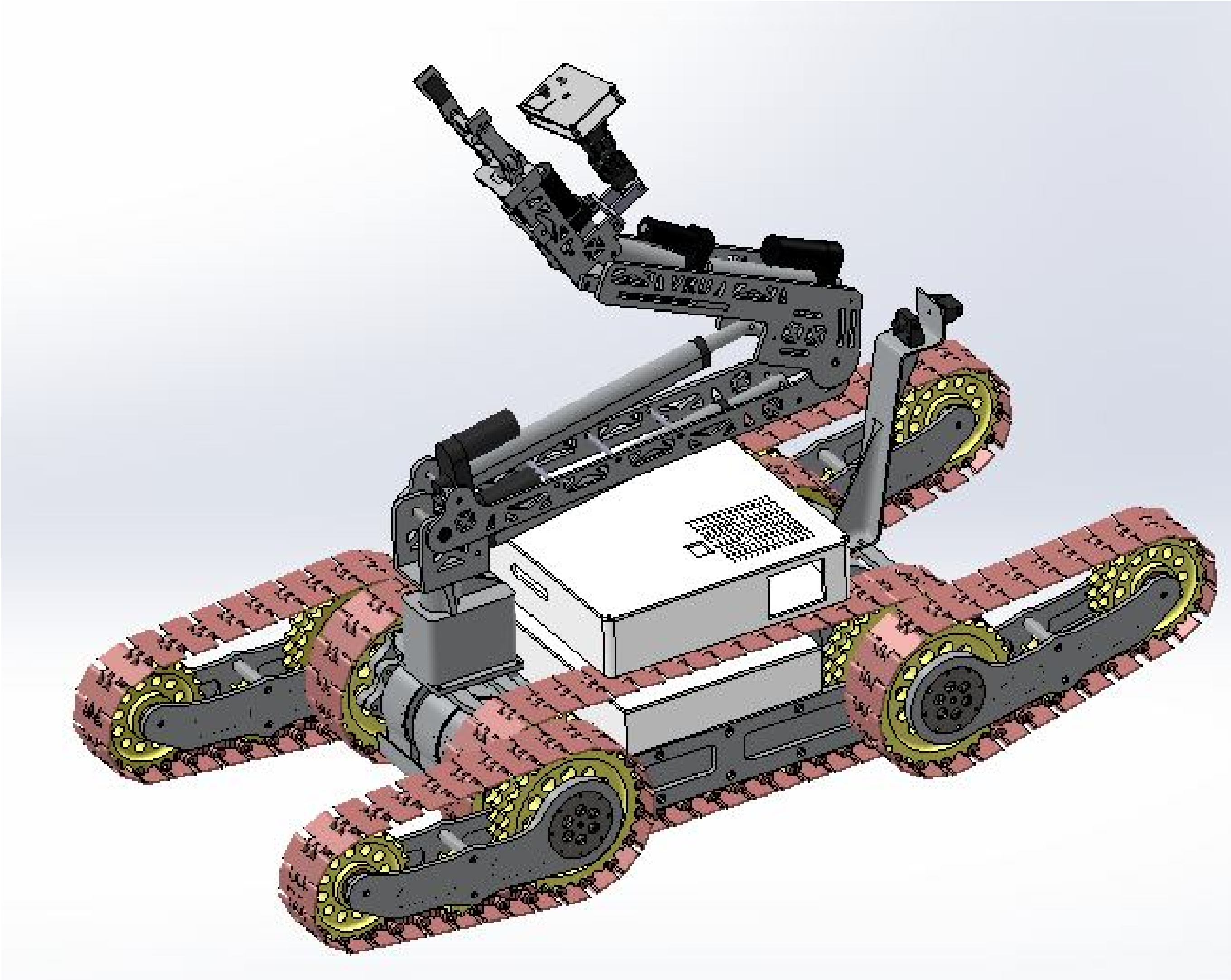

Fig. 6: Overall view of Hurtash robot in solidwork

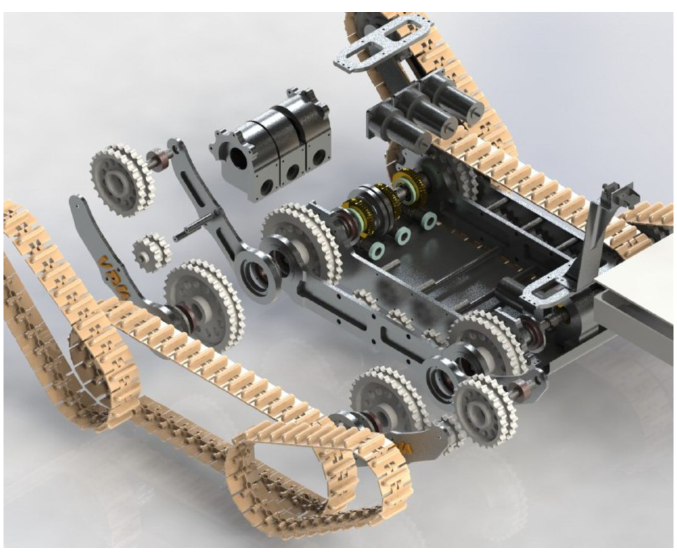

Fig. 7: Exploded view of Hurtash rescue robot in solidwork

Fig. 8: Hurtash robot arm with 8 Degree Of Freedom (DOF)

