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Rescue Robot League Competition
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www.robocup2005.org

RoboCupRescue - Robot League Team Intelligent Robot Laboratory (Japan)

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Abstract. This is a Team Description Paper which describes details of a participating robot from the Intelligent Robot Laboratory of University of Tsukuba in the RoboCup Rescue 2005 at Osaka. The participants from the Intelligent Robot Laboratory try to build the map based fully on SLAM technology at the competition. Actually, they already have some trials for map building by SLAM. The participating robot itself has been developed under the Urban Disaster Mitigation National Project (DDT). The robot is originally assumed to be used for reconnaissance operation of underground town after big earthquake. It can be expected that participation with this robot will be a good opportunity to evaluate its ability through the view scope of the RoboCup Rescue competition.

Introduction

We have been developing a tele-operation and interface system for a mobile robot whose final aim is to probe inside of buildings or underground town suffering from earthquake. We participate in the RoboCup Rescue 2005 competition with the robot which is now under development based on such an interest.
(http://www.roboken.esys.tsukuba.ac.jp:18888/cdlib/iros2004/papers/IROS04-1778.pdf)

Actually, it becomes a thriving issue to apply robot technology to rescue or on-the-spot information collection activities. To avoid risk of suffering from secondary disaster, it is necessary to investigate the inside of severe earthquake stricken buildings or underground town in advance of manned rescue operation. A tele-operated mobile robot must be useful for such an advance investigation to build the operation plan with decreasing risk of secondary disaster.

For information collection activities by means of tele-operated mobile robot, it is important not only to record necessary on-the-spot information but also to log the location where the information is obtained. The location will be inferred from the robot position which is estimated by odometry or other position measurement method. It is important to provide reliable localization facility. Map as foreknowledge about the environment must be very helpful and important for a tele-operator of the robot, however it is not always available. Conventional idea is to transmit live video images that are captured by a TV camera equipped on the robot. It seems to be a common understanding that such live video images are enough to piece out the circumstances around the robot. However, it has been proved at the RoboCup Rescue competitions so far that it is more difficult to piece out the environment without any foreknowledge than to do in already “known” environment for the operator.

If the tele-operated robot has only live video facility, the operator must piece out the path from the entrance to the current position by watching and memorizing the scene through the video images time to time. However, this piecing out activity must be very exhaustive work for the operator because perspective in the video image is elusive. It must be difficult to draw reusable map or floor plan of the environment only through such video observations. On site of the competition, the operator must acquire the good sense of direction to withstand complicated direction change operation to avoid obstacles or investigative search, assuming that no absolute posture information is available from the robot. On the other hand, displaying robot posture in the live and accurate map that the robot captures makes the operator easy to grasp the surrounding situation of the robot.

Therefore, we employ not only the live video images from the tele-operated robot but also live map by means of SLAM (Simultaneous Localisation and Mapping) technology for the operator. It must be desirable to display both the live video and live map on the screen of the PC at the tele-operation station, where spherical panoramic view will be provided from omni directional digital camera. The tele-operation utility includes interface system to have registration facility to record remarkable scenes or objects during the mission. It must be desirable to put icons indicating remarkable incidents on the live map.

In a dangerous environment where manned investigation is not desirable, volumetric map building based on SLAM technology with tele-operated mobile robot was already studied by Thrun. The system which is developed by our laboratory includes SLAM based map building in real time and tele-operation interface where the “live” map is positively utilized. We expect to make good use of the developed system to rescue activities.

1. Team Members and Their Contributions

Some of the students of the Intelligent Robot Laboratory will participate in the competition. The team is supervised by Mr. Takashi Tsubouchi as a team leader, who is in charge of an Associate Professor in the Department of Information Interaction Technology, Graduate School of Systems and Information Engineering, University of Tsukuba. The Intelligent Robot Laboratory has long been developing autonomous mobile robots whose family code name is “Yamabico”. (See the following URL http://www.roboken.esys.tsukuba.ac.jp as reference). The rescue robot which will be entered for the competition is also build up based on the pile of technologies and know-how in the laboratory.

