Robocup Rescue 2015 - Robot League Team iRAP_JUNIOR (THAILAND)

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Abstract. This paper describes about construction and operation of iRAP_JUNIOR. This is the next generation of iRAP_PRO, iRAP_JUDY and iRAP_FURIOUS who have got the 1st place four times in the World Robocup Rescue robot competitions (2009-2011 and 2013). Our team has two similar high mobility tele-operative robots and one autonomous robot. The tele-operative robots have front arms that driven by caterpillar, they can identify victims very well with commodity sensors and able to move autonomously in the radio drop-out zone. The difference between two tele-operative that is the one has used in the industrial rubber as a track wheel and another one used the chain with water-hose. The autonomous robot has a good mobility to move up the incline surface and identify victims by using vision system with image processing and thermal sensor. All of the robots are able to create explored map automatically and able to detect the QR code. The team is prepared for different scenarios that present in the World Robocup Rescue 2015 in Herfei, (China).

Introduction

"**iRAP**" which stands for "Invigorating Robot Activity Project" is the team of students from King Mongkut's University of Technology North Bangkok, Thailand

"**iRAP_JUNIOR**" is the new generation of rescue robot for the competition. The team members are the next generation of **iRAP_PRO, iRAP_JUDY and iRAP_FURIOUS** who have got the 1st place four times in the World Robocup Rescue robot competition (2009-2011 and 2013). The team has good experience and knowledge through these competitions.

The paper introduces our approach to Rescue Robotics. The team has designed and developed them for five years. The team designed three new robots, consisting of two similar tele-operative robots and an autonomous robot. The new robots have been designed by solving problems occurred from the last competition and improve the easiness in robots control and QR code detection. **Our main focuses are explorating all areas, detecting all victims and generating a map in 2-D**. The simulated situation included many rough surfaces, hard terrains, rolling floor, stairs, and incline floor; therefore, the rescue robot should be fast enough, light-weight and strong to circulate and explore.

The rescue robot for this competition is designed based on proficiency robots. Therefore, the team designed robot that can motivate roaming around rough terrain by using caterpillar wheel. The team designed stable cameras mounted arm on our robots and on the robot body to help identify possible victim. The team uses the high quality motor and sensory abilities. The full sets of affordable sensors are put on to the system to measure temperature, CO_2, distance, to create map, and two-way communication. Our preliminary goal of this activity is to achieve a practical rescue robot for real situation such as disaster, earthquake and building destroy. The team expects that all we did can help people's life in real disaster situation.

1. Team Members and Their Contributions

The **iRAP_JUNIOR** has twelve members and three advisors. The names and responsibilities of each member are listed as follows:

- Mr.Thanapon Sorndach Mechanical & development
- Mr.Pattaraphon Boonchai Controller development
- Mr.Yatip Uarmorn Mechanical design & Structure
- Mr.Jirath Sorndach Mechanical design & Structure
- Mr.Chatpong Rattanapan Mechanical design
- Mr.Yodsanon Chusanatas Tele-operative robot Hardware
- Mr.Tanawat Pongsathornpisuth Autonomous development
- Mr.Arphakorn Kunha Electronic design
- Mr.Anon Makchareon Electronic design
- Mr.Patipan Amnajsung Software & Control development
- Mr.Poommitol Chaicherdkiat Network system
- Mr.Noppadol Pudchuen Software & Control development
- Mr.Sai-yan Primee Advisor
- Asst. Prof. Chatchai Swrmpongpan Advisor
- Dr.Amornphun Phunopas Advisor(Team Leader)

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

The speed of the set-up and break-down process of each task is very crucial. The team realizes that the faster for set-up and break-down, the better time for other tasks. The team uses aluminum case as the station. When needed, just open this aluminum case and turn on the switch. The operations can be started within 1 minute. Inside this aluminum case, there are 3 monitors, a notebook, an access point, a printer and a UPS. Once all the tasks are completed, the report and the generated map can be quickly printed out.

