RoboCupRescue 2010 - Robot League Team <SEU-RedSun (China)>

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Abstract. This paper describes the SEU-RedSun rescue robot team， which will participate **R**oboCup 2010 with two robots. One robot is four-wheel independent driving construction, which is easy over the incline and low step terrain, and is easy to control. It focuses on implement the autonomous function. The other is a tracked robot with four flippers; it excels on rough terrain with tele-operation. Both robots are able to create map automatically, and share the information each other.

Introduction

SEU-RedSun rescue robot team was found in 2008, participated in China open 2009, original from virtual robot competition SEU-RedSun team, which won the champion in RoboCup 2008 Suzhou, China and was awarded 2nd place in RoboCup 2009 Glaz, Austria.

Fig 1 shows our robots: the left one is the robot awarded 2nd place in China Open 2009; the right one is the autonomous robot with four-wheel independent driving construction.

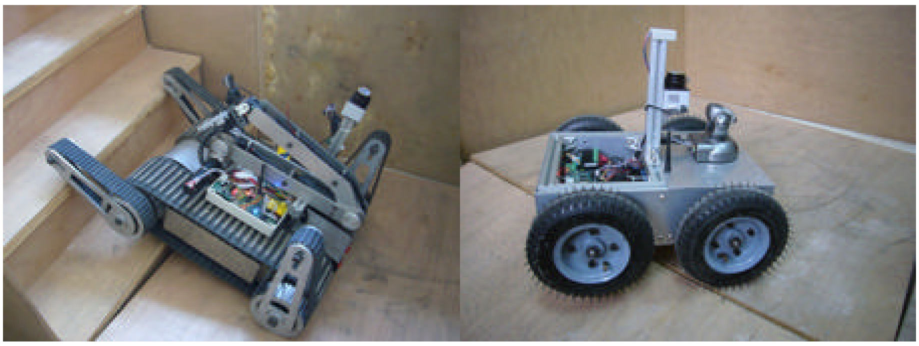

Fig.1 rescue robots in our laboratory

1. Team Members and Their Contributions

- Yingqiu Xu Advisor
- Yingzi Tan Advisor
- Ruiming Qian Advisor
- Yijun Zhou Advisor
- Jie Rong Mechanical design
- Yueliang Dai Mechanical design
- Qinglong Liu Mechanical design
- Jian Wang Controller development
- Peng Sun Controller development
- HeChang Rao Controller development
- Kai Wang Controller development
- ChunLu Jiang Software development
- Si Chen Software development

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

We use only one notebook PC for the operation, so our 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.

3. Communications

The robots are configured with wireless network with 802.11a/5GHz. Both robots only use one wireless communication channel. We use dual band router and miniPCI wireless board(See Fig.2). Considering the reliability of wireless communication in practice, we reduce the dependence on wireless, the autonomous robot can normally run in drop out zone because of fully on board data process control, the tele-operative robot can work in reduced functionality mode.

Fig.2 dual band router and miniPCI wireless board

Table 2. Communication channels

Rescue Robot League		
SEU-RedSun (CHINA)		
MODIFY TABLE TO NOTE ALL FREQENCIES THAT APPLY TO YOUR TEAM		
Frequency	**Channel/Band**	**Power (mW)**
5.0 GHz - 802.11a	1 channel/Selectable	100

4. 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. And on the tele-operative robot, we use PC/104+ construction to control the flexible mechanism. Meanwhile it is easy to update step by step, because each module is 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 use CAN bus.(See Fig.3)