Presently, Mr. Akichika Tanaka who is a graduate student in the 2nd year of master program is a key development person of the rescue robot in both of design and implementation. He has been developed a tele-operated mobile robot for a year for under ground town reconnaissance after big earthquake. Fundamentally, this tele-operated mobile robot will be utilized for the competition. Other laboratory members will support and cooperate with him to join the competition. Member assignments for each role in detail are not determined yet. For the time being, following list shows contributions

- Team Leader: Takashi TSUBOUCHI
- Operator: Akichika TANAKA and Lab. members
- Mechanical design: Akichika TANAKA and Lab. members
- Controller development: Akichika TANAKA and Lab. members
- Man-Machine Interface Design Akichika TANAKA and Takashi TSUBOUCHI

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

Rapid set-up and break-down of the operator station are under consideration by now. Only note-PCs will be used for our tele-operation station and the controller for our rescue robots. Note-PCs, peripheral equipments and cables will be assembled in the boxes with caster wheels to keep portability from the home laboratory to the field. Pre-assembled set-up in the boxes will help to shorten the set-up time less than 10 minutes when all the materials are taken out of the boxes.

Not only the hardware set-up time but also the software waking up time is important. After the operating system of the note PC becomes on operation, the necessary programs for the robot control and environmental data acquisition are defined so that the number of necessary programs for the tele-operation is restricted. This will help to decrease the time for the software set-up. “Launcher” software is implemented to launch predefined software group which is suitable to cope with the specific situations during the mission. Several groups of the software are implemented for possible situations during the mission.

3. Communications

We provide dual communication links with wired (optic fiber cable LAN) and wireless LAN between the tele-operation station and the robots. Also, analogue video signal will be sent from the robots to the station on air. In the following table, 5GHz band is for wireless LAN connection.

http://buffalo.htmelcoinc.co.jp/products/catalog/item/w/whr2-4g54/index.html

On the other hand, 1.2 GHz band is for the analogue video transmission.

http://www.ghz-link.com/bs550gt_products.html

Rescue Robot League		
Intelligent Robot Laboratory (Japan)		
MODIFY TABLE TO NOTE ALL FREQENCIES THAT APPLY TO YOUR TEAM		
Frequency	**Channel/Band**	**Power (mW)**
5.0 GHz - 802.11a		
1.2 GHz	16ch	300mW

4. Control Method and Human-Robot Interface

The operator will operate the key board, mouse and joystick which are equipped with the note PC, and use a head set (microphone and ear receiver). On the screen of the PC, originally developed GUI will be displayed. This GUI covers robot operation, display of video images and sensory information from the robot, map building operation and environment data logging.

Motion command for the robot will be issued by the operation of the joystick. There are also command buttons to be clicked by the mouse on the GUS display. Both operation command systems are always available.

Search for victims and grasping the environment situation will be performed through the video images from the robot and 3D map information which will be built during the motion of the robot. Both of omni-directional camera and wide view angle camera will be equipped on the robot to provide wide angle views. 3D map information building based on scanned data of a laser scanner on the top of the robot is performed based on so-called SLAM technology. Semi-automatic scan matching facility will be implemented and included in the tele-operation software on the station PC.

