RoboCupRescue 2013 - Robot League Team STABILIZE (Thailand)

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Abstract. This paper describes information construction and operation of the STABILIZE robot, the RMUTP rescue robot which has won 1st award of Thailand rescue robot championship 2011 & 2012, and won the 3rd place in World RoboCup Rescue 2011 in Turkey & 2012 in Mexico. The highlight of the STABILIZE is capability to move in roughness terrains, tilts and stairways hence the caterpillar wheel attached with rubber tires in order to enhance the friction when drive through and any surfaces. The robot, with built-in automatic arm, is able to extend the length of the arm. At the end of the arm is attached with carbon-dioxide sensor, temperature sensor to analyze the life sign of target. It is also located wide-angle cameras to observe surrounding area at the end of the automatic arm. The main structure of the robot is made from lightweight material, aluminum. The team is prepared for difference scenarios presented in the World RoboCup Rescue 2013, in Eindhoven, the Netherlands.

Introduction

"STABILIZE" rescue robot team is established by "Robot club" of Rajamangala University of Technology Phra Nakhon (RMUTP) in 2008. By the effort of the undergraduate engineering student in the Robot club, the team started to build the first rescue robot to join Thailand rescue robot championship 2008. Since then, STABILIZE is known as RMUTP's robot rescue team has been joined Thailand rescue robot championship every year. In 2010, the first success of the STABILIZE is to win the 3rd place in Thailand rescue robot championship 2010. In 2011, we joined the World

RoboCup Rescue 2011 in Istanbul, Turkey, which is our first world competition, and we won the 3rd place in that competition as shown in figure. 1. In 2011, the STABILIZE was the winner in Thailand rescue robot championship 2011 moreover, we also award as the best mobility in the same year as shown in figure. 2. (please refered to http://www.cedt.net/rescue/)

In year 2012, we joined the World RoboCup Rescue 2012 in Mexico city, Mexico, and we won the 3rd place in that competition. We also got the award as the best mobility as shown in figure 3.

In this year 2013, We are the winner in Thailand rescue robot championship 2013 against 44 competitors as shown in Figure.4. (please refered to http://www.trs.or.th/)

It has been shown that for 5 years since we established the team, STABILIZE has been develop our expertise in robot design, structure assembling, computer programming and controlling system as seen in our outcome. As the main part of the development is enhancing the movement control system in rescue robot, the background knowledge from RMUTP encourages the expertise for the team. Our robot is designed to operate under obstacle conditions such as roughness terrain by using caterpillar wheel attached with special rubber tire. It enhances the anti-slippery character of the robot. The automatic arm of the robot is also strong and stretchable in long length. Our control and analysis system is skilled to move and search for the rescue target in a short period. Using camera analysis, temperature sensor, sound sensor and carbon dioxide sensor as well as human-robot interface are functional compositions to analyze an accurate the life sign of victim. As seen that the STABILIZE is prepared our best for joining the World RoboCup Rescue 2013, in Eindhoven, the Netherlands.

Figure 1. Competition result in the World RoboCup Rescue 2011

Figure 2. Competition result in Thailand rescue robot championship 2011

Figure 3. Competition result in the World RoboCup Rescue 2012

Figure 4. Competition result in Thailand rescue robot championship 2012

1. Team Members and Their Contributions

Figure 5 “STABILIZE” team (RMUTP)

The “STABILIZE” Rescue Robot team from the RMUTP, Thailand consists of Engineering students and Academic members within the Faculty of Engineering. Among these members, their contributions stated below:

- Wannawut Pinit Controller development
- Watcharapong Chaikanta Mechanical Design
- Worawat Chaiwong Programming Design
- Jakkrit Chimphimol Autonomous robot design
- Nutthanun Tumbandalnsuk Autonomous development
- Rungroj Saechin Electronic board design
- Praphakorn Kamnuanek Electronic Hardware
- Kittanon Pueknoun Electronic development
- Nopparit Jansa Mechanical and Development
- Chatpisit Jearanaibanyong Mechanical and Development
- Chatcharit Jearanaibanyong Mechanical and Development
- Thanakit Wattakeekamthorn Team advisor
- Assist Prof. Kamontip Wattakeekamthorn Team co-advisor
- Dr.Chonlakarn Wongkhorsub Team co-advisor
- The RMUTP Team Sponsor
- The SCG (Siam Cement Group) Team Sponsor