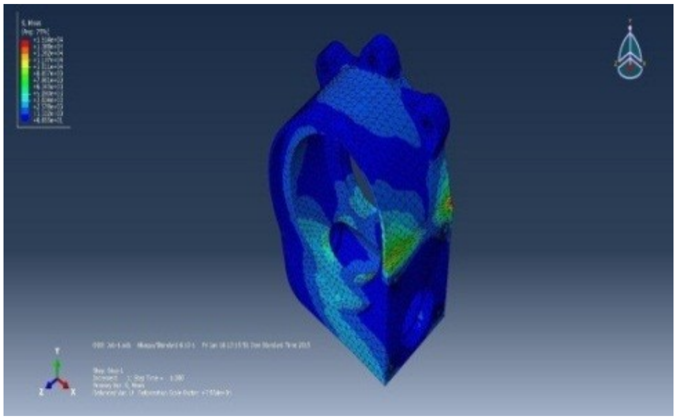

Fig. 9: Stress Analysis of fixed part of right worm gear box in solidwork

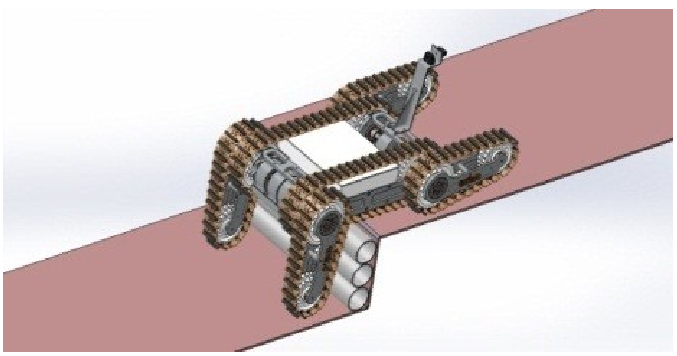

Fig. 10: Simulation view of Hurtash robot in solidwork

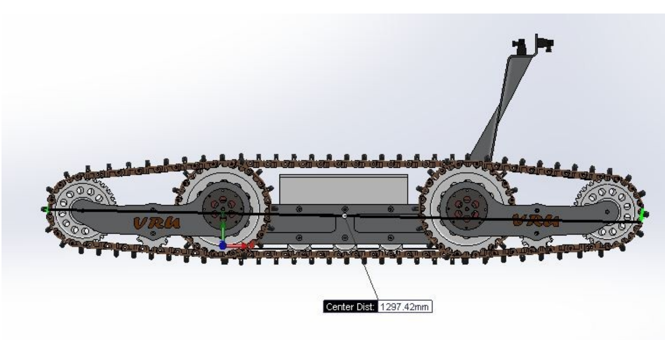

Fig. 11: Side view of Hurtash rescue robot in solidwork