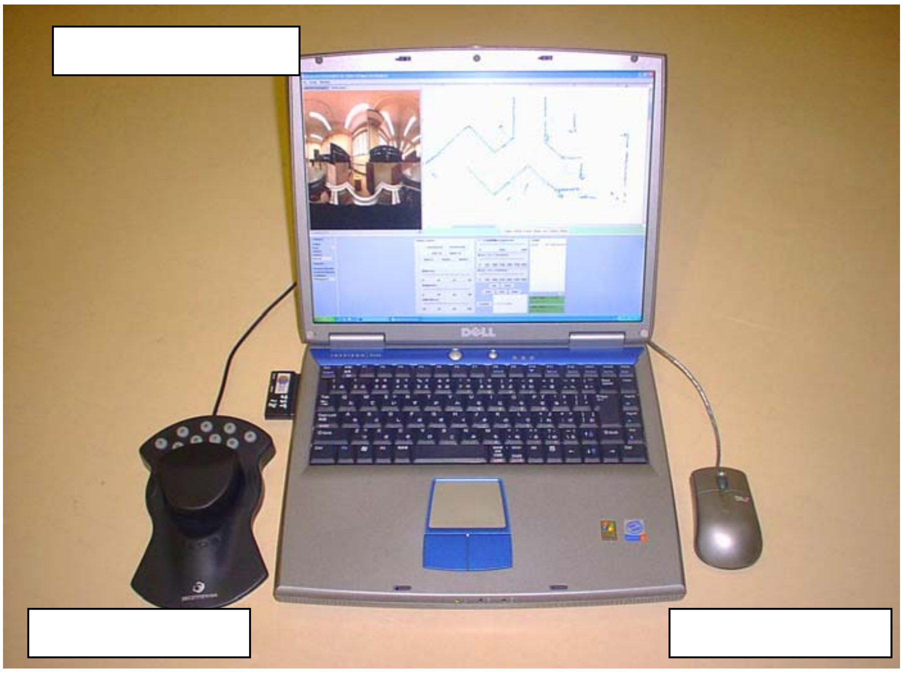

Fig.1 A tele-operation PC set up example and operation

Fig. 2 Operation snapshot

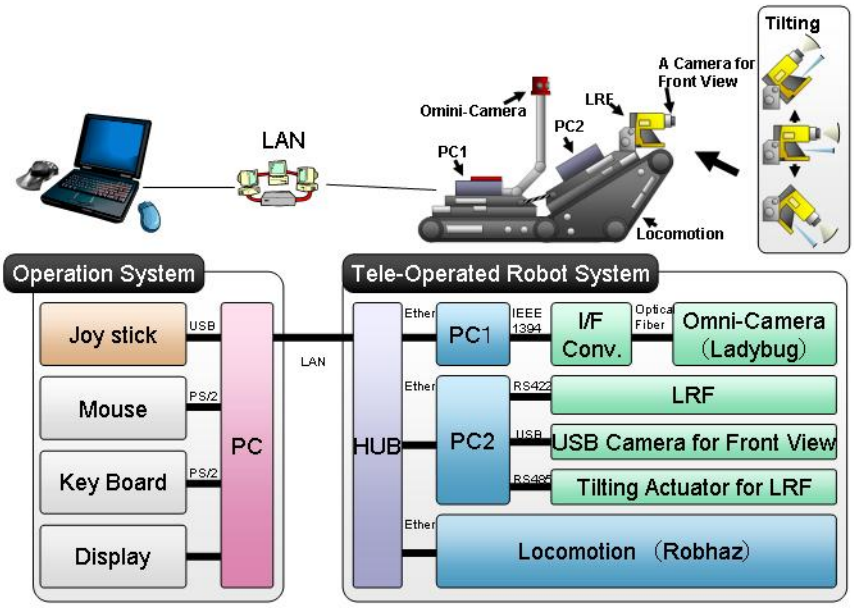

Fig. 3 System setup

5. Map generation/printing

Semi-automatic scan matching facility will be provided for map generation and building. A laser scanner together with mechanical tilt motion actuator is equipped on the robot. Where the robot stands still at every necessary position, scan data with covering more than half of the spherical space are available. Robot position and posture are estimated by means of sensory data fusion of odometry and 3D motion sensor. The 3D motion sensor is commercially available, which consists of gyros, accelerometers and electronic gyrocompass together with data fusion firmware. The scan data and estimated positions will be utilized for the scan matching to build the 3D environment map. The scan matching and map generation employ the SLAM technology. Consistency check, acceptance decision for the currently generated map and parameter refinement will be performed manually by the operator.