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

The duration period of program installation and configuration is a significant factor in this competition. Therefore, our control systems, i.e. , laptop, monitor , etc., are arranged in one single aluminum box in order to be immediately allocate and dislocate as shown in figure 6. In addition, the backup power is also a vital part in the racecourse as the urgent situation such as power loss might be happened; this aluminum box also has a UPS integrated to provide energy. Our team, therefore, is very much confident that our team will be able to setup and break down the operation within less than 10 minutes.

Figure 6. The operator station.

3. Communications

The communication between the STABILIZE operator and the robots is operated by using the wireless LAN base on IEEE802.11 a/n standard. This wireless LAN system is used as the data communication between control station and the robot. The functional instument i.e. cameras, sensors and control unit int the robot feedback all the data and will be collected, analysed and shown in control box. As well as other data, the automatic map generation recieve signal from the robot under 5GHz of IEEE802.11 a/n radio frequency, the signal is analysed and plotted in monitor. The working distance is in the range of 200m for outdoor, and of 100m for indoor by using 5.0 GHz-802.11 a/n which is adjustable with the power of 200mW. For the automatic robot, the communication base on 2.4 GHz of IEEE802.11 g standard.

Rescue Robot League		
STABILIZE (THAILAND)		
Frequency	**Channel/Band**	**Power (mW)**
5.0 GHz - 802.11a	Adjustable	200
2.45 GHz - 802.11 /g	Adjustable	30

4. Control Method and Human-Robot Interface

The feedback tools of this robot's control and interface are Temperature sensor, CO_2 sensor, camera selector switch, and drive motor arms units. They all are controlled by micro-processor board: PIC18F. The lighting and drive motor base units are controlled by micro-processor board: MCS51 controller.

The Graphical User Interfaces (GUIs) interface between robot unit and control station unit are installed individually each unit. These GUIs could be described along with figure 7 belows:

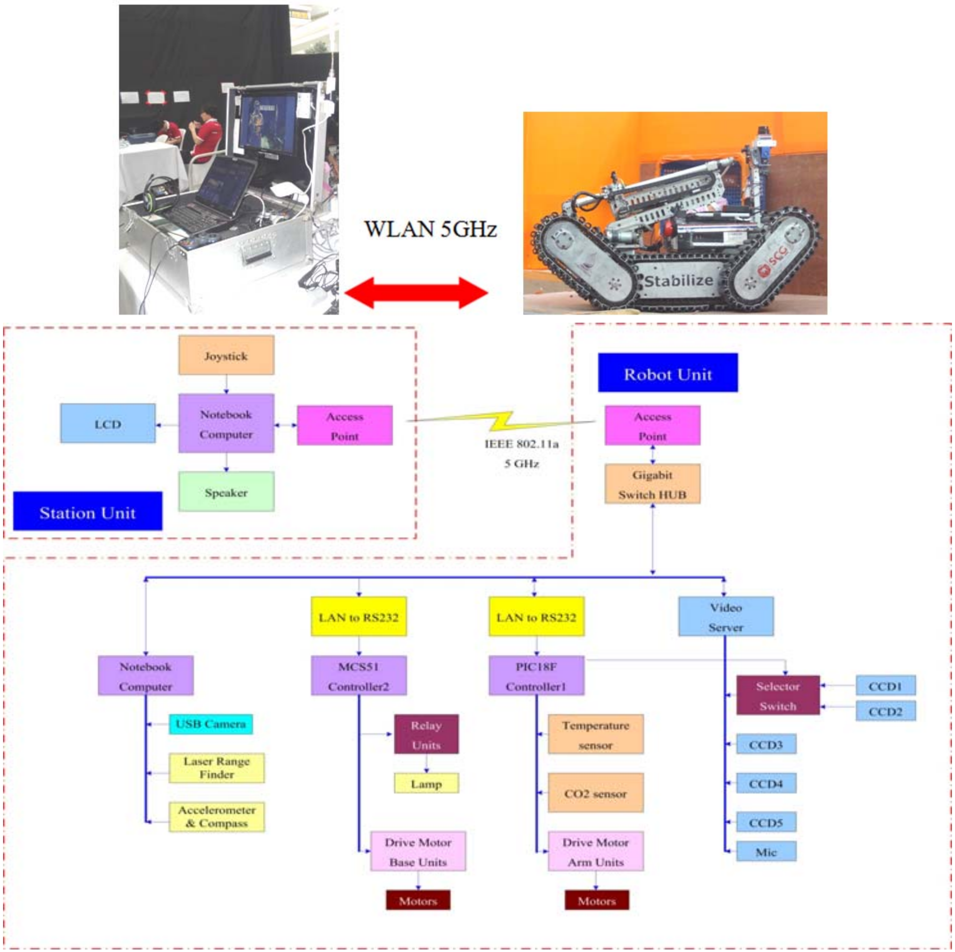

Figure 7. The control system & Block diagram used by STABILIZE's Robot.

The control interface employs wireless communications of 5 GHz frequency to control drive mechanism, robotic arm, and also monitor the CO_2 and temperature levels via the user monitor, as shown in figure 8.

Figure 8. GUI monitor screen.

The GUI monitor screen displays control and analysis information such as the temperature data, CO_2 data, the signal condition, etc. Additionally, the mapping survey is also plotted in this screen. The 4 level of moving speed of the robot and the on-off light status attached to the robot is as well appeared in the GUI monitor as shown in figure 8. The camera outputs are display separately from GUI monitor to assist the robot controller to observe environmental situation in the area while the robot seek for the victim as shown in figure 9.

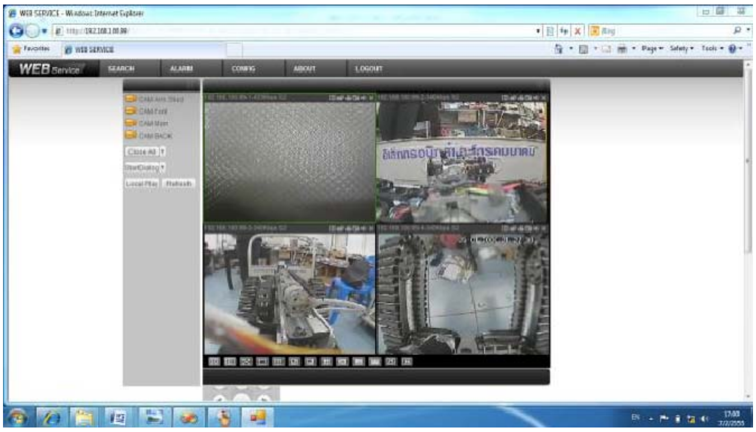

Figure 9. Vision screen.

5. Map Generation/printing

Mapping generation of the STABILIZE robot is done follow the recommendation of ROS (Robot Operating System; http://www.ros.org/wiki/), the open source program, which our team would like to acknowledge them here. The important node is required as followed;

- Hokuyo_node is a driver for SCIP 1.0 compliant Hokuyo laser range-finders. This driver is primarily designed for the Hokuyo URG-04LX, Hokuyo scans are taken in a counter-clockwise direction. Angles are measured counter clockwise with 0 pointing directly forward
- Laser_scan matching_node is applied as a picture matching filter.
- Slam-gmapping_node are contains GMapping, from OpenSlam, and a ROS wrapper. The gmapping package provides laser-based SLAM (Simultaneous Localization and Mapping), as a ROS node called slam_gmapping. By using slam_gmapping, it could create a 2-D occupancy grid map (like a building floorplan) from laser.
- map_server_node is used as an actual memory for the map.
- object_tracker is the core package of hector_worldmodel
- trajectory_server are contains a bunch of packages that help with trajectory smoothing
- geotiff_node is a node that generates a geotiff map along with georeference information.

Figure 10 and 11 shown below illustrated the location of the robot as it moved along. This is a 2D map where it is capable of displaying any selected victim.