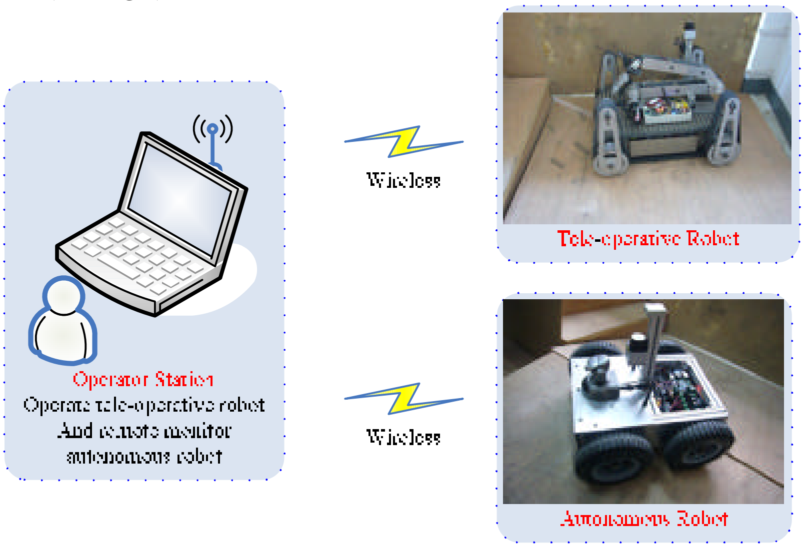

Fig.3 two robots control

4.1 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, 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 direct transmits to notebook through Ethernet. The operator station is option as a remote monitor.

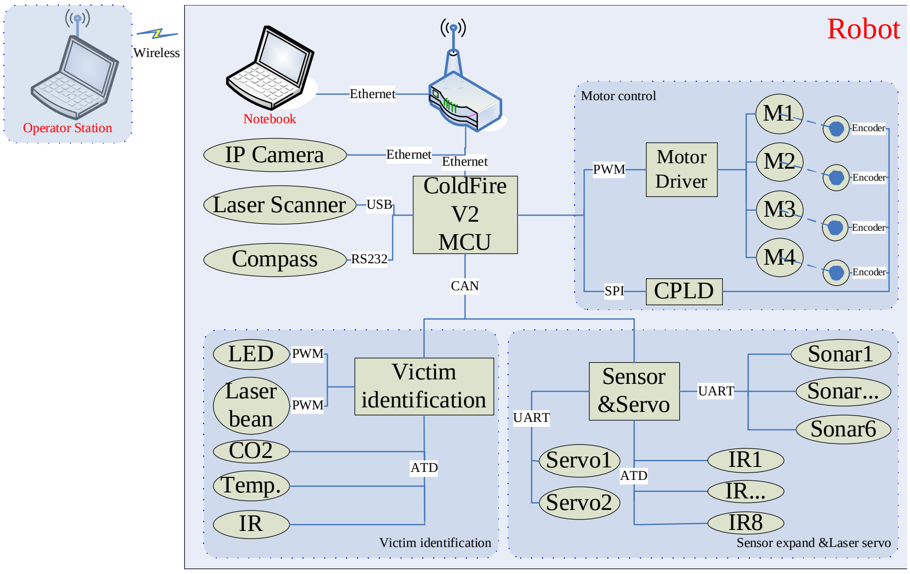

Fig. 4 Diagram of the autonomous robot control hardware structure

4.2 Tele-operative robot

In the old version, we use ARM as the main controller on the robot（Fig.5）, this way can obtain compact construction and we can design a system as we want. And it works well as we expect. But it is difficult to update step by step because of system integrated on the single board. Of course, we found it is difficult to compress video and process on the ARM processor.

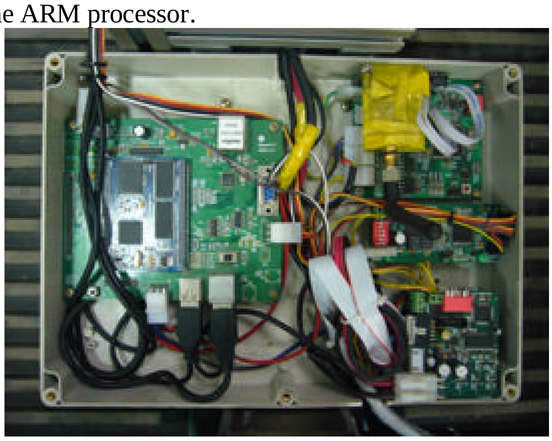

Fig. 5 The control box on the old robot

On the new version, we use PC/104 embedded PC as the main control on the robot(Fig.6), 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. Because we found the wireless communication is not always stable.

