RoboCupRescue- Robot League Team TeamName:NuTech,CountryName:Japan

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Abstract. The concept of our team is "assemble some robust low-tech subsystems and make a robust high-tech rescue robot." To do this, the sensitivity analysis of subsystem technology to the total performance is important. Therefore, the robot developed here is composed of popular rescue robot technology with slight modification, rear sub-crawler and point measurement distance meter, which will be alternatives to other rescue robots. In addition, prevention of the second disaster caused by rescue robots is considered, which is the crucial issue to utilize them. To tackle that, an operation board is developed to avoid the robot reaction due to unintended command input by using three position switches.

Introduction

The concept of our team is "assemble some robust low-tech subsystems and make a robust high-tech rescue robot."[1] To do this, it is important to clarify which parameters of the subsystems are essential for the total performance. In other words, it is important to perform the sensitivity analysis of subsystem technologies to the total performance to accelerate rescue robot development. Though several rescue robots are under development intensively, e.g, in reference 1) and 2), it still needs further investigation due to the complexity of the rescue situation. Therefore, we use some standard subsystems with slight modification for our robot in order to make it an alternative to others. Namely our robot has a rear sub-crawler (most of others are front sub-crawler), and the distance meter is point measurement type, not scanning type. In order to carry out the sensitivity analysis in a convenient and flexible way, the operator performs most of the decision-making, e.g. path planning.

In the viewpoint utilization, prevention of the second disaster caused by rescue robots is the crucial issue. To tackle that, an operation board is developed to avoid the robot reaction due to the unintended command input. Such unintended input will be applied to the board if it is dropped off or the operator moves unsteadily by aftershocks.

The robot developed here is an advanced version of the first prize winner of RobocupRescue Robot League Japan Open 2003.

[1] Based on comment from Dr. T.Amano of National Research Institute of Fire and Disaster in Japan.

This research was performed as a part of Special Project for Earthquake Disaster Mitigation in Urban Areas in Japan in cooperation with International Rescue System Institute (IRS) and National Research Institute for Earth Science and Disaster Prevention (NIED).

1. Team Members and Their Contributions

- Tetsuya Kimura — Leader
- Yoshiaki Shinagawa — Mechanical design
- Masanori Naruse — Sensor system design
- Masahiro Ishizaki — Human interface design
- Mie Someya — Advisor
- Japanese Ministry of Education, Culture, Sports, Science and Technology (MEXT) — Sponsor
- International Rescue System Institute (IRS) — Advisor

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

Estimated time:

Set-up: 8 minutes, Break-down: 8 minutes

Details:

Our system is composed of the following three items

I1. One robot with cable (<20kg)
I2. Controller board (<5kg)
I3. Notebook computer used as display and GUI for sensor control (<5kg)

The procedure of setting up:

0. Bring I1-I3 to control room. Note that any of the parts, I1-I3, is not so heavy, thus any of them can be carried by single person.
1. Attach the control board and the display to the operator. (2 min.)
2. Connetct I1-I3. (1 min.)
3. Boot computers (2 min.)
4. Check the sytem (3 min)

In total : 8 min (estimated)

The procedure of break down:

1. Bring back the robot to control room. The robot is tethered so it will take some minutes to handle the cable. (3 min.)
2. Shutdown computers (2 min.)
3. Disconnect I1-I3 and remove the controller board and the display from operator.(3 min.)
4. Bring them back to staff room.

In total: 8 min. (estimated)

3. Communications

No radio communication is used for our robot. Only wired-communication is used. Because of radio interference, we believe radio communication in rescue site is not so effective to control robots in real-time and obtain visual image which requires a lot of data transmission.

4. Control Method and Human-Robot Interface

4.1 Control Method

The robot is controlled via remote tethered operation. Based on the visual image and the distance information of some points, the operator decides the control strategies. (See Section 6 for the details of the sensors.) By using the tethered communication, the operator can obtain high quality image with x16 zoom camera. Cable tension control is automatic, and the all other movement are controlled by the operator manually.

4.2 Human Interface

In order to control the robot movement, the operation board is developed by our team composed of a joystick and some switches. To control sensors, GUI is used with a notebook computer.

To avoid the robot reaction due to the unintended command input to the operation board, three position switches (3PSs) are used. As applied force to the 3PS increasing, it changes the mode as Off-On-Off. Therefore, the operator should apply certain level of force to 3PS to indicate intended 'On' command input. According to this feature, the operation board accepts less unintended command input when e.g., the board is dropped off or the operator loose ones stability by aftershocks. This is important to prevent second disaster by the rescue robots.

