RoboCupRescue 2013 - Robot League Team <SEU-Jolly (China)>

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Abstract. This paper describes the SEU-Jolly rescue robot team, which are very interested in participating RoboCup 2013. We have two robots: One robot is two-wheel independent, which can autonomously navigate or be tele-operated in relatively flat environment. The other one is a tracked robot named SEU-Ⅲ with four flippers; It can move rough terrain with tele-operation. Both robots are able to automatically create global maps by fusion of multi-sensors' information that can be shared with each other. We have made considerable improvements since the Robocup 2011 and we are still moving on.

Keywords: tele-operation, multi-sensor, SLAM, rescue.

1 Introduction

SEU rescue robot team was found in 2008 at Southeast University Robocup research group, which had participated in China Open 2009, China Open 2010, RoboCup 2010 Singapore and RoboCup 2011 Istanbul. Our team are originated from virtual robot competition SEU-RedSun team, which won the champion in RoboCup 2010 Singapore and RoboCup 2008 Suzhou, China and was awarded 2nd place in RoboCup 2009 Graz, Austria. We have got support from Nanjing Jolly Company since last year. We will use SEU-Jolly as our team name.

Our first version of robot named SEU-Ⅰ made by our team which awarded 2nd place in China Open 2009; Our second version named SEU-Ⅱ which got 2nd place in China Open 2010 and participated in RoboCup 2010 Singapore and also participated in RoboCup 2011 Istanbul.

Fig 1 shows our newest robots: the top one is the autonomous robot with two-wheel independent driving construction which also participated in China Open 2010 and RoboCup 2010 Singapore and RoboCup 2011 Istanbul. The bottom one is our newest tele-operative robot named SEU-Ⅲ, which has obtained big improvement compared to SEU-Ⅱ. Our SEU-Ⅲ robot also participated in China Open 2011 and RoboCup 2011 Istanbul.

adfa, p. 1, 2011.

For some reasons such as exit visa, Our team could not attend Robocup 2012 in Mexico. We hope we can participate the Robocup 2013 in Netherland.

Fig. 1. rescue robots in our laboratory

2 Team Members and Their Contributions

• Yingqiu Xu	Advisor
• Yingzi Tan	Advisor
• Ruiming Qian	Advisor
• YiJun Zhou	Advisor
• Jie Rong	Mechanical design
• Zhengxiang Li	Mechanical design
• Jian Wang	Controller development
• Kai Wang	Controller development
• Pei Zhu	Controller development
• Xiaobo Gu	Software development
• Muyuan Chen	Software development
• Tianyi Zhu	Software development

3 Operator Station Set-up and Break-Down (10 minutes)

We use only two notebook PC and one 70*40*10cm control box in which a network bridge and network switch are equipped for the operation, so our main devices are only one robot , two notebook PC and one control box. Therefore the operation is plug and play and the Set-up and Break-Down operation will be quick in a similar way.

4 Communications

The robots are configured with wireless network with 802.11a/5.8GHz. Both robots only use one wireless communication channel. We use high-power network bridge for communication (See Fig.2). Considering the reliability of wireless communication in practice, we reduce the dependence on wireless. The autonomous robot can run normally in drop-out zone because of fully on board data process control. The tele-operative robot can work in reduced functionality mode.

Fig. 2. the high power network bridge

Table 1. Communication channels

Rescue Robot League		
SEU-Jolly (China)		
MODIFY TABLE TO NOTE ALL FREQENCIES THAT APPLY TO YOUR TEAM		
Frequency	**Channel/Band**	**Power (mW)**
5.8 GHz - 802.11a	1 channel/Selectable	500

5 Control Method and Human-Robot Interface

According to the different functionality, each robot use independently control method. On the autonomous robot, we use MCU + Notebook PC construction. Taking into account the scalability and flexibility for SEU-Ⅱ and SEU-Ⅲ, we use PC/104+ construction to control the flexible mechanism. Meanwhile it is easy to update step by step, because each module is relatively independent. The common function control module, such as CO_2 , temperature, laser 2-degree servo module, can work on both robot platforms by no modification due to the use of CAN bus.(See Fig.3).

