RoboCupRescue 2006 - Robot League Team
INDEPENDENT (THAILAND)

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Abstract. Research and development on rescue robots is becoming popular among robotics researchers. This is resulted from rescue robots’ obvious usages and applications. Roboticians in Thailand are also interested in rescue robotic technology. The Thai Robotics Society (TRS) has organized an annual national league, “The Thailand Rescue Robot Championship” to select the best team from more than 60 applicants around the country in this year. The Independent team has won the first place and the best technique award from the Thailand Rescue Robot Championship 2005. The design of Independent robot has been inspired from vehicles in the Armageddon movie. This leads to a development of the robot’s multi-wheeled driving and suspension systems. This causes the accomplishments of the Independent robot’s extreme mobility. The robot is a wireless remote-operated vehicle using various bandwidths for communicating between robot and operator. This is to solve any communication problem which is a major concern during the rescue mission, especially, in the actual operation. The robot is equipped with a RT multi-DOF video camera system to capture and transfer motion images to the operating station. Moreover, the robot is also equipped with a semi-automatic map generating system and a variety of sensing systems for functioning in rescue missions.
Introduction

Research and development on rescue robots is gaining popularity among robotics researchers. This is resulted from rescue robots’ obvious usages and applications. Roboticians in Thailand are also interested in rescue robotic technology. The Thai Robotics Society (TRS) has organized an annual national league, “The Thailand Rescue Robot Championship” to select the best team from more than 60 applicants around the country in this year. The Independent team has won the first place and the best technique award from the Thailand Rescue Robot Championship 2005. The Independent team has a total of 7 members who 6 of them are undergraduate engineering students, and the other one is a lecturer at the King Mongkut’s Institute of Technology North Bangkok (KMITNB), Prachin Buri campus. The Independent robot has been designed and developed by the team members. The design of Independent robot has been inspired from vehicles in the Armageddon movie. This leads to a development of the robot’s multi-wheeled driving and suspension systems. This results to the accomplishments of the Independent robot’s extreme mobility. The robot is able to access various types of extreme terrains. The robot is a wireless remote-operated vehicle using various frequency ranges for communicating between robot and operator. This is to solve any communication problem which is a major concern during the rescue mission, especially, in the actual operation. The robot is equipped with a RT multi-DOF video camera system to capture and transfer motion images to the operating station. Moreover, the robot is also equipped with semi-automatic map generating system and a variety of sensing systems for functioning in rescue missions. Therefore, the robot has a function

1. Team Members and Their Contributions

- Pinit Khueansuwong  Controller development and robot operator
- Adisak Duangkaw  Mechanical design
- Thongchai Photsathian  Software development
- Nati Namvong  Algorithms
- Suchat Junlee  Electronics design
- Yotaka Chompusri  Advisor
- Dr. Vara Varavithya  Coordinator

The team has been sponsored by KMITNB, Thai Robotics Society and Siam Cement Company of Thailand.

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

The setting-up team is divided into 2 groups which are control room setting-up group and robot setting-up group. The setting-up procedures are described below.
1) Control room and robot preparations:
This includes setting up communication devices, PCs and their peripherals, and preparing robots at the starting point. (Approximately 3 minutes)

2) Quick testing:
This step is to perform a quick test and re-adjustment (if needed) to the sensing and communicating systems on both robot and control room. The task is to ensure their functionality. (Approximately 2 minutes)

3) Operator Verifying:
This stage is to verify functionality of transmitting and receiving all data between robot and control station. This includes sensing information and motion images. (Approximately 3 minutes)

3. Communications

The Independent robot’s communication system consists of two subsystems. Fig. 1. shows the communication architecture.

3.1 Robot Controlling Subsystem: A 7-channel remote-controller is used at the 72 MHz frequency range.

3.2 Data Transferring Subsystem: An Ethernet I/O system is used in transferring and receiving motion images and sensing data (CO₂ sensor, digital compass, temperature sensor and encoding systems) between the robot and operator station. This connection is communicating via access points at 2.4 GHz frequency range (802.11 b/g) and 5.0 GHz frequency range (802.11 a).

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Channel/Band</th>
<th>Power (mW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.0 GHz - 802.11a</td>
<td>Any</td>
<td>250mW</td>
</tr>
<tr>
<td>2.4 GHz - 802.11b/g</td>
<td>1,6,11</td>
<td>250mW</td>
</tr>
<tr>
<td>72 MHz</td>
<td>7</td>
<td></td>
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</tbody>
</table>

4. Control Method and Human-Robot Interface

The operator remotely controls the robot through a 7-channel RF controller at 72 MHz frequency range. The robot is also equipped with various sensors and a RT video camera to capture victim’s information, such as, motion images, voices, temperatures and CO₂ quantity. All data is transferred to operator station via a wireless LAN communication system, and is displayed on a PC monitor. The operator is able to read the data in graphical interfacing system. The information is then used to indi-
cate victim’s information, such as, status, location and others. Fig. 2. and Fig. 3. show examples of graphical interface on PC monitors.

Fig. 1. Communication architecture

Fig. 2. Graphical Interface to the robot operator
5. Map generation/printing

The robot is installed with ranging sensors, encoders, accelerators, digital compass and other sensors to provide enough information to operator station. The information is used to semi-automatically generate a mission map on a station PC which can be printed after a mission. Fig. 4. illustrates generated map after a mission.

