Robocup Rescue 2013 - Robot League Team iRAP_FURIOUS (THAILAND)

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Abstract. This paper describes about construction and operation of iRAP_FURIOUS who has got the 1st Runner up award of rescue robot competition in Thailand. The team is the next generation of iRAP_PRO and iRAP_JUDY who have got the 1st place three times in a row in the world robocup rescue robot competitions (2009 - 2011). 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 2013 in Eindhoven, (Netherlands).

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_FURIOUS**" has got the 1st Runner up award of rescue robot competition. The team members are the next generation of **iRAP_PRO** and **iRAP_JUDY** who have got the 1st place three times in a row in the world robocup rescue robot competition (2009-2011). 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_FURIOUS** has twelve members and two advisors. The names and responsibilities of each member are listed as follows:

- Mr.Teppakorn Sitiwanchai Network System (Team Leader)
- Mr.Alan Blattler Robot Controller
- Mr.Phongphon Laowakul Mechanical Section
- Mr.Pranot Mekloy Mechanical Section
- Mr.Tanachon Nitisuchakul Mechanical Section
- Mr.Rapeepat Teankum Head of Mechanical Section
- Mr.Natinan Kuttanan Electronic Section
- Mr.Nonthawat Danwiang Head of Electronic Section
- Mr.Karnchanan Karnchanachettanee Autonomous Robot
- Mr.Krit Panas-Ampol Tele-operative Robot
- Mr.Porn-anan Raktrakulthum Programming
- Mr.Jiraphan Inthiam Programming
- Mr.Sai-yan Primee Advisor
- Asst. Prof. Chatchai Sermpongpan Advisor

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.

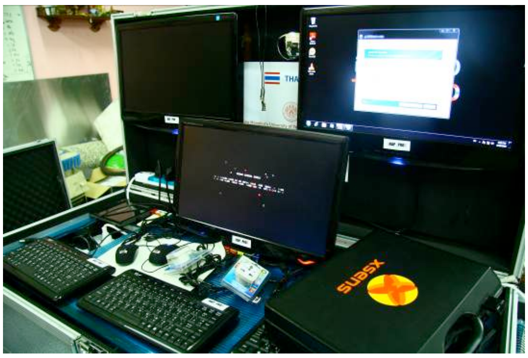

Figure 1: The operator station

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 checks sensors feedback for locating the status of robots on computer monitor as well as for the automatic map generation. The range of the working distance is 400 m for outdoor and 200 m in the building.

Rescue Robot League		
iRAP_FURIOUS (THAILAND)		
Frequency	**Channel/Band**	**Power (mW)**
5.0 GHz - 802.11a	Adjustable	630

4. Control Method and Human-Robot Interface

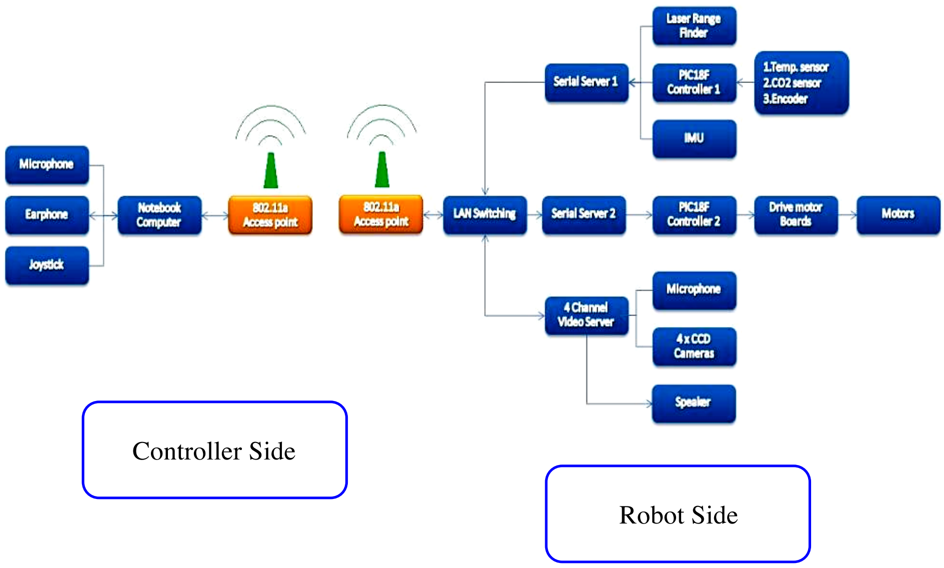

Figure 2: The control system diagram

The main control is based on one CPU (PIC Microcontroller). 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.