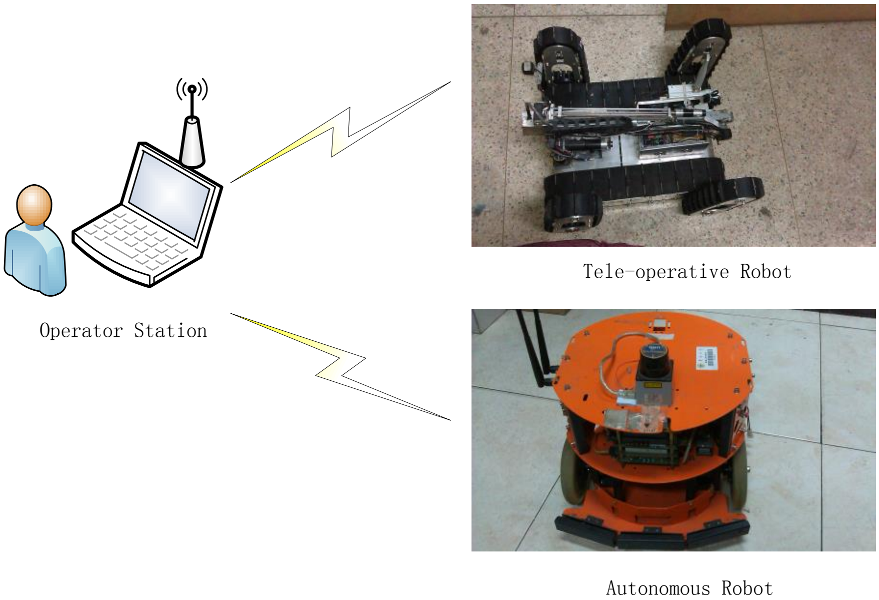


Fig. 3. two robots control

5.1 Autonomous robot

Fig.4 describes the autonomous robot construction. The robot is equipped with notebook, the ColdFire MCU（the main controller on the robot for robot motion control）, sensor data acquirement (including laser scanner, electronic compass, CO_2 , temperature sensor, sonar and IR distance sensor). For decode the rotate encoder pulse, one CPLD is used. The video and audio stream is obtained by PTZ IP camera, and directly transmitted to notebook through Ethernet. The station is alternative as a remote monitor. The robot can be fully autonomous in the Yellow arena that is relatively flat.

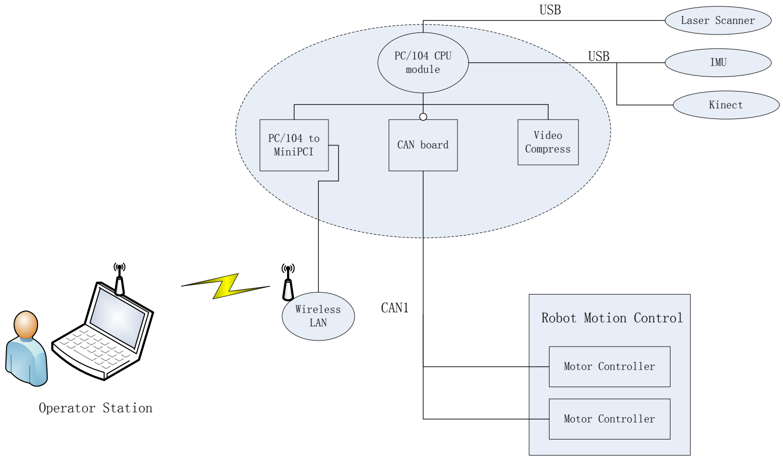


Fig. 4. Diagram of the autonomous robot control hardware structure

5.2 Tele-operative robot

On SEU-Ⅱ SEU-Ⅲ, we use PC/104 and embedded PC as the main controller on the robot(Fig.5). As a common local bus standard, it is easy to implement each function independently. Meanwhile, for enough performance of CPU, the robot can run in drop-out zone with reduced function as we found the wireless communication is not always stable.

