RoboCup2004
Rescue Robot League Competition
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RoboCupRescue - Robot League Team SHINOBI, Japan

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Abstract. We will operate four robots by teleoperation at the competition: two track type, one snake type and one wheel type. Each type of the robots has its own unique control mechanism and possesses different advantages when traveling in various environments. Cooperation of these hetero-type multiple robots will give high task achievability in search and rescue missions. To improve the remote operation ability of mobile robots, we have developed an innovative remote control method that provides the operator a bird's eye view of the robot and the environment. This helps the operator to easily recognize the robot situation even in unknown surroundings. For this reason, any operator can make full use of the robot's mobility with this novel feature and requires only few effort and training to control the robot at a remote site. Interactive topological map generation with extracted useful information is also implemented.

1. Team Members and Their Contributions

- Naoji Shiroma Team leader, operator
- Tetsushi Kamegawa Mechanical design, system development, operator
- Noritaka Sato System development, operator
- Yu-huan Chiu System development, operator
- Hideaki Nii System development
- Masahiko Inami System development
- Fumitoshi Matsuno Advisor
- Hiroki Igarashi Mechanical design

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

We will operate four robots at the arenas (refer to Table 1). The MA1 & 2 along with its complete control system can be packaged in a portable suitcase for efficient transportation. A custom made metal container for the snake-type robot, KOHGA, has been specially developed for moving such long size robot. Other device setups like monitors, PCs and etc., are small in size thus can easily fit in any general size box. For this reason, small size robot can be carried around easily by its operator, though the long size snake-type robot like KOHGA needs 2 people for the set-up and break-down.

3. Communications

We will operate four robots: two track type (Figure 1), one snake type[1], [2] (Figure 2), one wheel type (Figure 3). And the communication methods for the robots are shown in Table 1.

4. Control Method and Human-Robot Interface

Considering the difficulty of autonomous robot control in current technology, we will operate the robots by teleoperation, especially for practical rescue robots it is important to improve such ability. The problem is how we can improve it. Our approach is as follows:

- Use a commonly used game pad (PlayStation 2 Game Pad) which is easily controllable and has been recognized in the world as a very suitable robot control interface device.
- GUI display which present the snake-type robot configuration to help operators understand the current robot situation in order to remote control it efficiently (Figure 4).

- Remote control based on bird's eye view. This innovative viewing method helps an operator to easily understand robot's situation in an unknown environment and this is currently under development to improve teleoperation ability (Figure 5).

Table 1. Team SHINOBI wireless communication table

Robot	Radio frecuency	
	Control	Camera
MA1	main: 5GHz (IEEE802.11a) (sub: 2.4GHz (IEEE802.11 ｇ))	1.2GHz
MA2	40MHz	1.2GHz
KOHGA	main: 5GHz (IEEE802.11a) (sub: 2.4GHz (IEEE802.11g))	1.2GHz
FUMA	main: 5GHz (IEEE802.11a) (sub: 2.4GHz (IEEE802.11g))	1.2GHz

Fig. 1. MA1 & MA2 are small-size tank model robots that are driven independently, and have good mobility in flat surface environment.

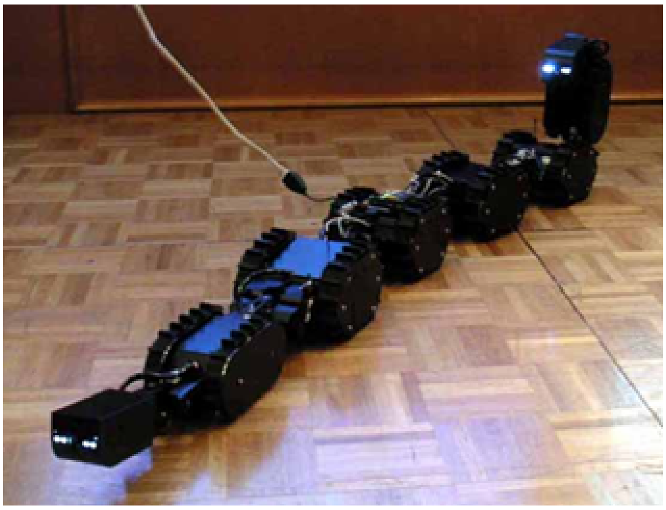


Fig. 2. KOHGA is a snake-type robot consists of eight units. Each unit has two tracks except the two heads. These units are serially interconnected with both ends first two joints as 2-DOF active joint and rest of the joints as 3-DOF passive joint. The passive joints provide good adaptation to complex environments. For this reason, KOHGA has high mobility even in rough terrains.