(a) over view (b) joystick with three position switch

Fig.1 Control board with three position switches.

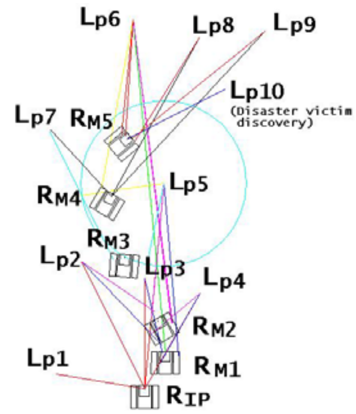
4.3 Tasks in mission

The operator will perform the following tasks:

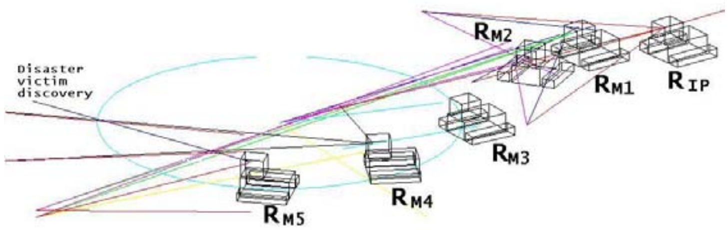
1. Control all robot movements through the operation board, except the tension control of cable. The tension is controlled automatically.
2. Read the sensor outputs to identify the victims through GUI of a notebook computer.
3. Select some points in the image as the standards in a triangulation. Enter the data to a CAD system to estimate the current location by triangulation

5. Map generation/printing

The operator inputs the measured data to a CAD system manually, which is used to support the triangulation and check the fairness of the estimated position and geometry of environment intuitively.



(a) top view



(b)from another angle

Fig.2 Estimated position display by triangulation by using a CAD system

6. Sensors for Navigation and Localization

The location of robot and geometry of environment are estimated by triangulation via an integrated sensor composed of a visual sensor(x16 zoom IP camera) and laser distance meter. Navigation and localization performance improvement by combining the distance information of some points in the image is under investigation.

(a) front view (b) side view

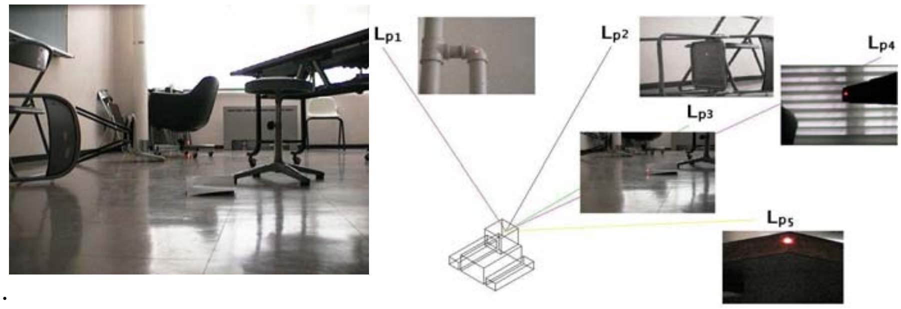
Fig.3 integrated sensor (lower: visual sensor, upper: laser distance meter)

-Visual sensor:
Color network camera. Remote control of pan(plus-minus 100degree), tilt(-30 to +90 degree) and zoom(x16).

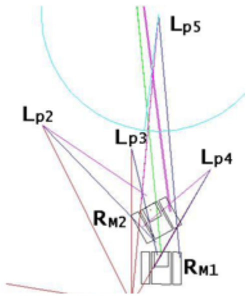
- Laser distance meter:
Laser range finder (measuring each points, not scanning type), class 2 laser, range:0.2 to 30m, accuracy plus-minus 3mm, weight:360g(without battery)

In addition, the inclination is also measured via an inclination sensor. Specifications: Yaw angle:plus-minus 180 degree, pitch and roll angle:plus-minus 60 degree