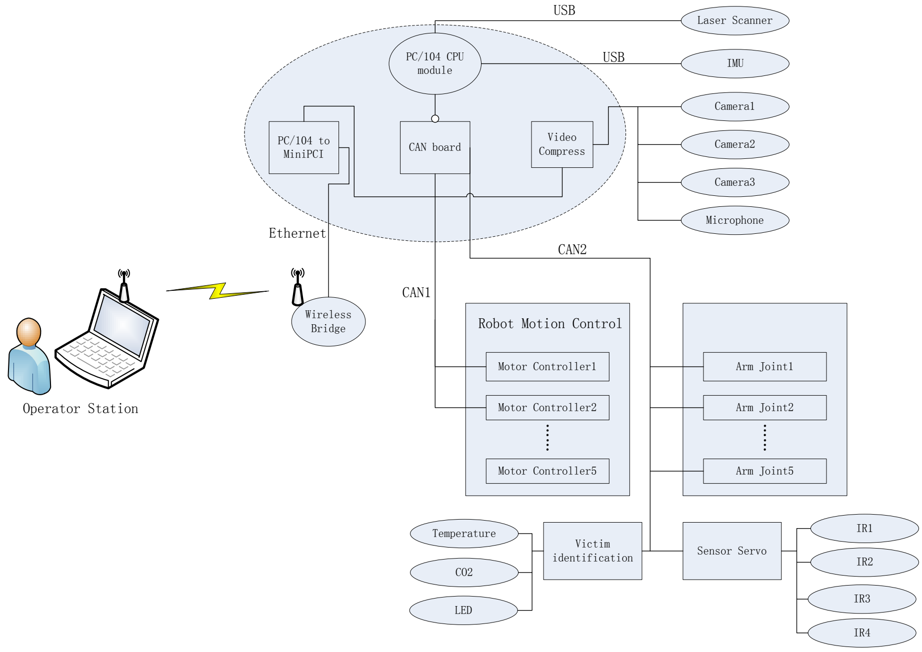


Fig. 5. Diagram of the tele-operative robot control hardware structure

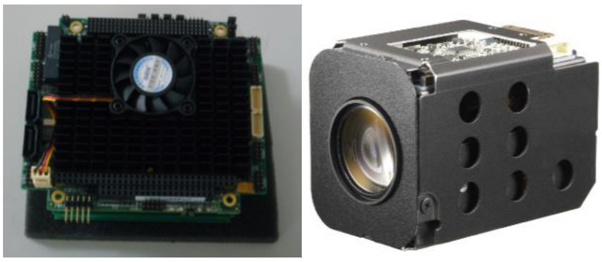


Fig. 6. Embedded computer and camera on tele-operative robot

5.3 Autonomous and Human-Robot Interface

There are some effective ways on localization, navigation, and multi-robot cooperation, which are tested in the simulation environment. We focus on complement this way on our real robot, and meanwhile find the differences between real world and the simulation environment in detail (the unconfirmed factor is more than the simulation environment). However, in the early phase, it is effective to use UARSim to develop the software framework and new method for testing, and it is not enough to test the method which used on the real robot. So in the new vision, we still use UARSim in the early phase to develop the software when the hardware of the robot is in update. In the framework of the software, there is a hardware-independent layer to reduce the effects of different hardware framework, which is shown on Fig.7. The flow chart of the software is shown on Fig.8. Fig.9 shows the GUI of robot control.