During the mission, the operator can place the icon with description text on the live map to indicate the remarkable incidents by means of GUI on the tele-operation station, once the operator finds the incident such as victims on the floor, much debris or severely broken location. Therefore, not only the 3D volumetric map but also remarkable incidents location can be displayed on the screen of the PC of the station. If desired, such map with incident locations can be printed out. Furthermore, the map data are shared by other rescue commanders in distant location via internet.

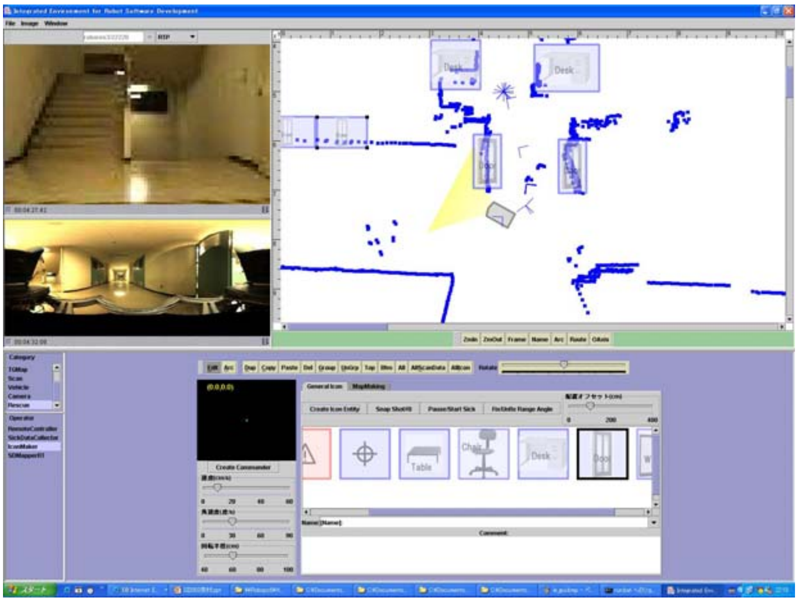

Fig. 4 Screenshot of GUI (2D SLAM map version)

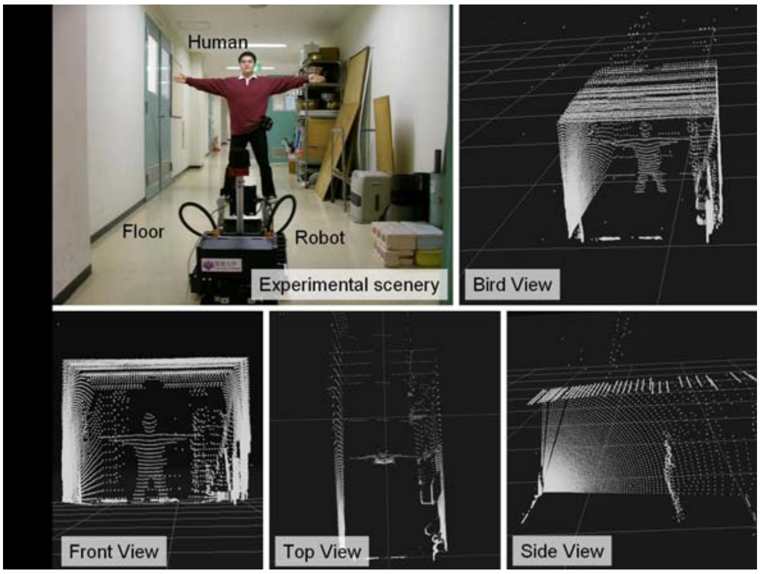

Fig. 5(a) Screenshot of 3D Scanning Experiment (Scenery of a Man and a Floor)