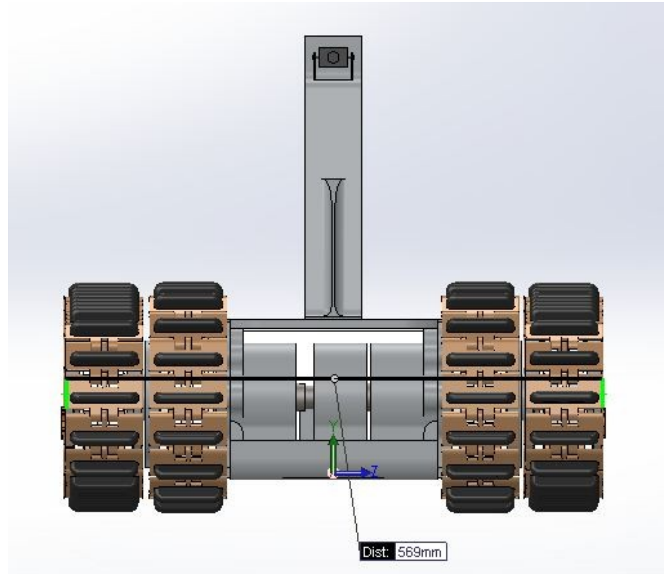

Fig. 12: Front view of of Hurtash rescue robot in solidwork

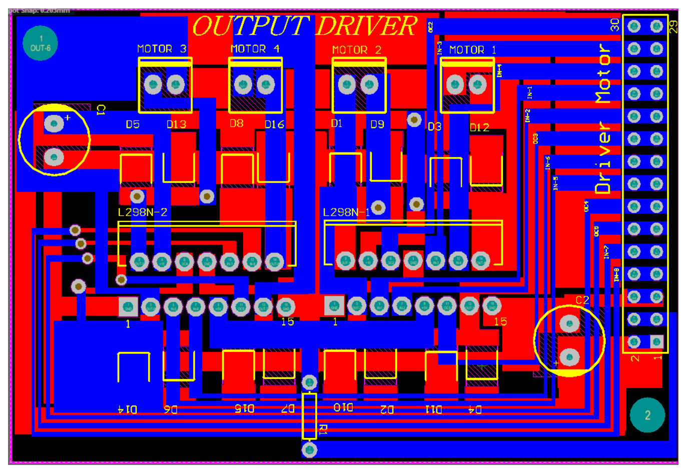

Fig. 13: Board designing in Altium designer

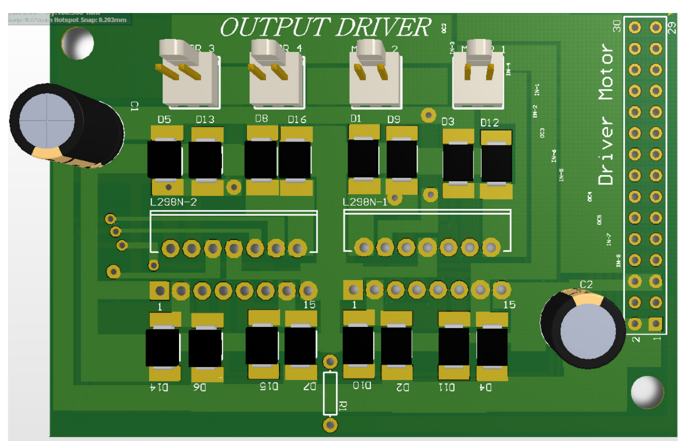

Fig. 14: Board designing in Altium designer