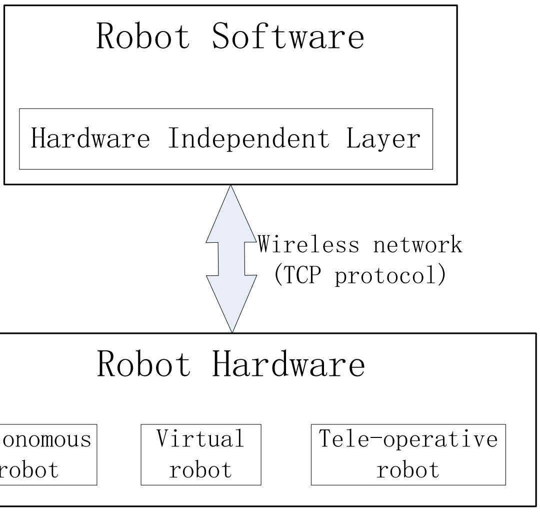
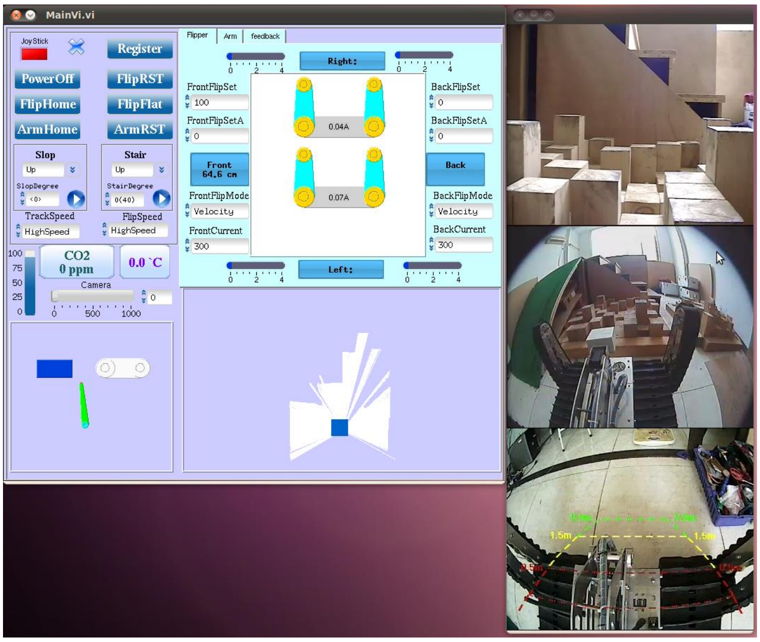
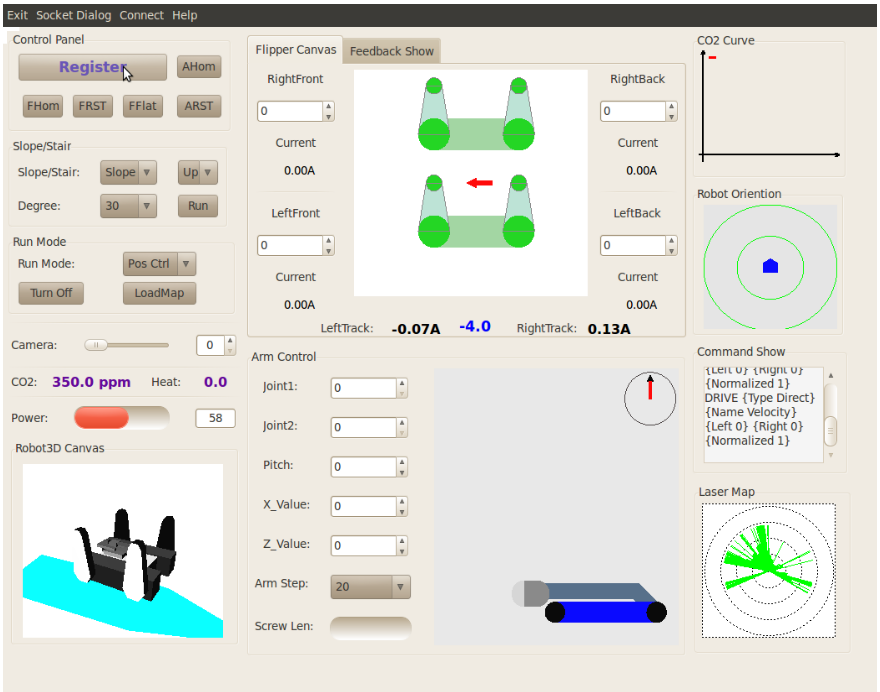