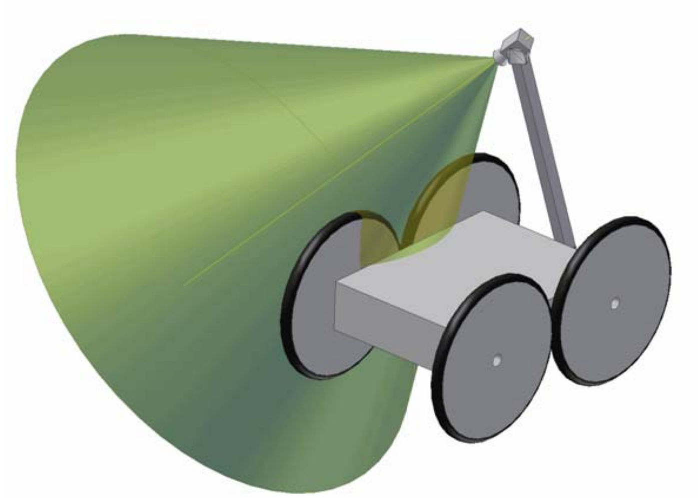


Fig. 3. FUMA is a middle-size four wheeled robot. Each side of the wheels can be driven independently. The arm mounted on the robot contributes high mobility to step over rough terrains and provides a high position camera viewing point (the robot is still under construction).