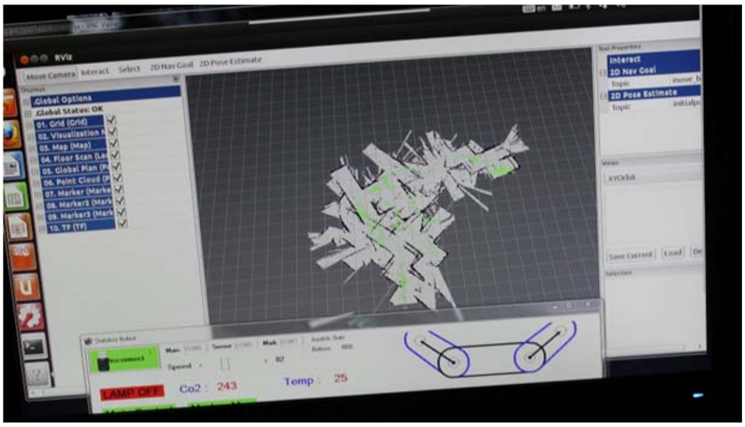

Figure 10. 2D-Map screen.

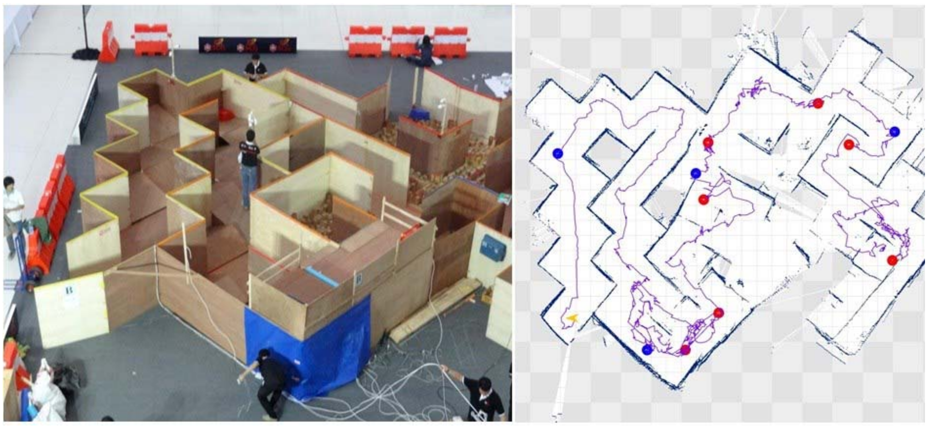

Figure 11. Comparison between real arenas & mapping result.

6. Sensors for Navigation and Localization

For our team, there are components detailed below for various sensors:

- Laser Range Finder [1] 1 set for measuring distance and report the map size. It is installed on the automatic tilt compensation or the stabilizer.
- Inertial Measurement Unit [2] 1set for measurement the attitude of the robot. It is equipped with 9 degree of freedom inertial sensor ITG3205, ADXL345 and HMC5883L which measures three-axis gyroscope + tri-axial accelerometer + three-axis magnetic field
- Camera CCD 3 cameras is used as a navigator system.

7. Sensors for Victim Identification

All of these components would be integrated into one box. This box would be put into the far end of the robotic arm. These components are:

- Camera CCD 2 cameras for displaying the victim physical conditions.
- Temperature sensor [3] for measuring victim's body temperature.
- CO_2 sensor [4] for measuring climate around the scene.
- USB Camera [5] 3 set for reading QR code.
- Emergency light for using in the dark area.

8. Robot Locomotion

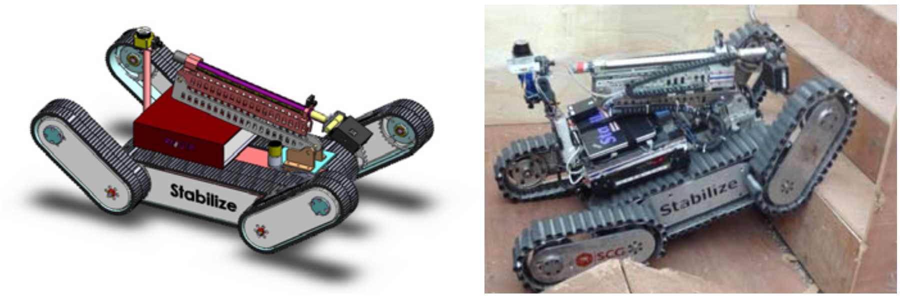

Figure 12. STABILIZE ‘s tele-operative robot.