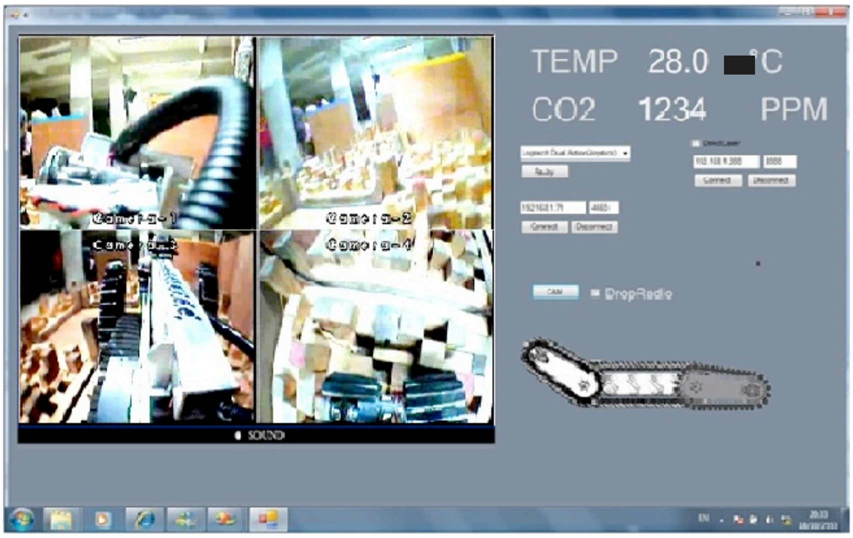

Figure 3: Operator console illustrated the real time quad videos and the information of robot's sensors.

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 move 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.

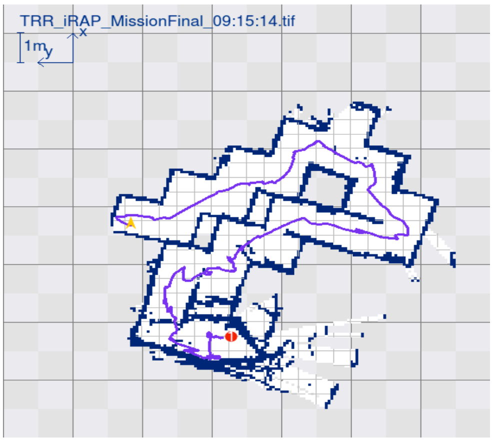

Figure 4: Automatic map generated by iRAP_FURIOUS's software

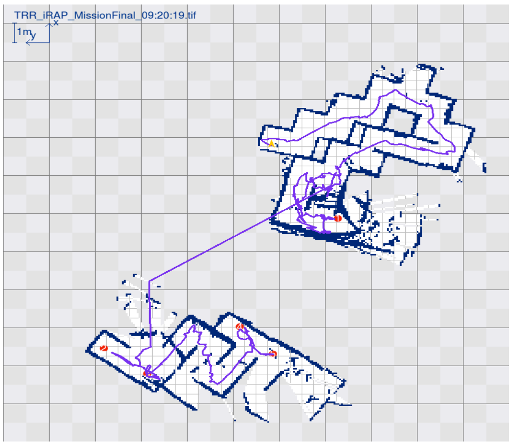

Figure 5: Automatic map generated by iRAP_FURIOUS's software

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. CCTV cameras with wide-angle lenses (Figure 6)
2. Inertia Measurement Units (Shared with map generation) (Figure 7)
3. LIDAR Sensors (Shared with map generation) (Figure 8)
4. Incremental Encoders (Shared with map generation) (Figure 9)

Figure 6: CCTV cameras

Figure 7: Inertia Measurement Unit[3]

Figure 8: LIDAR Sensor[4]

Figure 9: Encoder

7. Sensors for Victim Identification

For victim identification, the team will analyze information from different kinds of sensor that 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 temperature by utilizing temperature sensor in figure10. In some circumstances, this victim informed by the temperature will be incorporated with data from CO2 sensor in figure 11 and the surrounding sound, which will be received via microphone in figure 12, to analyze the situation of the victim. The figures below illustrate the pictures of temperature sensors, CO2 sensor and microphone. These sensors are listed as follows:

Figure 10: Temperature Sensor[5]

Figure 11: CO_2 Sensor

Figure 12: Microphone

8. Robot Locomotion

Regarding designing the robot locomotion system, the team has learned and has improvements through our team advisors "iRAP_PRO" and "iRAP_JUDY" that have gained experiences from many competitions. In this competition, our team 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 made of the conveyer belt system that the team 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 13 to figure 15).

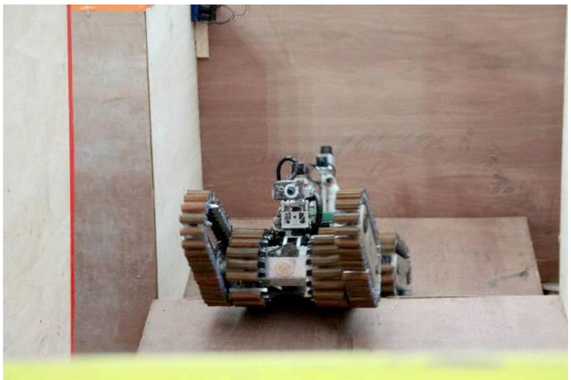

Figure 13: Tele-operative robot I locomotion

Figure 14: Tele-operative robot II locomotion

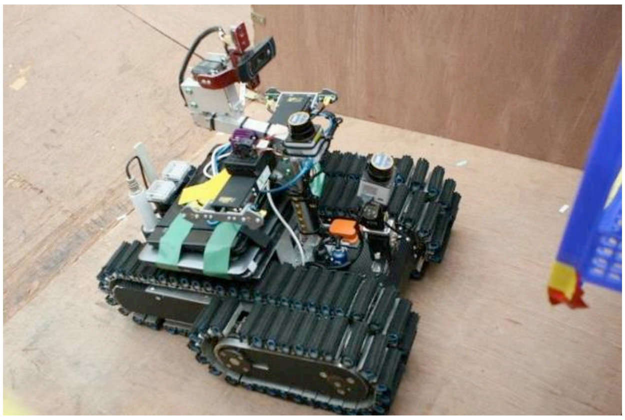

Figure 15: Automatic robot locomotion

9. Other Mechanisms

The manipulator of the robot arm which was installed a video camera and sensors shows the high mobility. It can be rotated 360 degrees and can be extended closer to the victim, if necessary, to increase visualization. Also, there is a gripper at the edge of this manipulator which is capable of moving objects which weigh less than 5 kg. and can be stretched up to 1.50 m high from the floor (as shown in figure 16).

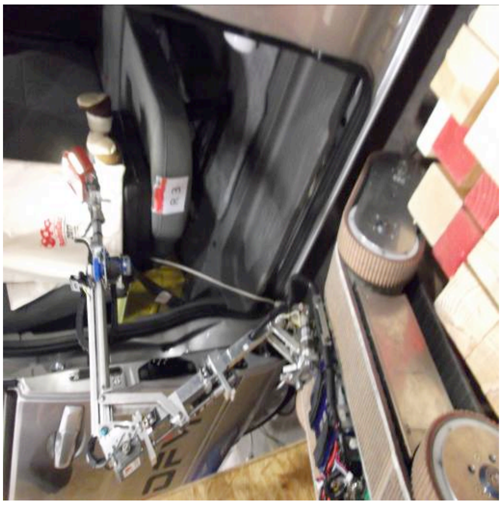

Figure 16: Robot manipulator arm

10. Team Training for Operation (Human Factors)

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

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 and iRAP_JUDY that won three times in a row in the world robocup rescue robot competitions (2009 - 2011).

11. Possibility for Practical Application to Real Disaster Site

Our main goal for this activity is used for real disaster situation. The team designed all the parts of the robot for real rescue application. We are confident that our robot is very useful for disaster defender but still not be of 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_FURIOUS 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	$ 1,500
Sensors	
- Encoders x 2	$ 150
- Xsense Inertia Measurement Unit	$ 2,800
- Hokuyo laser range finder	$ 5,950
- Temperature sensor	$ 2,100
- High quality microphone	$ 65
- 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
Total Cost	**$14,600**

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."

References

[1] R. Siegwart, I, Nourbakhsh: Introduction to Autonomous MRobots (2004)

[2] http://en.wikipedia.org/wiki/Simultaneous_localization_and_mapping

[3] http://www.xsense.com

[4] http://www.hokuyo-aut.jp

[5] http://www.raytek.com