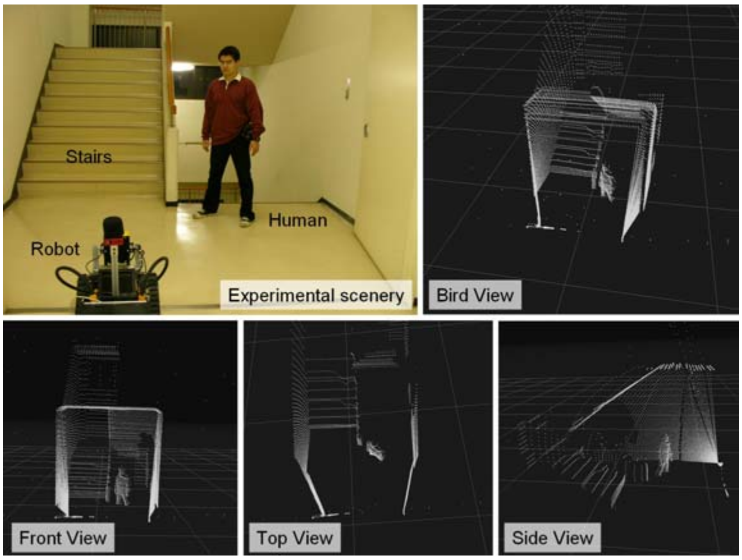

Fig. 5(b) Screenshot of 3D Scanning Experiment (Scenery of a Man and Stairs)

6. Sensors for Navigation and Localization

The mobile robot base has fundamental odometry function. This is available from encoders which are attached in the axles of the propelling DC motors of the crawlers. However, the odometry measured position itself has unavoidable error arising from cumulative integral or slippage. Therefore, we employ 3D motion sensor. The position data of 3D motion sensor and odometry will be fused by means of extended Kalman filter.

As already described in the previous Section, live 3D map is also available based on SLAM. Therefore, the robot position is always displayed in the live map. The SLAM software integrates the scan data from the laser scanner and estimated robot position by odometry and 3D motion sensor. Consistency check of the location in the 3D live map can be performed by the operator with live video image.

Navigation itself relies only on the tele-operation of the operator by seeing the live video image and 3D map. Simple and useful motion commander will be provided to help the operator investigating the environment to find remarkable incidents. We do not rely on full autonomous navigation in the environment.

7. Sensors for Victim Identification

Currently, we rely on the live video image and object shape in the live 3D map based on SLAM. We expect the operator to find any suspicious object which is a candidate of the victim through the video image. Typical shape of human head, body, arms or legs will be easily identified in the 3D live map. This will provide additional information for the victim to the operator. The robot is equipped with loudspeaker and microphone, so that bidirectional verbal communication between the victim and operator is possible.

8. Robot Locomotion

We utilize a mobile platform of passively adaptive double-track mechanism of ROBHAZ-DT3, which is commercially available form Yujin-Robotics in Korea (http://www.yujinrobot.com/english/product/robhaz.php) (Fig. 5). We use hardware mechanism including body, DC-Motors, crawlers, motor drivers. However, we have modified a control PC inside of it.

We have equipped this platform with a laser scanner with tilting actuator, omni-directional digital camera and necessary board PC as presented in Fig. 6.

Fig. 5 ROBHAZ-DT3 and stair climb

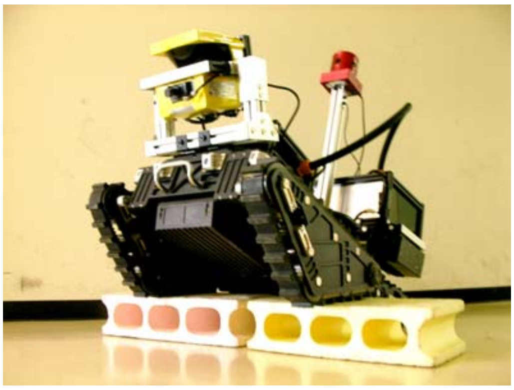

Fig. 6 Equipped platform - ACROS

9. Other Mechanisms

We provide both wireless and wired communication link between the robot and the station. For wired link, fiber optic LAN cable will be used. The cable must not be dragged. We will equip a reel to wind the cable. The reel will be driven by small DC motor which is controlled according to the motion of the robot. An illustrated Figure of the reel is as presented in Fig. 7.