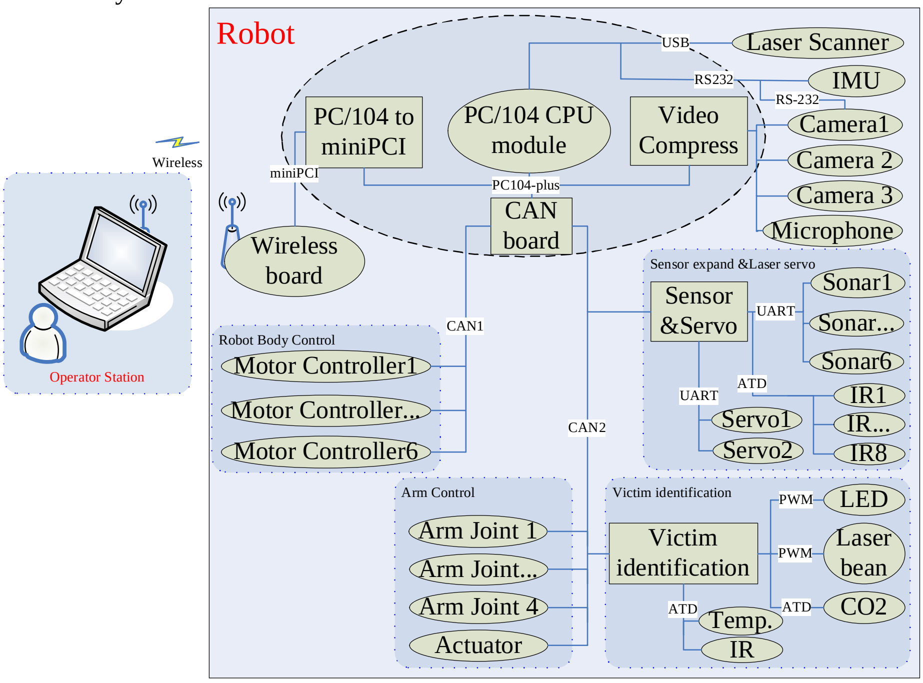

Fig. 6 Diagram of the tele-operative robot control hardware structure

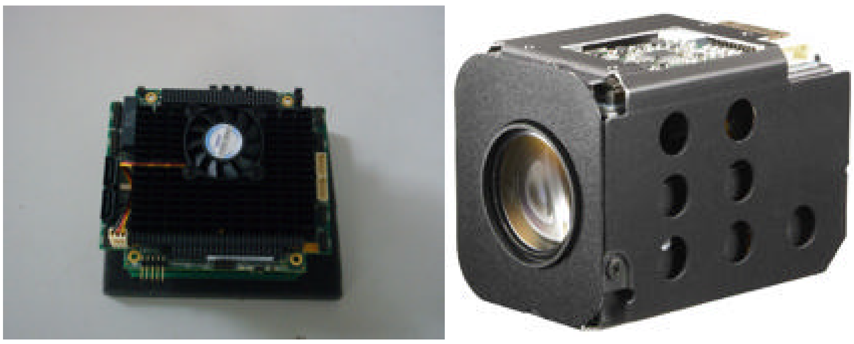

Fig. 7 Embedded computer and camera on tele-operative robot

4.3 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, meanwhile, find the different 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 first test, 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, so in the framework of the software, there is a hardware-independent layer, to reduce the effect about different hardware framework, which is shown on Fig.8. The flow chart of the software is shown on Fig.9. Fig.10 shows the GUI of robot control.