Fig.4 inclination sensor



(a) test room (b)standard points for triangulation



(c)estimated position in a CAD system

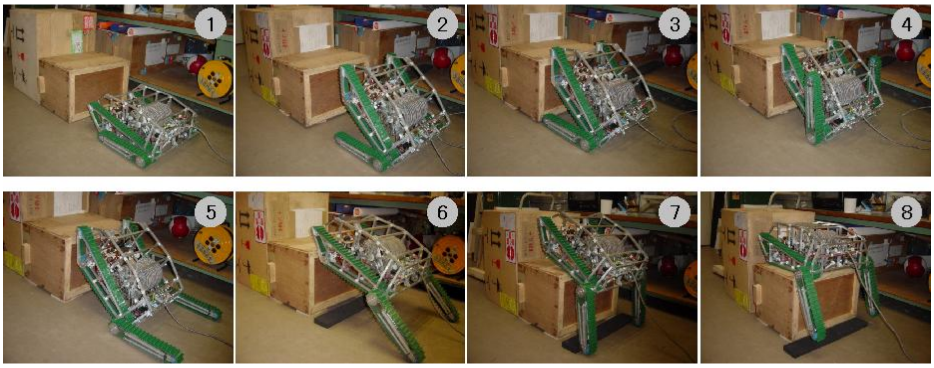
Fig.5 position estimation by triangulation by using proposed system

7. Sensors for Victim Identification

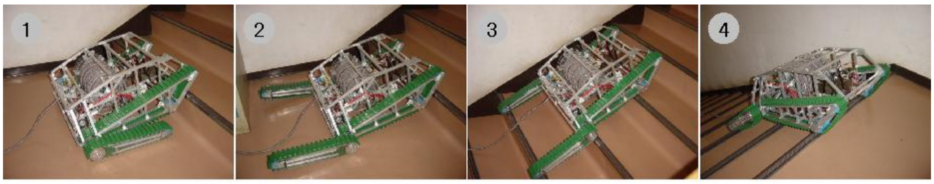
In addition to the sensor described in Section 6, a radiant-type thermometer will be installed our robot. By measuring temperature, we will estimate the condition of victims. 280g with battery, range:0 to 200 degree, accuracy: plus-minus 2 degree.

8. Robot Locomotion

The robot has two crawlers, where the sub-crawler is located in rear side. By using the rear sub-crawler it can move as in the following figures:



(a) box climbing. Max. 40cm. Note the height of robot: 26cm, length:80cm(sub-crawler extended.)



(b). stair crimbing.

Fig. 6 robot locomotion

In addition, by using rear sub-crawler, it can turn itself over to normal position.

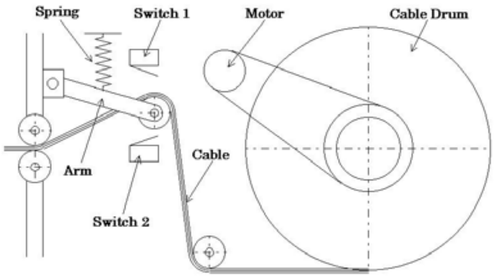
Due to our analysis, for this dimension (main- and sub-crawler length ration), the rear sub-crawler system can climb approximately 20% higher than the front one.

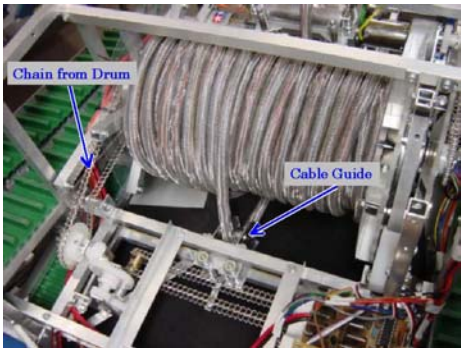
The tethered system used here degrades its movement, and hence it will not suitable for most of mobile robots. In contrast, in order to avoid the second disaster caused by rescue robots, the rescue robot cannot move too much. It should move as little as necessary, so the deterioration of movement is not significant problem to the robots in other field. Therefore, we believe the tethered mobile rescue robot should be studied.

9. Other Mechanisms

The robot involves a cable control mechanism that has the following features:

1. The tension of cable is controlled automatically to avoid stopping on.
2. When the robot fall into a hole, the robot can pull itself up by rewinding the cable.(The motor has enough power).





(a) structure (b) over view

Fig. 7 cable tension control mechanism

10. Team Training for Operation (Human Factors)

10.1 Training to use the system

Our system is simple and thus easy to understand the whole system. In addition, the human interface is also simple based on joystick and a common notebook computer. Hence, one can operate our system intuitively. For simple movement, a few minutes might be enough for training. However, the effective use of sub-crawler and avoidance of unexpected bump to environment will take longer training (some hours or some days).