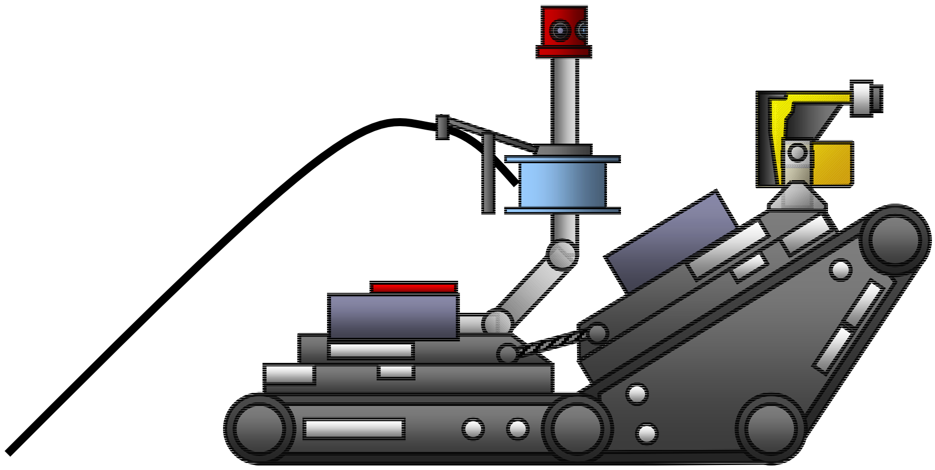

Fig.7 Reel and cable will be equipped on the robot

10. Team Training for Operation (Human Factors)

It is easy to command the robot for motion. Therefore, special training for robot motion itself is not necessary. However, it needs matured operation to find victim through sensory information which will be displayed on the screen. We will train the operator at the competition in the practical filed.

11. Possibility for Practical Application to Real Disaster Site

This robot has been developed with thanks to Japanese Urban Disaster Mitigation National Project (DDT). The robot is assumed to be used for reconnaissance operation of underground town after big earthquake. Therefore, this robot itself is not necessarily tuned for the RoboCup Rescue test field itself.

http://www.roboken.esys.tsukuba.ac.jp:18888/cdlib/iros2004/papers/IROS04-1778.pdf

12. System Cost

Please use this section to total the costs of key system components and the overall expense of your system. In this section, we're looking for **particular information that other teams could use to replicate your successful approaches**. So part numbers, prices and websites are much appreciated. This information will only be available to the other teams (and the public) when it is published after the competition season is over.

TOTAL SYSTEM COST (per robot): US$90,000._

KEY PART NAME: Mobile Vehicle
PART NUMBER: Robhaz-DT3
MANUFACTURER: Yujin Robotics
COST: US$60,000._
WEBSITE: http://www.yujinrobot.com/
DESCRIPTION/TIPS:

KEY PART NAME: Laser Range Finder (Laser Scanner)
PART NUMBER: Rotoscan RS4-4
MANUFACTURER: Leuze electronic GmbH + Co KG
COST: US$4,000.
WEBSITE: http://www.leuze.de/english/index.html
DESCRIPTION/TIPS:

KEY PART NAME: Laptop PC
PART NUMBER: Precision M60
MANUFACTURER: Dell Inc.
COST: US$4,000.
WEBSITE: http://www.jp.dell.com/
DESCRIPTION/TIPS:

KEY PART NAME: Laptop PC
PART NUMBER: VGN-U70P
MANUFACTURER: Sony Corp.
COST: US$2,000.
WEBSITE: http://www.vaio.sony.co.jp/Products/VGN-U50/
DESCRIPTION/TIPS:

KEY PART NAME: Laptop PC
PART NUMBER: VGN-U70P
MANUFACTURER: Sony Corp.
COST: US$2,000.
WEBSITE: http://www.vaio.sony.co.jp/Products/VGN-U50/
DESCRIPTION/TIPS:

KEY PART NAME: Omni Directional Camera
PART NUMBER: Ladybug Lite
MANUFACTURER: Viewplus
COST: US$18,000.
WEBSITE: http://www.viewplus.co.jp/
DESCRIPTION/TIPS:

References

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