Fig. 7. The control method of software



Slop: Up
SlopDegree: <0>
Stair: Up
StairDegree: 0(40)
TrackSpeed: HighSpeed
FlipSpeed: HighSpeed
Camera: 0
FrontFlipSet: 100
FrontFlipSetA: 0
FrontFlipMode: Velocity
FrontCurrent: 300
BackFlipSet: 0
BackFlipSetA: 0
BackFlipMode: Velocity
BackCurrent: 300

Fig. 8. Flow chart of robot control software



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{Left 0} {Right 0}
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DRIVE {Type Direct}
{Name Velocity}
{Left 0} {Right 0}
{Normalized 1}
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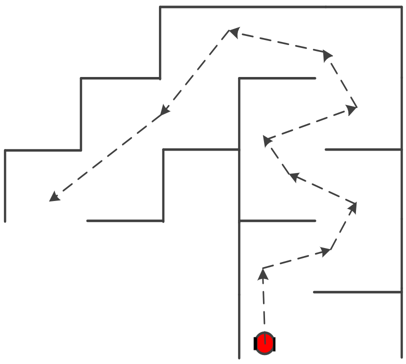
Fig. 9. GUI of robot control

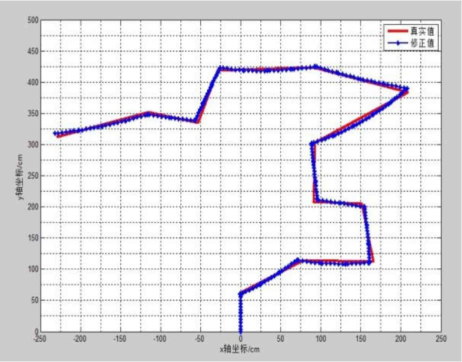
6 Map generation/printing

To achieve an accurate geo-referenced map, the robot should know its position synchronously and exactly during the exploration. While the position data got from the odometry senor or inertial navigation sensor is always with a large error, laser range scanners can deliver highly accurate measurements, and a position estimated based on scan matching is impressive for indoor environments.

In unknown environment, our robot generates incremental geometric map using geometric prototype such as point, line, flat to approximate signpost characteristics. Through the fusion of multi-sensor, robot locates itself in global map, on which the mode of environment is established. The fusion of multi-sensor is divided into two steps. First, collect line segment's information from laser's data, match adjacent cycle's line segment to preliminary redress the pose and position of the robot. Then, use EKF algorithm to realize second time fusion to further redress robot's pose and position data. In the mapping progress, we constantly match the partial line segment with global line segment and update the set of global line segment. The mapping progress shows in Fig.10.

Fig.11 shows the map in China Open 2011.

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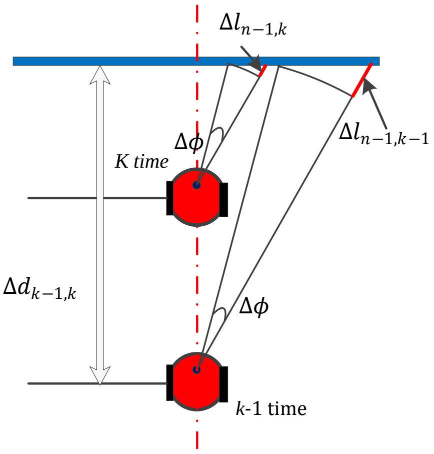
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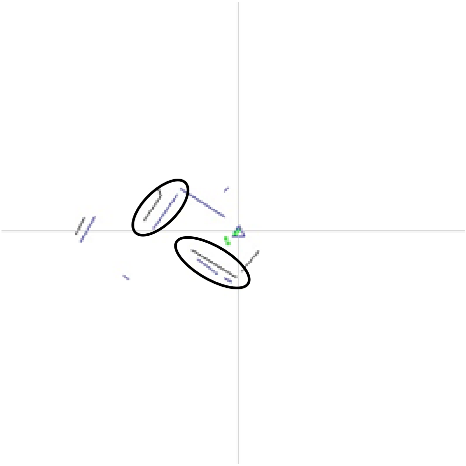