Due to tethered communication, the visual sensor provides high quality image, which is our main sensor. In addition, by using the laser distance meter, the distance of any point in the visual image can be measured. This helps the operator to understand the environment in detail. The operation of the visual-distance integrated sensor is carried out through GUI, so the operator can use it intuitively.

The position estimation is carried out by triangulation based on manual selection of standard points. Thus, in order to obtain good estimation, it is crucial for the operator to selection suitable standard points in visual images. This needs some training in fictitious rescue situation, e.g., environment covered with dust.

10.2 Benefit knowledge for operators

Basic knowledge of the followings would improve the operator performance

- Basic kinematics to understand the relation of the robot and the command input to the actuators.
- Basic knowledge about how to use computer to collect sensor information effectively.
- Basic knowledge about the sensors used in the robot for its effective and correct use. For example, mirrors and windows is not suitable for the laser range finder measurement.

10.3 Training of team members

Robocon approach:

Some of the members of our project had been participated Robocons, contests of robots for students, for several years and have a lot of experiment to compete by using robots. To produce a good Robocon robot, they should think many kind of situation because the rule is changed year by year, and there are opponent robots based on many kind of ideas. Hence, they know how to evaluate the robot in an experimental site and to improve it based on their engineering sense or intuitively. Such experience is useful to simulate unexpected situation and improve the robot. While they have less knowledge about systematic project management, the leader takes care of the overall training.

Advice from experts

We have good cooperation with local fire department to develop the robot. Their suggestions are also valuable to train the team, e.g., they train the basic skill significantly even if the rescue site is complex.

Fig.8 Human Interface evaluation in a local fire department

11. Possibility for Practical Application to Real Disaster Site

The operation board with 3PS, which avoid the robot reaction due to unintended command input, will be applicable to a real disaster site with minor modification because the main parts of the board is used in tough environment in many heavy industry factories, e.g, with oil, water and dust.

12. System Cost

- Main and sub crawlers: 200,000 yen, a standard product of Gates Unitta Asia Co. http://www.unitta.co.jp/
- Visual sensor: 230,000 yen, Network camera VB-C10 of canon, http://www.canon.co.jp, http://cweb.canon.jp/Product/vsl-com/vbc10.html

- Laser distance meter:110,000 yen, LEM30 of JENOPTIK Co.
- Three position switch: some hundred to thousand yen. IZUMI ELECTRIC Co. http://www.idec.com

References

(These references are for formatting purposes only! I have no idea who they are!)

1. Center for Robot-Assisted Search and Rescue. http://www.crasa.usf.ac
2. International Rescue System Institute http://www.rescuesystem.

ROBOCUP2004
RESCUE ROBOT LEAGUE COMPETITION
LISBON, PORTUGAL
JUNE 27 – JULY 5, 2004

TRAVEL SUPPORT FORM (Please complete all the fields below and answer the questions on the next page)

NOTE: If the Travel Support Form is not included as part of the qualification material, this will be understood as no financial support required. The submission of this form does not ensure the allocation of travel support to the team.

LEAGUE NAME:	RESCUE ROBOT LEAGUE
TEAM NAME:	NUTECH
ORGANIZATION:	NAGAOKA UNIVERSITY OF TECHNOLOGY
COUNTRY:	JAPAN
CONTACT PERSON:	TETSUYA KIMURA
EMAIL:	KIMURA@MECH.NAGAOKAUT.AC.JP
TELEPHONE:	+81-258-47-9708
NUMBER OF FACULTY:	1
NUMBER OF STUDENTS:	2
ESTIMATE YOUR TRAVEL ACCOMMODATION COSTS:	5500 EUR
ESTIMATE YOUR TRAVEL SHIPPING COSTS:	500EUR
HOW MUCH DOES YOUR TEAM REQUEST:	5500 EUR

What is your justification for travel support?:

Japan is far from Portugal so the travel costs a lot. The cost is half of our fund from the affliation. Tough our team will be supported by the Project for Earthquake Disaster Mitigation in Urban Areas in Japan through International Rescue System Institute (IRS), we are not informed how much fund we can use in 2004FY. In addition, we are not sure whether we can use that fund in June and July. (In 2002, it starts December and in 2003, August)

Have you ever participated in previous competitions? If so, note the year/event/league/result:

2003, RobocupRescue Robot League Japan Open 2003, the first prize winner.

Do you have paper(s) submitted to the associated Symposium? If so, please note the title(s) and author(s):

No

Detail any sponsorship you have for participating in this event (either institutional grants or company support):

We will apply institutional grand.

Add any other information concerning your team/research group that you consider relevant: