RoboCupRescue 2017 Team Description Paper <SEU-UniRobot(China)>

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Info

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Abstract—This paper describes the SEU-Jolly rescue robot team, which are very interested in participating in RoboCup 2017. The robot we owned named SEU-V, which is a tracked robot with two pairs of flippers. It can tonomously navigate in relatively flat environment and move rough terrain with tele-operation .In addition, operation, the robot is able to automatically create global maps by fusion of multi-sensors' information.

I. 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, China Open 2013, RoboCup 2010 Singapore, RoboCup 2011 Istanbul and Robocup 2013 Netherland, Robocup 2016 German. 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 2012. We will use SEU-Jolly as our team name.

Our first version of robot named SEU-Ⅰ was awarded 2nd place in China Open 2009; Our second version was named SEU-Ⅱ, which got 2nd place in China Open 2010 and participated in RoboCup 2010 Singapore and in RoboCup 2011 Istanbul. Our third version named SEU-Ⅲ participated in RoboCup 2013 Netherland. Our fouth version named SEU-Ⅳ participated in RoboCup 2014 Brazil and RoboCup 2015 Hefei,China. Our latest version is named SEU-V, which got 2nd place in China Open 2016 and participated in RoboCup 2016 German.

Fig 1 shows our newest robot: It participated the competition in German last year. Compared to itself last year, our robot has made great improvement.

For some reasons such as exit visa, our team did not attend Robocup 2012 in Mexico. But we have successfully attended Robocup 2013 Netherland, Robocup 2014 Brazil, Robocup 2015 in Hefei China and Robocup 2016 in German. We hope we can participate in the Robocup 2017 in Nagoyo, Japan.

Fig.1 rescue robot in competition

II. System Description

A. Communication

The robot is configured with wireless network with 802.11a/5.8GHz. 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. When operating in autonomous mode, our robot can run normally in drop-out zone because of its fully on-board data process control. Switching to manual operation mode, our robot can work in reduced functionality mode.

Fig.2 the high power network bridge

Table 1 Communication channels

Rescue Robot League		
SEU-UniRobot (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

B. Control Method and Human-Robot Interface

According to the different functionality, we use independently control method in different modes. In the autonomous mode, we use MCU + Notebook PC construction. Taking into account the scalability and flexibility for manual operation mode, 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 modes by no modification due to the use of CAN bus.(See Fig.3).

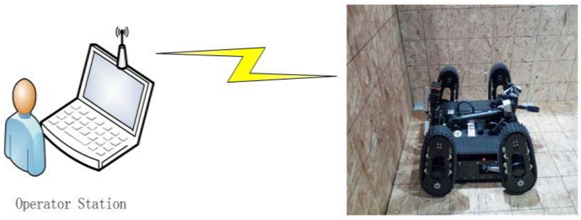

Fig.3 robot control

2.1 Robot

Fig.4 describes the robot construction. The PC/104, video server and MiniPC are three main parts of the robot. PC/104 is used as the main controller for robot motion control. As a common local bus standard in our motion module, it is easy to implement each motion function independently. Meanwhile, for enough performance of CPU, our robot can run in drop-out zone with reduced function as we found the wireless communication is not always stable. There are five cameras in our system, which will occupy a lot of load of the CPU. To ensure the performance of our motion control, we add a small video server to process the video progress. Almost all the sensor information are sent into the MiniPC, which undertake the obligation of SLAM and Navigation. The information of our robot system including video and robot motion location is transmitted to the operator station through Ethernet.