Independent robot utilizes a microcontroller to process data from digital compass and encoder systems. The signal from the digital compass is then transmitted via the I²C architecture to verify robot’s heading. In order to specify the robot’s position during the mission, the system combines heading information to the distance information from wheels’ encoder. The operator also uses the Real-Time motion images transmitted and displayed on station monitor to aid in robot navigation. Fig. 5. shows the digital compass installed on robot.

![Fig. 4. Integrated digital compass for robot navigation](image)

7. Sensors for Victim Identification

The robot victim sensing system consists of:

1) Temperature sensor:
   The robot’s temperature sensor is an infrared-type thermometer. This allows robot to indicate victim’s temperature without any contact. The sensing temperature range is -40 °C to 600 °C which covers possible human temperature.

2) CO₂ sensor:
   The CO₂ sensor installed in the robot is able to measure the concentration of CO₂ gas in the range of 350 – 100,000 ppm. The sensor’s output signal is
processed through amplifier and signal conditioner, while is finally converted from analog to digital signal by A/D converter.

3) Victim’s motion and voice sensing system:
A RT multi-DOF video camera is used to capture victim’s motions and voices. The robot operator uses this information to identify victim’s status.

Fig. 5 – 7 show multi-DOF video camera station on robot, temperature sensor and CO₂ sensors, respectively.

Fig. 5. Multi-DOF video camera base installed on the robot

Fig. 6. Infrared-type temperature sensor
8. Robot Locomotion

The robot locomotion has a 10-wheeled driving system, which 6 wheels are on the body and 4 wheels are on its manipulators. This allows the robot locomotion system to be adaptable. The robot can fold or adjust its manipulators (with 4 wheels on them) in angle to suit with any circumstance, such as, to relocate along a limited space – the robot can completely fold the manipulator to create the smallest footprint, or to climb up/down highly un-even terrain – the robot can gradually adjust the manipulators’ angle to fit with surfaces. This assists the robot to extend its mobility. The locomotion has 4 DC motors and 2 chain systems for driving all the wheels. A set of stepping motors is used to drive the manipulators. Fig. 8. – 11. show various views of Independent team’s robot.
Fig. 8. The Independent robot’s locomotion

Fig. 9. The Independent robot in climbing action
9. Other Mechanisms

In order to minimize problem, major mechanisms are locomotion related systems. The only other mechanism is the RT video camera base. The mechanism allows robot operator to manipulate the camera in several degrees of freedom. The results expend robot’s visibility which is very important for victim’s searching and identifying, and robot’s navigating.
10. Team Training for Operation (Human Factors)

Major preparation before the competition is as describe below:
1. Setup preparation within 10 minutes is required a laborious training with the robot starting, immediate fixing in case of accidental failure and robot maintenance. The more practice, the less unexpected errors we encounter.
   People in charge:
   - Mr. Suchat Junlee
   - Mr. Thongchai Photsathian
   - Mr. Adisak Duangkaw
   - Mr. Nati Namvong
2. Robot remote operating control has been practiced several times with the simulated competition situations. Then the output data is used to correct and improve the performance of the remote control operator.
   People in charge:
   - Mr. Pinit Khunswuong

11. Possibility for Practical Application to Real Disaster Site

The Independent robot has been successfully performing multiple tasks in simulate disaster sites during the first round and the final round of the Thailand Rescue Robot Championship 2005. The simulate disaster site in the final round competition was comparable or a little bit more difficult than the simulate site at Osaka RoboCup Rescue in year 2005. (This is claimed by the Thai Robotics Society who organized the national league.) Several national organizations, including military and national disaster rescue agency, have stated their interests and possibilities of employing the Independent robot in real circumstances.

12. System Cost

TOTAL SYSTEM COST in USD (per robot): ~$4060

1. Mechanisms:
   - DC Motor, chain and gear drive system $250
   - Fasteners $50
   - Material (Aluminum sheet and others) $150
   - Labor cost $100

2. Wireless sets:
   - CMOS cam $130
   - IP address adapter from CMOS cam $500
- Access point modules $200

3. Sensors:
- Infrared temperature sensor $500
- CO₂ sensor $400
- Ultrasonic ranging sensors $100
- Digital compass $70

4. Control:
- Ethernet I/O $110
- Remote Control $350
- Motor driving circuit board $100
- Microcontroller and its circuit board $50
- Accessories $100

5. Power Supply and accessories
- Battery and other related items $1000

References

www.design-gateway.com
www.planet.co.th
APPENDIX:

Pictures from Thailand Rescue Robot Championship 2005
Organized by the Thai Robotics Society
October to November 2005.

Fig. A1. Invitation Poster of the Thailand Rescue Robot Championship 2005, which was sent out to more than a hundred institutes around the country.
Fig. A2. Over 60 robots were attending Thailand Rescue Robot Championship 2005

Fig. A3. The first round competition site at Mahidol University
Fig. A4. The Independent robot

Fig. A5. The Independent robot in action
Fig. A6. The final round competition site of the Thailand Rescue Robot championship 2005 held in MCC Convention Center, Bangkok Thailand (Broadcasted on National Television)

Fig. A7. Other view of robot competition site
Fig. A8. Closed view of competition site

Fig. A9. Other view of competition site which can be seen a stair way to the second floor.
Fig. A10. Other robot was stuck in the path

Fig. A11. The Independent team is awarded the first place and best technique award from the Thailand Rescue Robot Championship 2005.