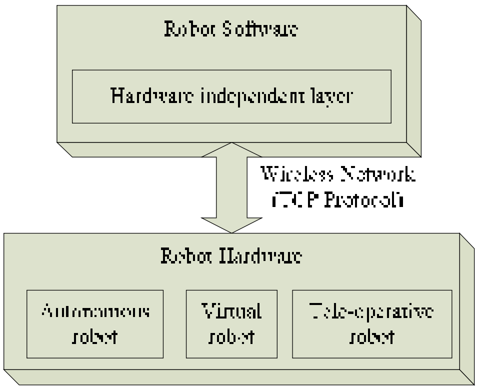

Fig. 8 The control method of software

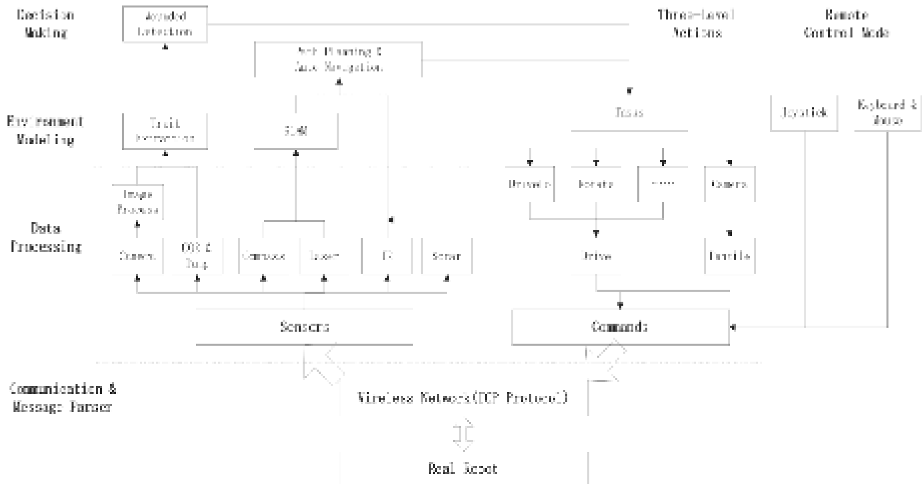

Fig. 9 Flow chart of robot control software

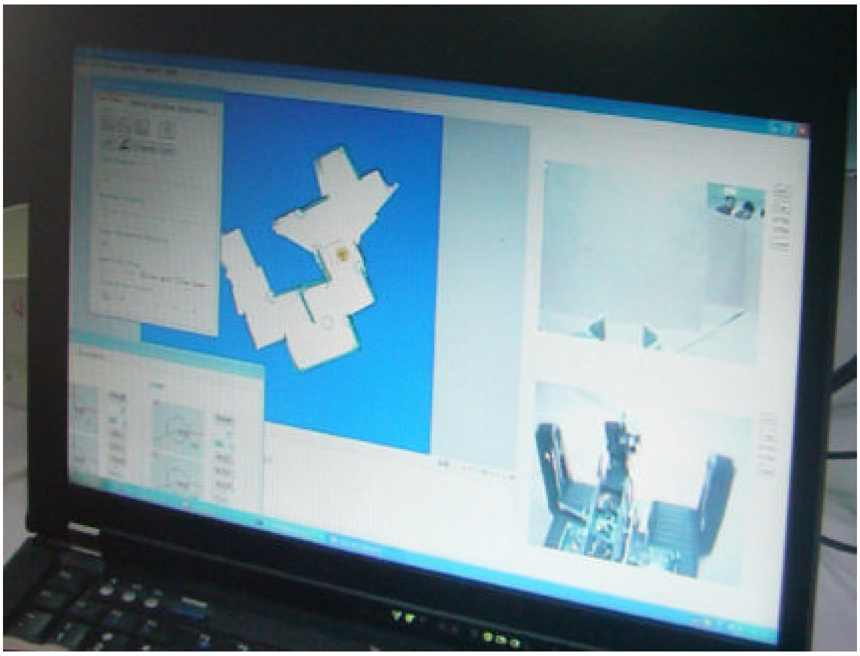

Fig. 10 GUI of robot control

5. 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. Fig.11 shows the map in China open 2009.

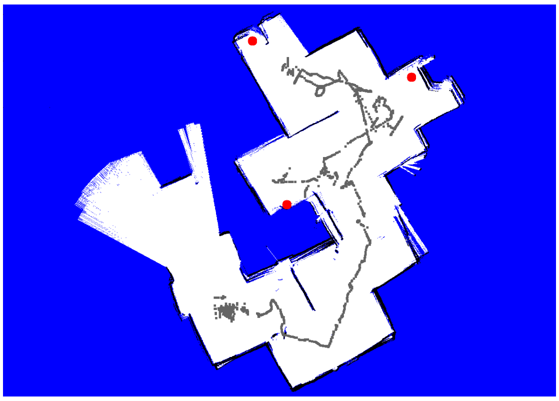

Fig. 11 The map in Robocup China OPEN 2009

6. Sensors for Navigation and Localization

In order to manipulate the robot in an unknown environment, we use several digital sensors to gather information about 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. Digital Compass Module (HMR 3300) measures the roll, pitch and heading direction of the robot [5].
3. Digital Compass Module (OS5000S) is same to HMR3300,but the output data frequency is configurable, it is easy to sync to other sensor ouput.
4. MTi xsens AHRS, it is good in dynamical on measuring the roll, pitch and heading.
5. 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.