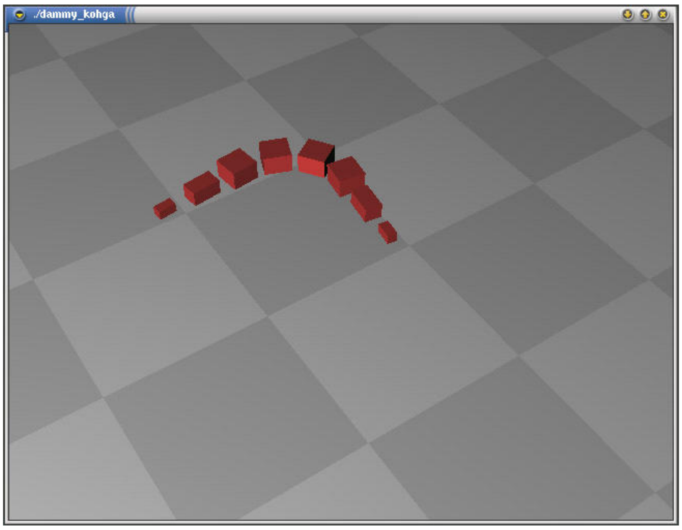


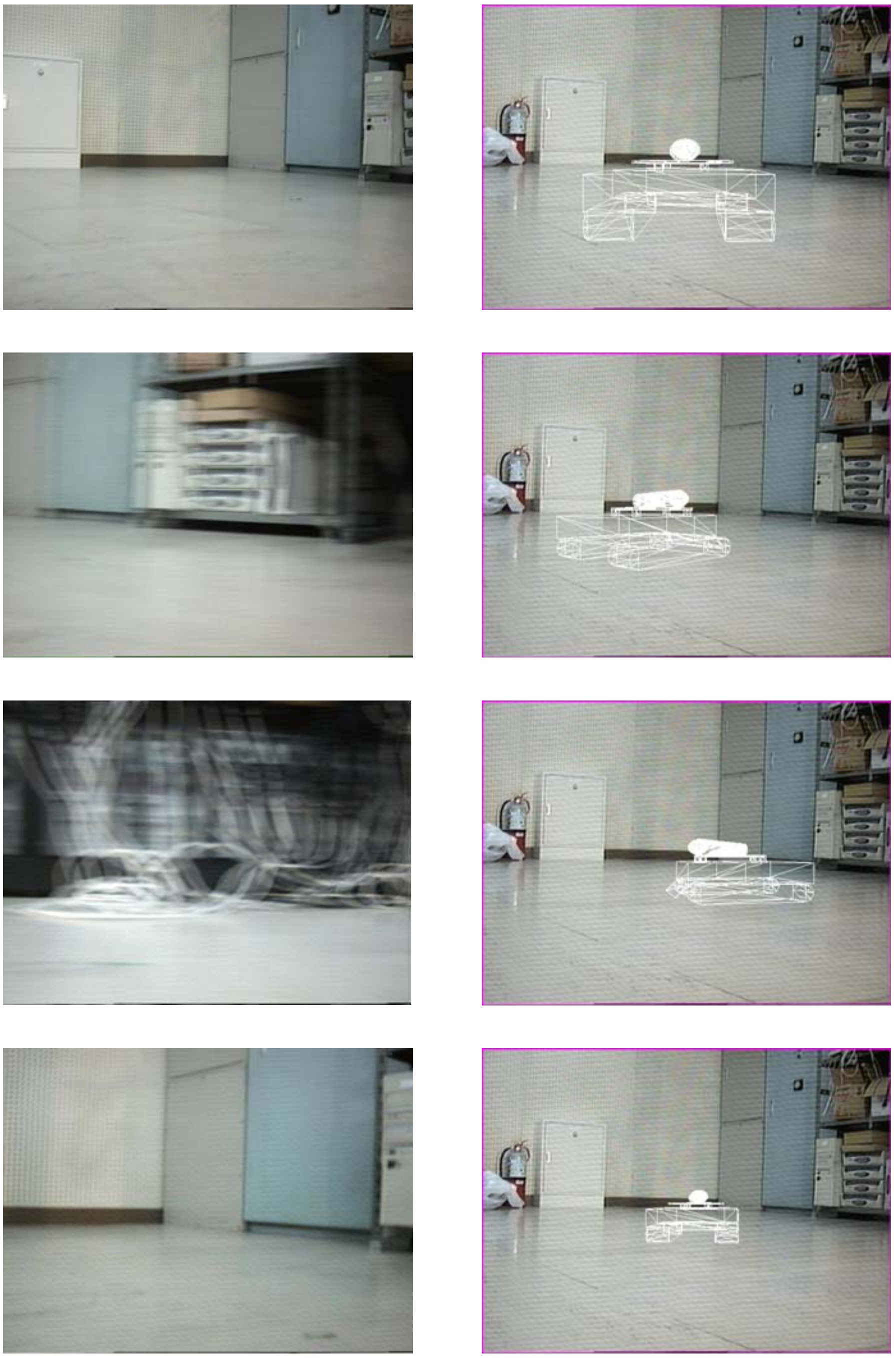
Fig. 4. GUI for KOHGA's movement configuration.

5. Map generation/printing

How we can generate easily understandable map is the key factor in map generation. Topological map is a simplified processed map that offers only the necessary information for a given task, where other unnecessary information is not considered. Our map is the topological map generated interactively using CUI interface by an operator according to the sensor data. Each node in the map is an interest site selected by an operator which may be the victims, land marks or other useful information. Such information about the site is entered by an operator using a CUI interface based on the camera images. Each node is then connected by links with distance and direction information which is obtained by the sensors. The operator can also draw on the maps by themselves based on the camera images. By combining these two types of maps we can generate a map which has rich information about the disaster site.

6. Sensors for Navigation and Localization

Main sensors for the robot navigation are the CCD cameras. Operators can control the robots by viewing the image from the cameras or virtually generated innovated views as mentioned above. Any operator can easily control our snake-type robot by giving the control command only to the head unit and then movements of rest of the units are automatically generated as it follows the movement of the head unit. GUI display for the snake robot and bird's eye view for rest of the robots assist operators to teleoperate them.



(a) **(b)**

Fig. 5. (a): actual camera images; (b) synthesized images from past camera image data and then the robot position information. Images at each row in (a) and (b) are images at the same time stamps.

The snake-type robot will use potentiometers at the joints and rotary encoders at the motor axes for its localization. Other robots use rotary encoders, gyro sensors and accelerometers for its localization. A laser projector and IR-sensors are used for obstacle detection and avoidance.

7. Sensors for Victim Identification

The CCD cameras, microphones and thermal sensors are used for victim identification. The laser projector is used to recognize victim shape.

8. Robot Locomotion

There are three types of robot locomotion in our team: track type, snake type and wheel type.

Track type: small size, tank shape, independently driven two crawler robots have good mobility in flat surface environment.