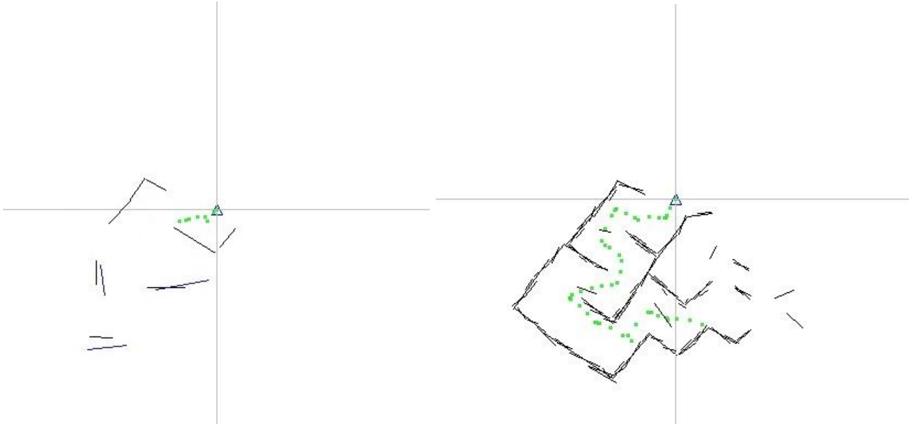

Fig. 10. The mapping progress

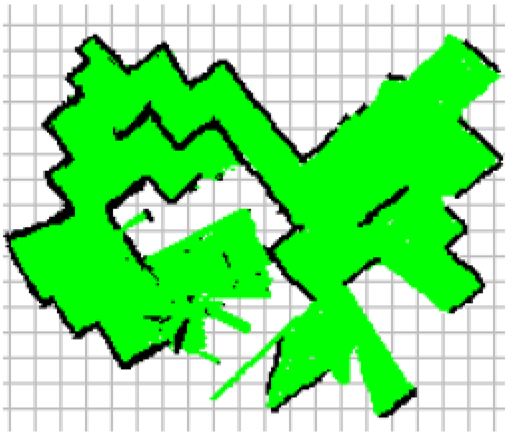

Fig. 11. The map in RoboCup China OPEN 2011

In the same time we are developing method of generating 3D map by Kinect 360 device assembled on out two-wheel robot. Fig 12 shows the 3D map example.

Fig. 12. The 3D map of simulated environment

7 Sensors for Navigation and Localization

In order to manipulate the robot in an unknown environment, we use several digital sensors to gather information of the environment. The robot is equipped with the following sensors for localization and navigation:

(a) Scanning Laser Range Finder (URG-04LX) is used to provide a precise measurement [4].
(b) Odometry, it use the rotate output to compute the head and distance. It is worth in the skipped environment, but it one option to help localization and navigation.
(c) Kinect, it use two camera to get 3D information of the environment.

The sensors are shown in Fig.13.

Fig. 13. Scanning Laser Range Finder & IMU & Kinect

8 Sensors for Victim Identification

We use a camera fixed on the arm of the robot for identifying and localizing victims. The video streams with picture 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.

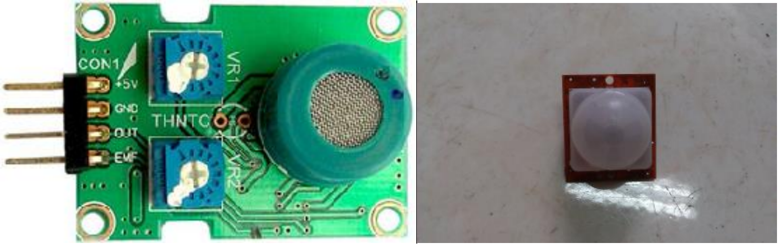

Fig. 14. CO_2& Temperature module

9 Robot Locomotion

The robot is the same as shown in the Fig 15. The drive system of the robot use conveyer belt which can be used on different types of terrain. This robot includes several parts: two movement modules for the left and right and two pairs of flipper (front and back). Each pair of flipper can rotated 360 degree and work independently of each other. Through compare and research, we find that this structure is better for the disaster situation. In order to step up the bottom of the body, the body and movement module are entirely separated except several linkers. Therefore, three DC motors are hided in the body of movement module, one for the movement of belt and the others for the rotation of flippers. Most of the structure is made of Aluminum and the belt is made of synthetic rubber. This year we re-designed the belt to adapt to complex terrains.

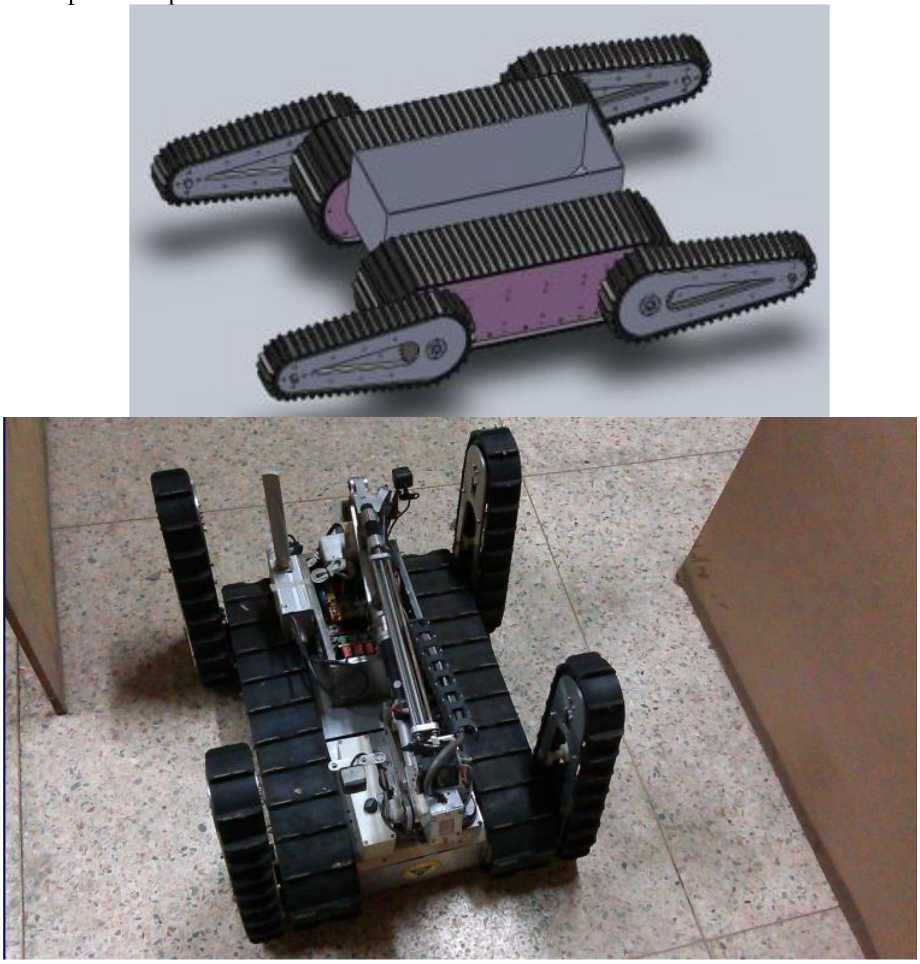

Fig. 15. Tele-operative robot

10 Other Mechanisms

Modular design approach is used for the robot. In that way, the robot can be divided into several modules: left and right main track modules, two pair of flipper, body control section and mechanical hand. Every module can be easily removed and assembled. When a certain part comes across with a problem, we can quickly get to replace the module in a short time, so the robot can play a greater rescue role.