The STABILIZE has designed by using 6 caterpillar wheels to be able to access to the rough and steep terrain. The robot is able to climb up to steps if needed due to the caterpillar wheel design and the attached high friction rubber tire. Main driving the wheels are occupied by 2 motors with the same gear ratios attached in each side to balance the robot. The robot could be easily turn left and right by these 2 motors. The main drive motors are 24V 95 RPM. The drive chain for these 2 wheels is chains no. 40 and sprocket no. 49. It also has 2 extra motors to drive the front and back pair of the caterpillar wheels. The drives system are using worm gears connect the motor to the wheel in order to resist uncircumstance load and support climbing to rough and steep terrain. The drive chains of the front and back wheels are the chain no. 40 and the sprocket no. 49 and 36 respectively. The robot has its weight of 65 Kilograms and has its dimension of 550x650x600 mm as shown in figure 12.

The STABILIZE automatic robot is driven by 4 individually DC motor. It contains CO2 sensors, temperature sensors, camera and image control processing to analyse the victim. Ultrasonic system and analysis is applied for moving and obstacle avoidance as well as mapping analysis as shown in figure 13. The robot has its weight of 28 Kilograms and has its dimension of 350x500x550 mm.

Figure 13. STABILIZE ‘s Autonomous robot.

9. Other Mechanisms

The robotic arm can be held as high as 1.5 metres measured from the ground. The designed robots are agile and relatively fast. Although they are light-weighted, they are reasonably strong, durable, and suitable for tough conditions as shown in figure 14.

Figure 14. The robot 's searching and identifying some victim.

10. Team Training for Operation (Human Factors)

Team STABILZED has joined the National robot rescue competition since year 2008. What we have learnt from past makes us stronger and more confident in design rescue robots. We are also proud that we are one of the teams in Thailand that still active and gaining interested not only from students insides but also the Administrative in the RMUTP for funding this robot without hesitation.

11. Possibility for Practical Application to Real Disaster Site

We believe that our rescue robot will be essentially used in diaster situation in order to reduce using human rescue team in the risk situation. For example, in any earthquake situations, some building collapesed, the situation might be too vital for the rescue team to get in and search for the life sign by themself. Our rescue could be assist to search for the life sign and analyse the situation in the area to evaluate the suitable rescue method.

12. System Cost

STABILIZE team has three robots. Two of which are tele-operative robots and the other one is an autonomous robot. The cost of parts on each robot is listed as follows:

Tele-operative Robot	
Structure of robot and drive train	$ 3,000
Sensors:	
Hokuyo laser range finder	$ 2,600
Temperature sensor	$ 150
CCD cameras x 5	$ 300
CO_2 sensor	$ 300
WEBCAM x 3	$ 120
IMU	$ 80
Controller	$ 350
Communication system	
Access point IEEE 802.11a x2	$ 320
Quad channel video server	$ 300
RS-232 to LAN converter x 4	$ 650
Thinkpad Notebook	$ 1,150
Total Cost	**$ 9,320**
Autonomous Robot	
Structure of robot and drive train	$ 200
Sensors:	
Hokuyo laser range finder	$ 2,600
Temperature sensor	$ 540
CO_2 sensor	$ 300
WEBCAM x 3	$ 120
IMU	$ 80

Controller	$ 100
Communication system	
Access point IEEE 802.11a x2	$ 320
RS-232 to LAN converter x 4	$ 650
Thinkpad Notebook	$ 1,150
Total Cost	**$ 6,060**

13. Lessons Learned

The team, since started working together, has learnt and gained experience not only in engineering designs such as mechanical engineering, electrical engineering, electronic engineering, etc. but also team work which is the most important compared to all required technologies.

References

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