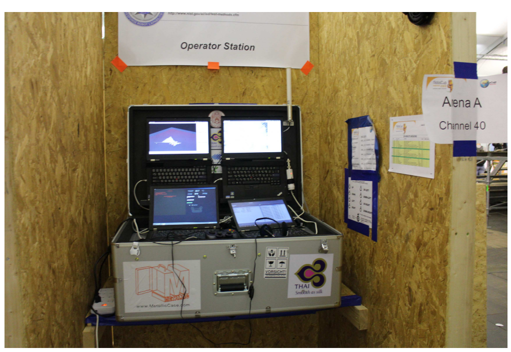

Figure 1: The operator station

3. Communications

There are two communication systems used between the operator and the robots. The first one is wireless LAN based on IEEE 802.11a standard which functions as the main communication system. That is, it controls robots, receives video streaming from cameras on robots, and checking sensors feedback for locating the status of robots on computer monitor as well as for the automatic map generation. The second one is the RC controller with the radio frequency of 72 MHz as the backup communication system for an emergency situation. The range of the working distance is 400 m for outdoor and 200 m in the building.

Rescue Robot League		
iRAP_JUNIOR (THAILAND)		
MODIFY TABLE TO NOTE ALL FREQENCIES THAT APPLY TO YOUR TEAM		
Frequency	**Channel/Band**	**Power (mW)**
5.0 GHz - 802.11a	Adjustable	630

4. Control Method and Human-Robot Interface

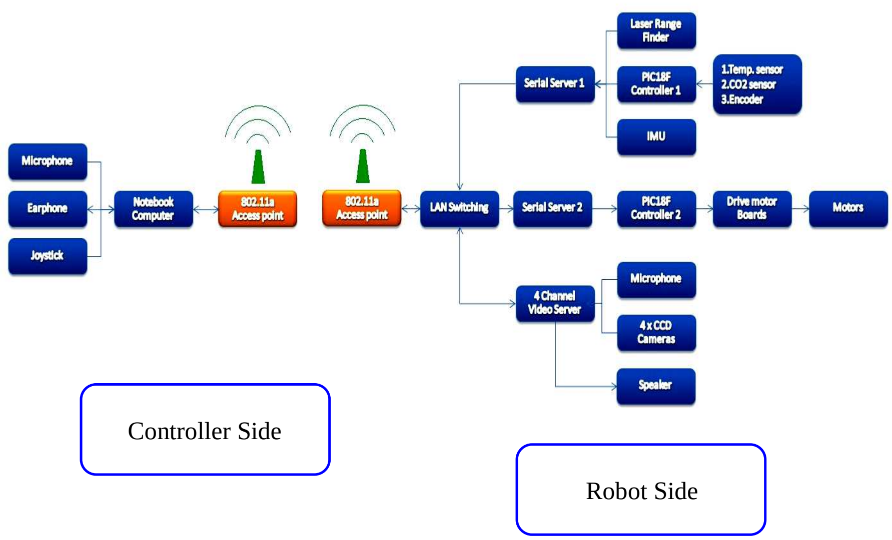

Figure 2: The control system diagram

The main control is based on one CPU (PIC microcontroller 80 pins). Figure 2 shows the diagram of the control system which has two main tasks as follows:

4.1 To receive the data for identifying the status of the robots as shown in figure 3 (Quad-video and sensors information) and create 2-D map automatically as shown in figure 4. This information will be shown to the robot operator via a second computer monitor.

4.2 To send the data for controlling the movement by sending the signal to the drive control for controlling DC motor at various locations on the robots.

The RS-232 communication system will be used for sending and receiving the data of CPU. Therefore, there must be a serial server to convert RS-232 system to Ethernet system.

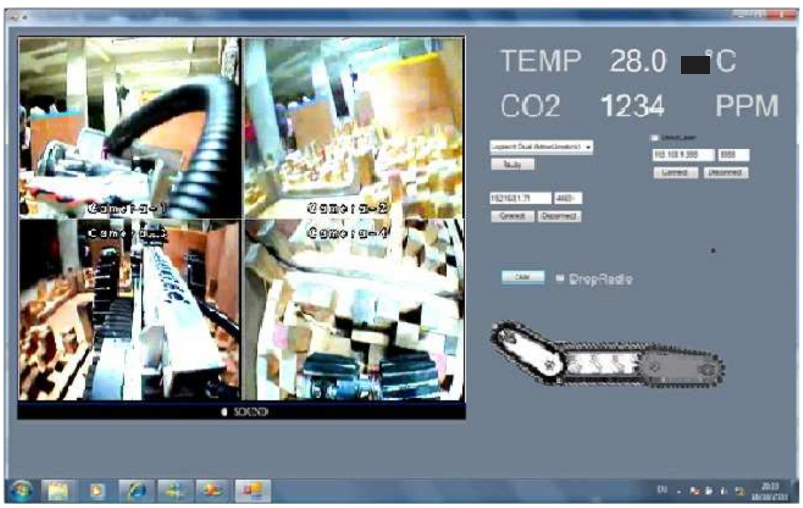

Figure 3: Operator console illustrated the real time quad videos and the information of robot’s sensors.