Snake type: each unit has two crawlers and these units are serially interconnected. Both ends first two joints are 2-DOF active joints and rest of the joints are 3-DOF passive joints. These passive joints have good adaptation to complex environments. For this reason, this robot has high mobility in rough terrain.

Wheel type: this is a middle size four wheeled robot. Each side of the wheels can be driven independently. The arm mounted on the robot contributes high mobility to step over rough terrain.

9. Other Mechanisms

The snake-type robot can enter narrow spaces and climb over obstacles easily with its combination of active and passive joints. This robot can transform into scorpion-shape configuration to provide the operator a complete view of the robot from its rear camera which offers great efficiency during teleoperation.

The wheel robot has an arm which gives the robot high mobility in rough terrain and presents good high position view of the environment. It also has round shape wheel covers to prevent from rolling over.

10. Team Training for Operation (Human Factors)

Since we employ a commonly used game pad as our control interface device, most people are familiar with such controller. We configured the input commands for the robots as simple as possible so that the operator only needs to input few commands to control the robots. We have specially developed a leader follow type control method for the snake-type robot, so the operator can control the robot by only considering the head unit in simple environments. One of the difficulties of remote operation is that it is hard to control a robot in remote site only from the information provided by the cameras, as it does not provide enough details for us and made it difficult to recognize a robot's situation in an environment. Our remote control method which uses virtually generated bird's eye view will overcome this problem and also allows the operator to control the robots with ease even without long training time. In addition, we will simulate three different level arenas in our experimental laboratory and train ourselves for the competition.

11. Possibility for Practical Application to Real Disaster Site

For practical use of our robots we need to improve the ability to control it within tough environments like water, dust, vibration, shock resistance and etc. Ordinal wireless communication system has some weakness in not well structured areas. Ad-hoc network system in wireless communication would overcome this problem.

12. System Cost

Track type: a remodeled radio control tank which is off-the-shelf product. Total cost for a single tank is one hundred thousand Japanese Yen.

Snake type: a custom made robot developed in our lab. Total cost is five million Japanese Yen.

Wheel type: a custom made robot developed in our lab. Total cost is two and a half million Japanese yen.

References

1. Tetsushi Kamegawa, Tatsuhiro Yamasaki, Noritaka Sato, Naoji Shiroma, Hiroki Igarashi, Dai Akimoto, Hiroshi Otsuka and Fumitoshi Matsuno : "Sequentially Connected Multiple-unit Rescue Robot Platform", First International Workshop on Synthetic Simulation and Robotics to Mitigate Earthquake Disaster, Padova, Italy. July, 2003.

2. Tetsushi Kamegawa, Tatsuhiro Yamasaki, Hiroki Igarashi and Fumitoshi Matsun: Development of The Snake-like Rescue Robot “KOHGA”, International conference on Robotics and Automation, 2004. (to be appear)

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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:	SHINOBI
ORGANIZATION:	The University of Electro-communications, Tokyo Institute of Technology, International Rescue System Institute, SGI Japan, Ltd.
COUNTRY:	JAPAN
CONTACT PERSON:	NAOJI SHIROMA
EMAIL:	naoji@hi.mce.uec.ac.jp
TELEPHONE:	+81 42 443 5552
NUMBER OF FACULTY:	4
NUMBER OF STUDENTS:	4
ESTIMATE YOUR TRAVEL ACCOMMODATION COSTS:	2660 EUR
ESTIMATE YOUR TRAVEL SHIPPING COSTS:	11500 EUR
HOW MUCH DOES YOUR TEAM REQUEST:	14160 EUR

What is your justification for travel support?:

First of all, although there is a part support from the International Rescue System Institute, there is still no full travel support for our students from the university and also no full support for the faculties. Since the competition runs about two weeks, the cost to participate is huge. And secondly, we will bring four robots to participate in the competition: two small type, one snake type and one middle type. Shipping for these robots and related setups is expensive as well. For this reason, it would be greatly appreciated if we could receive some financial support.

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

We have participated in previous competitions as follows:

- 2003 / RoboCup2003(Padova) Rescue Real Robot League / 6^{th} position
- 2003 / RoboCup JapanOpen2003 Rescue Robot League / 2^{nd} prize
- 2002 / RoboCup2002(Fukuoka) Rescue Real Robot League / 2^{nd} prize

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):

International Rescue System Institute.

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

No.