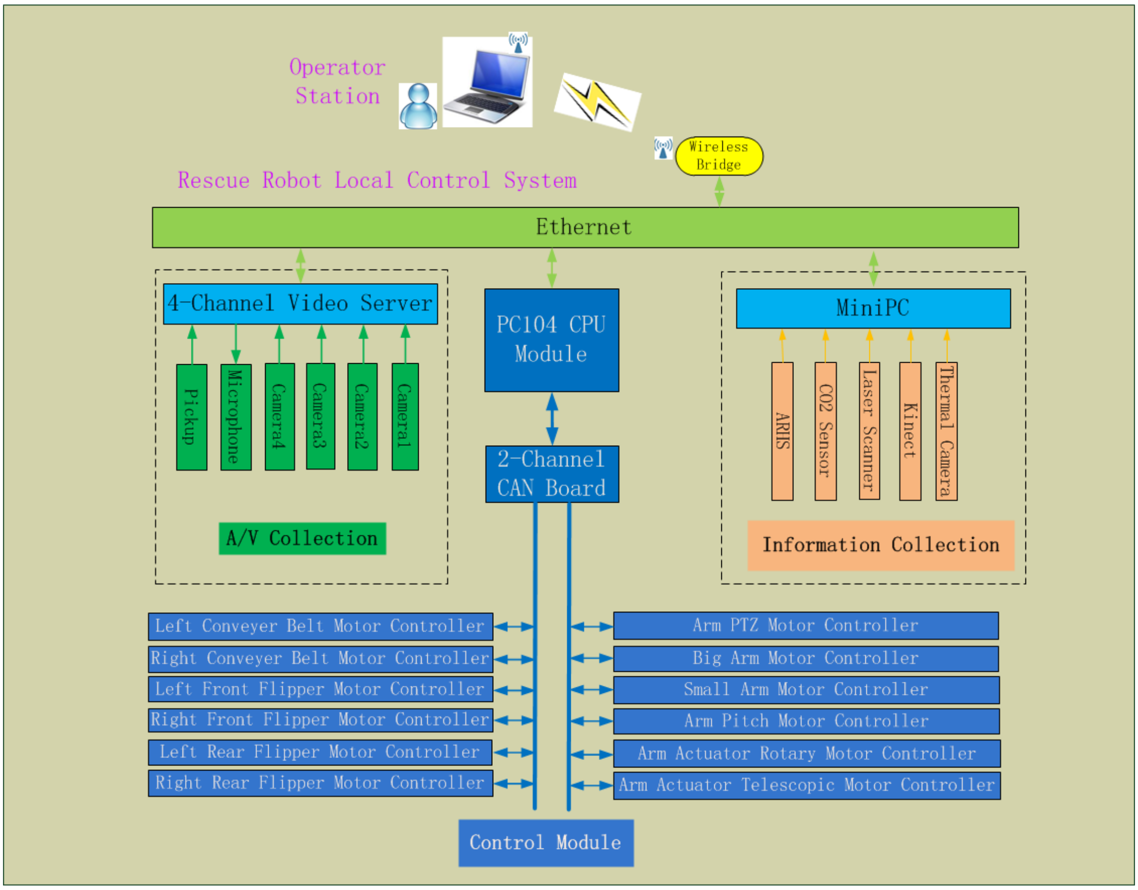

Fig.4 Diagram of the robot control hardware structure

2.2 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 implementing these methods on our real robot, and meanwhile find the differences between real world and the simulation environment in detail (the unconfirmed factor in real world is more than in 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 version, we still use UARSim in the early phase to develop the software when the hardware of the robot is updating. 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.5.

Fig.6 shows the GUI of robot control. We use a control box instead of a PC to tele-control our robot, which is very effective in operation. The control box have buttons, two screens, one of which is a touch screen, joysticks and other interfaces.

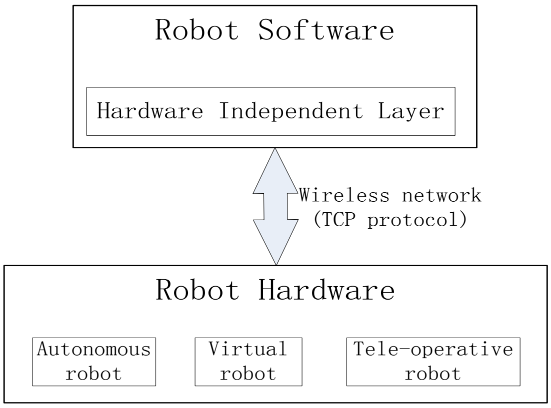

Fig. 5 The control method of software

Fig. 6 GUI of robot control

C. 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.

We plan to use gmapping algorithm to create 2D occupancy grid map. The approach takes in raw range laser range data generated by range lasers like Hokuyo scanner and odometry collected by mobile robot. The robot is equipped with a horizontally-mounted, fixed laser range-finder. Each period when receiving the data, we can get a roughly estimate of the location and orientation of the robot according to the odometry data,, but the estimates have large error. So we need to correct the pose of robot by the following ways. Firstly, we get pose fixed preliminarily by matching the fitting straight line with the globe map. Secondly, using grid-based SLAM with Rao-Blackwellized particle filters is an effective way to solve the simultaneous localization and mapping problems. The main principle of Rao-Blackwellized particle filters is adaptive proposals and selective resampling proposed by Giorgio Grisetti.. What's more, we can get the accurate pose of the robot and maps matching well. To mark victims, the operator just needs to press the "Enter" key and the algorithm can get the signal and draw marks on the map. Generally the map of the environments is produced successfully.

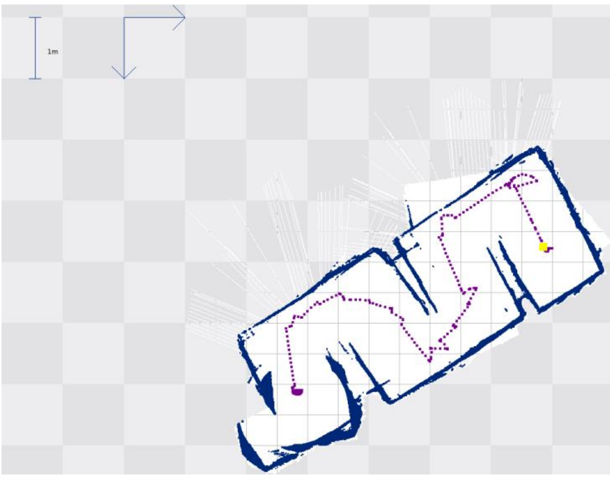

Fig. 7 the map in experiments

At the same time we are developing method of generating 3D map by Kinect 360 device assembled on out two-wheel robot. Fig 8 shows the 3D map example.

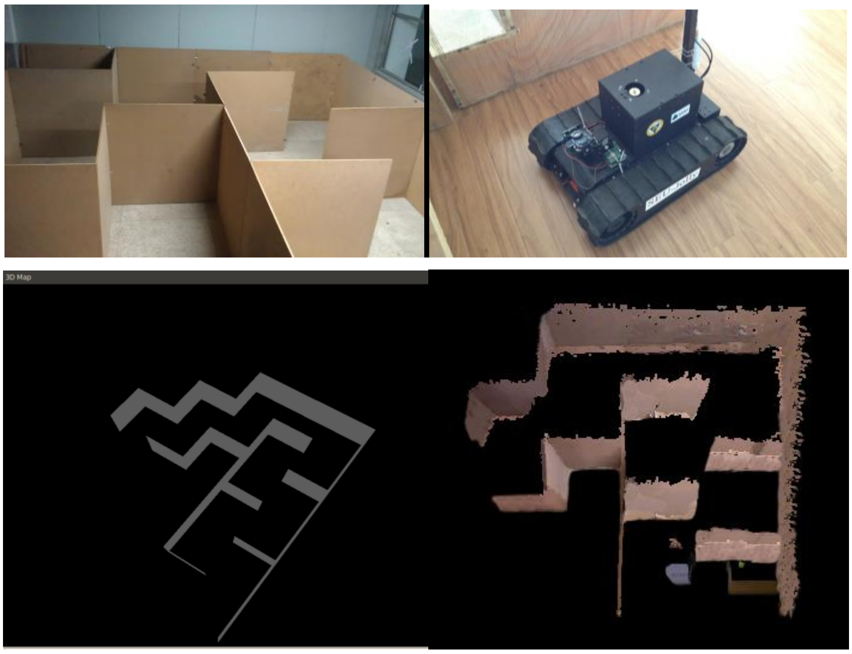

Fig. 8 The 3D map of simulated environment

D. 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:

1) Scanning Laser Range Finder (URG-04LX) is used to provide a precise measurement [4].
2) Odometry, it use the rotate output to compute the head and distance. It is worth in the skipped environment, so it's also an essential condition to help localization and navigation.
3) Kinect, it use two camera to get 3D information of the environment.

The sensors are shown in Fig.9.

Fig. 9 Scanning Laser Range Finder & IMU & Kinect

E. Sensors for Victim Identification

In the competition of RoboCup Rescue, the main target is find victims in an unknown environment. The victims are simulated by a puppet with a heating panel in the background. . In order to detect heat source and determine whether it is a victim, we use several sensors to gather visual information of the environment. The robot is equipped with the following sensors for Victim Identification:

1) Thermal Camera (Optris PI 160) is used to detect heat source in the search arena.
2) Depth Camera (Asus Xtion) is used to obtain depth information for avoiding obstacles and estimating the position of victims.
3) RGB Camera (Asus Xtion) is used to determine whether there is a victim in the heat source.

The sensors are shown in Fig.10.

Fig. 10 Thermal Camera & Depth Camera for Victim Identification

F. Robot Locomotion

The robot is the same as shown in the Fig 11. 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 flippers (front and back). Each pair of flippers can rotated 360 degree and work independently. Through comparison 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, five DC motors are hided in the body of movement module, two of the motors is responsible for the movement of main pedrails and others are responsible for the rotation of flippers. Most of the structure is made of Aluminum and the belt is made of synthetic rubber.

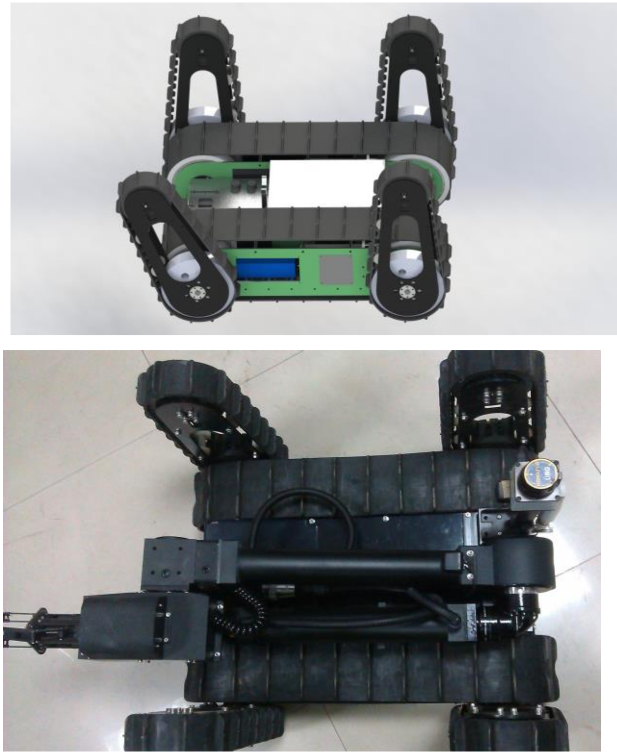

Fig. 11 robot

G. Other Mechanisms

Modular design method is used for the robot. In that way, the robot can be divided into several modules: left and right main movement modules, two pair of flippers, 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 replace the module, so the robot can play a greater rescue role.

We have redesigned a new mechanical arm that can lift up to 5kg payload. The new designed mechanical arm has two fingers, which can clamp and deliver various shapes payloads, besides SEU-Ⅴ is more lighter than SEU-Ⅳ's. The Fig 12 shows the design.

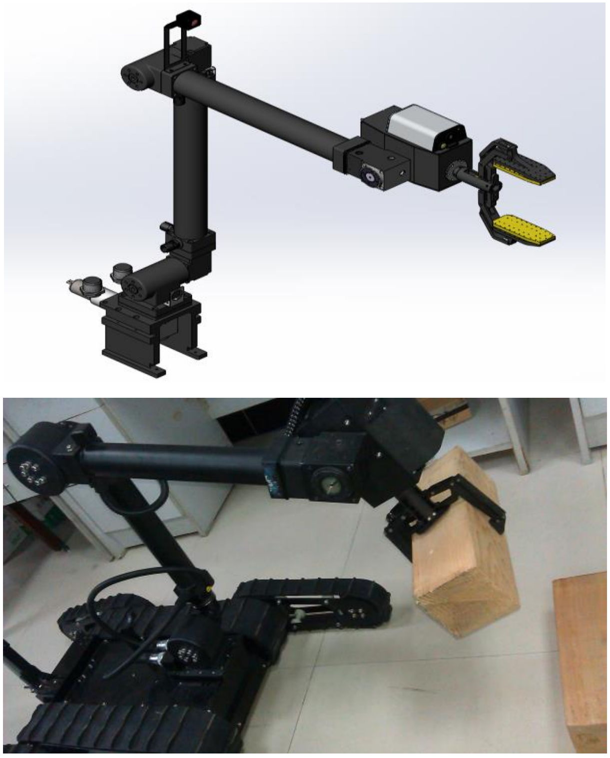

Fig. 12 Mechanical arm and hand

We use embed computer as control center with two display screen, one of screens is a touch screen. The control box has various buttons and joysticks that can be used to control the motion of our robot.

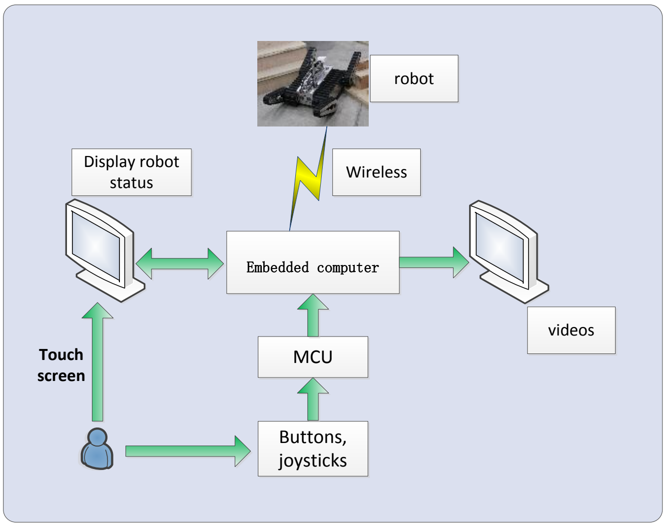

Fig. 13 Hardware structure of control box

III. APPLICATION

A. 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 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.

B. Possibility for Practical Application to Real Disaster Site

We have no practical experience with real disaster sites yet. 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 it possible for robot to detect victims in rear disaster site. And the audio communication module can help us establish communications with victims.

IV. CONCLUSION

A. Team Members and Their Contributions

- Yingqiu Xu Advisor
- Yingzi Tan Advisor
- Ruiming Qian Advisor
- YiJun Zhou Advisor
- Guanming Su Mechanical design
- Zhijun Wu Controller development & Operator
- Shichao Zhang Software development

B. 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 14) in lab which has ramps, stairs, flat flooring, walls, stepfield terrains and so on. The operator spends a lot of time to familiar with driving. To understand the structure of the robot, the operator also separates the robot into different modules and then re-assembles the robot many times.

Fig. 14 Simulated Environment

C. Lessons Learned

We never stop improving and perfecting our robot. We will continue to improve the SEU-Ⅲ robot, and with the same time our SEU-Ⅵ is in perfecting progress. On SEU-Ⅵ, 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-Ⅵ 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-Ⅵ 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.

D. System Cost

Table 2 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

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