5. Map generation/printing

Several kinds of sensors are installed on each robot in order to gain the data for processing and creating automatically 2-D map on the operator's computer monitor. The map is generated by using the information from the distance of the robot movement from encoders, inclination of the robot and direction of the robot sensed by Inertia Measurement Unit, and distance between the robot and obstacles from laser range finder. However, when the robot moves on different kinds of surface, the slipping problem is unavoidable. This slipping is a major problem for designing and constructing the robot. Therefore, SLAM algorithm [1, 2] is utilized to help generate the map in addition to the information from the encoders and assign position on axis x, axis y and axis z from camera with lidar scan.

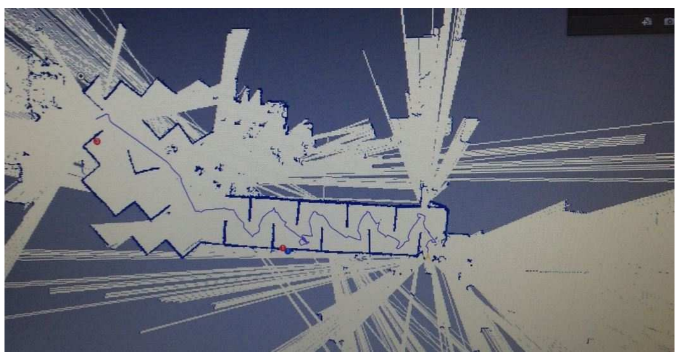

Figure 4: Automatic map generated by iRAP_JUNIOR software

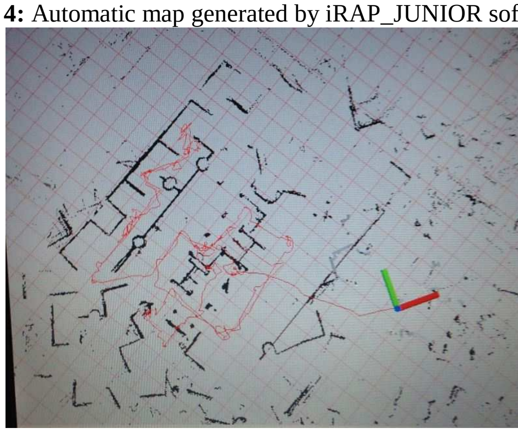

Figure 5: Automatic map generated by iRAP_ JUNIOR's software

6. Sensors for Navigation and Localization

Sensors, used for guiding the robot movement and identifying the location of the robots for 1 Robot, are described as follows:

1. Four of CCTV cameras with wide-angle lenses, in Figure 6
2. axis Accelerometer (Shared with map generation), in Figure 7
3. LIDAR Sensor (Shared with map generation), in Figure 8
4. Digital Compass (Shared with map generation), in Figure 9
5. five Encoders (Shared with map generation), in Figure 10
6. four Servo Motors for show position of mechanism in Figure 11

Figure 6: CCTV cameras

Figure 7: Accelerometer

Figure 8: LIDAR Sensor

Figure 9: Digital Compass

Figure 10: Encoder

Figure 11: Servo Motor

7. Sensors for Victim Identification

For victim identification, the team will analyze information from different kinds of sensor that are located at the robot surveying arm. For preliminary step, the team will check the status of the victims through the CCTV camera in figure 6 and measure the victim body's temperature by utilizing temperature sensor in figure12. In some circumstances, this victim is informed by the temperature. And, it will be incorporated with data from CO2 sensor in figure13 and the surrounding sound, which will be received via microphone in figure14, to analyze the situation of the victim. The figures below illustrate the pictures of temperature sensor, CO2 sensor and microphone.

Figure 12: Temperature Sensor

Figure 13: CO_2 Sensor

Figure 14: Microphone

8. Robot Locomotion

Regarding designing the robot locomotion system, the team has learned and improved through our team advisors “iRAP_PRO”, “iRAP_JUDY” and “iRAP_FURIOUS” that have gained experiences from many competitions. In this competition, our team has designed new three robots consisting of two tele-operative robots and one autonomous robot. The team is looking forward to researching the better locomotion system.