We are also designing mechanical hand that can be used to deliver payload. The Fig 16 shows the design.

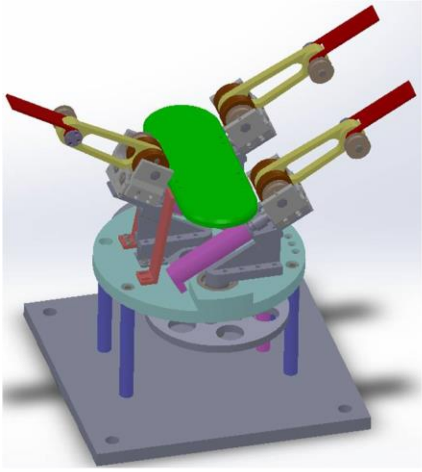

Fig. 16. 3D picture of mechanical hand

11 Team Training for Operation (Human Factors)

The operator should be familiar with the structure and the function of the GUI and be able to immediately understand the data of all sensors showed in the GUI. As the operator, he also needs to drive the robot remotely according to the video stream of the camera and the distance of the obstacles scanned by laser. So we set up a similar simulated environment(see Figure 17)in lab which has ramps, stairs,flat flooring, wall, stepfield terrains and so on. The operator spends a lot of time to familiar with driving. To totally understand the structure of the robot, the operator separates the robot into deferent modules and then re-assembles the robot.

Fig. 17. Simulated Environment

12 Possibility for Practical Application to Real Disaster Site

We yet have no practical experience with real disaster sites. However, we consider the practical application when designing the robot, such as compact mechanism, modular design, less operator station setup time. The using of life-detecting sensor and modern mobility make the robot having the possibility for detecting victims in rear disaster site. The audio communication module can help us establish communications with victims.

13 System Cost

Table 2. autonomous robot cost

Part Name	Quantity	Unit Price(RMB)
Motor+Gearhead+Encoder	2	3,000
Other mechanical parts and manufacture		6,000
Scanning Laser Range Finder(URG-04LX)	1	19,000
HMR3300	1	3,000
Wireless router (DIR-628)	1	1,000
Laptop	2	15,000
PCB		2,000
Other electrical parts		2,000
Battery	2	1,000
Total		68,000

Table 3. tele-operative robot cost

Part Name	Quantity	Unit Price(RMB)
Maxon motor (RE36) + Gearhead + Encoder	3	5,160
Maxon motor (RE40) + Gearhead + Encoder	2	6,400
Maxon motor(RE-max21) + Gearhead + Encoder	1	10,575
Maxon motor (RE26) + Gearhead + Encoder	1	5,828
Maxon motor (RE35) + Gearhead + Encoder	3	5,414
Other mechanical parts and manufacture		80,000
PC104-plus computer	1	15,000
Scanning Laser Range Finder(URG-04LX)	1	19,000
MTi AHRS (MTi-28 A53 G35)	1	18,000
Laptop	1	15,000
Camera	3	5,000
Video card	1	1,500
Laser servo controller	2	2,000
PCB		3,000
Other electrical parts		5,000
Battery	2	4,000
Total		245,925

14 Lessons Learned

We never stop improving and perfecting our robot. We will continue to improve the SEU-Ⅱ robot, and with the same time our SEU-Ⅲ is in perfecting progress. On SEU-Ⅲ, we have carried out many changes in the mechanical structure. It will be lighter, more flexible and more powerful. As the wireless communication maybe unstable in disaster environment, in the SEU-Ⅲ robot, we use high-power network bridge for communication to ensure stability.

Autonomous robot also has application in extreme environment. So a new robot that can be used in extremely cold environment in our lab is on the way.

We are also designing mechanical hand that can be added to the SEU-Ⅲ robot. With the mechanical hand, our robot can deliver fluids, nourishment, medicines to found victims.

We will do our best to prepare this year's competition.

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