The sensors are shown in Fig.12.

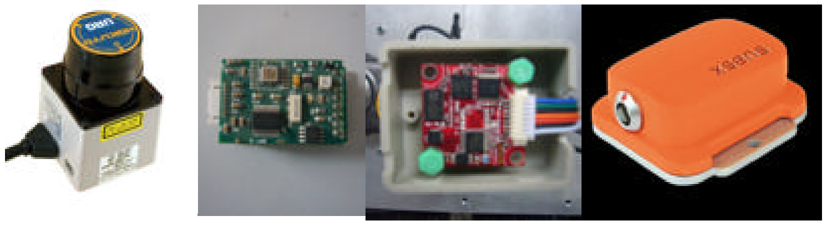

Fig. 12 Scanning Laser Range Finder & Digital Compass & IMU

7. 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.

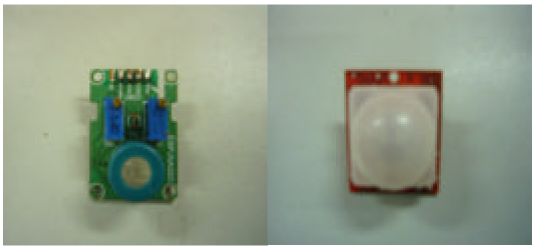

Fig. 13 CO_2 & Temperature module

8. Robot Locomotion

The robot is the same as shown in the Fig 14. 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.

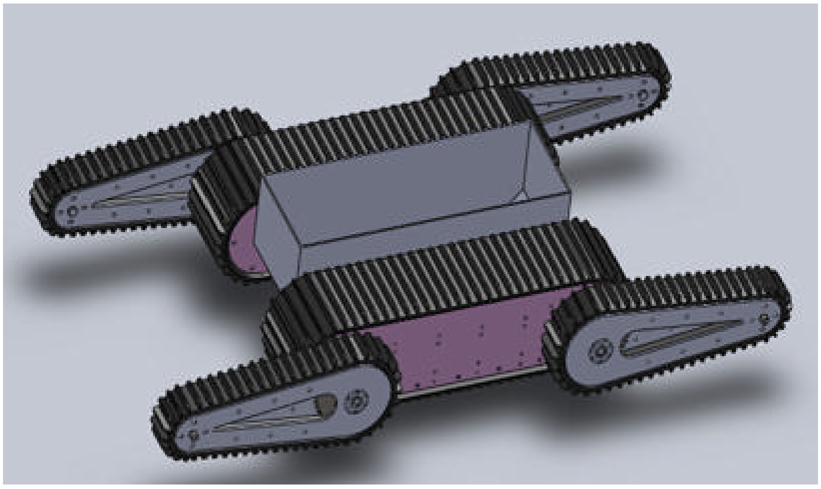

Fig. 14 Tele-operative robot

9. 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 easy removal and assembly. 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 effect.

10. 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.

11. 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 design the robot, such as compact mechanism, modular design, less operator station setup time.

12. System Cost

Table 2. autonomous robot cost

Part Name	Quantity	Price
motor + Gearhead + Encoder	4	¥3,000
Other mechanical parts and manufacture		¥3,000
Scanning Laser Range Finder(URG-04LX)	1	¥19,000
Digital Compass Module (OS5000S)	1	¥3,000
Wireless router (DIR-628)	1	¥1,000
Laptop	2	¥30,000
Laser servo controller	2	¥2,000
IP Camera(FSC1010)	1	¥2,800
PCB		¥2,000
Other electrical parts		¥2,000
Battery	2	¥1,000
Total		¥68,800

Table 2. tele-operative robot cost

Part Name	Quantity	Price
Maxon motor (RE36) + Gearhead + Encoder	4	¥36,000
Maxon motor (RE40) + Gearhead + Encoder	2	¥20,000
Other mechanical parts and manufacture		¥60,000
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
Laser servo controller	2	¥2,000
PCB		¥3,000
Other electrical parts		¥5,000
Battery	2	¥4,000
Total		¥202,000

13. Lessons Learned

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