The locomotion of all tele-operative robots is made of the conveyer belt system that the team has examined from different surface characteristics of the terrain. Many parts of the robot have been improved in order to be tough, light weight and easy for maintenance as much as possible. Each drive system consists of two motor-- 24V, 95 rpm DC with gear-boxes for the movement on the left and right. The structure of the drive system is made of aluminum. The synthetic rubber is used to make the belt. The robots have a pair of flipper that can be rotated 360 degrees (as shown in figure 15 to figure 17).

Figure 15: Tele-operative robot I locomotion

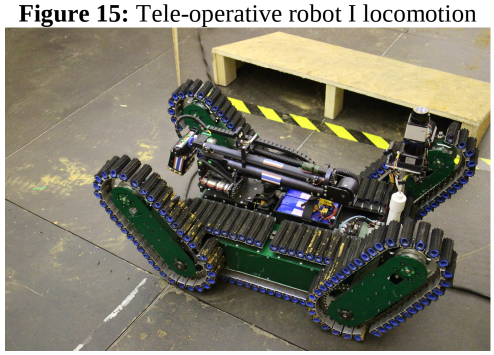

Figure 16: Tele-operative robot II locomotion

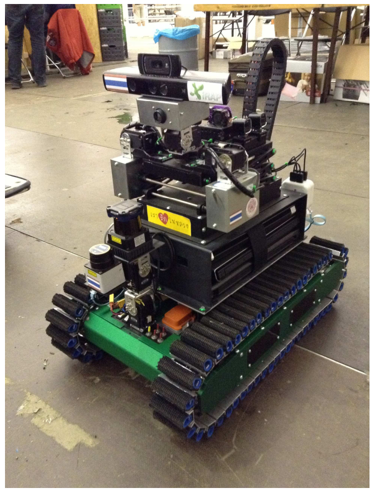

Figure 17: Automatic robot locomotion

9. Other Mechanisms

The manipulator of the robot arm is installed with a video camera and sensors. It shows the high mobility. If necessary, to increase visualization, it can be rotated 360 degrees and can be extended closer to the victim. Also, there is a gripper at the end of this manipulator. It is capable to move an object which weighs less than 5 kg. , and can be stretched up to 1.50 m high from the floor (as shown in figure 18).

Figure 18: Robot manipulator arm

10. Team Training for Operation (Human Factors)

The tele-operative robot requires a long training period. Competing members have to build challenging arenas in order to train the current operator. The team has designed planned in different regular competitions among the team members in order to determine the most suitable person for tele-operation.

This is our first time for the world class rescue robot competition. All of us do not have many experiences but the team has learned and trained with our senior the iRAP_PRO, iRAP_JUDY and iRAP_FURIOUS that won four times in the World Robocup Rescue robot competitions (2009 – 2011 and 2013).

11. Possibility for Practical Application to Real Disaster Site

Our main goal in this activity is for real disaster situation. The team has designed all the parts of the robot for real rescue application. We are confident that our robot is very useful for disaster defender but it is still not for water proof.

In the future, the team might improve and change a lot of robot parts for better results that may be able to prevent the water and fire. For example, the team will increase the toughness of some robot parts, create weightless robot, extend the effective range of WLAN's signal, and improve the quality of video cameras. The team plans to make them in the real application soon.

12. System Cost

iRAP_JUNIOR has three robots. Two of which are 2 tele-operative robots and the autonomous robot. The cost of parts on each robot is listed as follows:

Structure of robot and drive train	$ 2,500
Sensors	
- Encoders x 5	$ 420
- Xsense Inertia Measurement Unit	$ 2,800
- Hokuyo laser range finder	$ 5,950
- Temperature sensor	$ 2,400
- High quality microphone	$ 120
- Video cameras x 4	$ 320
- CO2 sensor	$ 125
Controller and electronics	$ 350
Communication system	
- Access point IEEE 802.11a	$ 190

-	Quad channel video server	$ 800
-	Serial server	$ 250
-	Servo motor x4	$ 5000
Total Cost		**$21,225**

13. Lessons Learned

After the competition, the team knew how to make the better robots. The team learned the new technologies from other countries' competitors, learned how to be a good team. The team gained many experiences. Importantly, the team knew that "The great competition is not practicable, if you do not have a good teamwork."

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