RoboCup2005
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# RoboCupRescue - Robot League Team SPQR (Italy)

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**Abstract.** In this Team Description paper we describe the characteristics of SPQR-Real Rescue for the Osaka 2005 Real Rescue competition.

## Introduction

SPQR-Rescue Robot team comprises two wheeled robots: ActivMedia Pioneer AT and Pioneer III. Our main objective for RoboCup 2005 competition is to perform the rescue mission with minimal interaction among the operator and the robot team.
In particular we plan to devise a team of mobile robots which is able to:

- build a dense metric map
- safely navigate in the environment, even executing complex maneuvers
- explore the environment
- autonomously identifying the victims and their relevant characteristics
- coordinate for completing the mission in a minimal time.

Although our goal is the complete autonomy, in case of failure or when a dangerous situation is detected by the operator, our system allows the interaction at any abstraction level. This interaction can go from the switch of the robot team high level plan, to the change of the navigation system goal, up to the direct joystick control of the robot.

## 1. Team Members and Their Contributions

- Team Leader: Daniele Nardi
- Operator: Shahram Bahadori
- Map Building: Giorgio Grisetti, Luca Marchionni
- Navigation: Daniele Calisi

- Software Architecture: Andrea Censi
- Coordination/Communication: Alessandro Farinelli, Massimo Ferri
- Victim Detection Luca Iocchi, Shahram Bahadori

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

Our base station consists of a laptop pc, running under Linux. The robots control is done using a graphical user interface. We assume a wireless LAN to be available in the area of competition. The robots are equipped with onboard computational units.

All of the processing is done on the robots onboard PC. The console performs only the monitoring and allows the operator to interact with the robots in case of necessity.

The setup phase consists of:

- switching on the robots, and the onboard PCs.
- starting on each robot the controlling program
- establishing the GUI-robots communication.

The entire process takes less than 10 minutes without considering the network and connectivity problems.

## 3. Communications

The communication in our system uses 802.11 a\b\g standards. We prefer the 802.11a and 802.11g due to the highest bandwidth available under these standards.

We use an UDP based protocol for inter-robots communication and a TCP /UDP based protocol for robots/console communication.

In particular the commands are send from the console to the robots using the reliable TCP stream while the robot state is broadcasted using UDP datagrams.

| **Rescue Robot League** | | |
|---|---|---|
| SPQR (Italy) | | |
| MODIFY TABLE TO NOTE <u>ALL</u> FREQENCIES THAT APPLY TO YOUR TEAM | | |
| **Frequency** | **Channel/Band** | **Power (mW)** |
| 5.0 GHz - 802.11a | Any | <u>100</u> |
| 2.4 GHz - 802.11b/g | Any | 100 |
| 2.4 GHz – Bluetooth | spread-spectrum | |
| 2.4 GHz – Other | | |
| 1.2 GHz | | |
| 900 MHz | | |
| 40 MHz | | |
| 27 MHz | | |
| <FILL IN OTHER> | | |

| | | |
|---|---|---|
| <FILL IN OTHER> | | |

## 4. Control Method and Human-Robot Interface

We use a single control program which can connect to more than one robot and the operator has the possibility to control and supervise the activities of the robots from it.

The console is a dumb terminal which displays the state of the processes running on the robots. In particular it is possible to display:

- the sensor readings (LRF contour, sonar readings, camera images, thermal sensor output)
- the actual map as estimated by the mapping process
- the intermediate steps of the autonomous navigator module
- the joint intentions of the mobile robot team
- the human body detection module intermediate output.

Additionally the user can dynamically modify the parameters of the running processes. Even if we designed our system to me completely autonomous, in case of failure the operator can have direct access to the robot. The operator can give the robot speed commands through the keyboard or an USB joypad eventually connected to the console PC. In the same way the user can directly control the pan-tilt mechanism mounted on some of the robots, using the keyboard or the joystick.

## 5. Map generation/printing

The map is built using an approach integrates LRF output, sonar readings and encoder information. The maps are estimated by a robot onboard process, in an occupancy grid fashion.

Together with the map we can estimate the path taken by the robot during the exploration process. The map can be displayed on the operator console while the robots are operates, together with the robot position in the environment.

The map is finally converted in a bitmap image. On such a map the identified victims can be annotated to produce a final report.

## 6. Sensors for Navigation and Localization

The safe navigation is achieved using an integrated approach of **LRF** and **<u>sonar sensors</u>**.

The navigation process assumes to operate on a reliable robot position estimate provided by the mapping process. The trajectories are computed using a dynamic prob-

abilistic topological map approach which requires the robot position, the partial map estimated and a target point, which is provided by an exploration algorithm.
The robot motion is planned in the full configuration space of the robot, taking into account also its orientation, in order to cross the narrow passages which characterize the rescue arenas.

## 7. Sensors for Victim Identification

For the Victim identification and body part localization we use Stereo vision and Image processing. Our victim identification system is a shape-based approach that find identifies the position of the limbs and generate a 3D model of the victims.

The victim detection system could transmit both the position of the found victim and the position of some body limbs without finding the entire body parts.

We also use the other complementary sensors like chemical gas detection, voice transmission and thermal sensors in order to detect also the un-visible victims.

## 8. Robot Locomotion

Differential drive 2 wheels and 4 wheels robots.

## 9. Other Mechanisms

Pan tilt unit.

## 10. Team Training for Operation (Human Factors)

The Graphical User Interface is user friendly enough. Minimum of on week training for a computer expert user is necessary to command the entire functionalities of robots from user interface.

## 11. Possibility for Practical Application to Real Disaster Site

The present mobile base is a laboratory and experimental prototype. Because of the locomotion limitations it is not possible to use the present mobile base in real disaster scenarios.

## 12. System Cost

TOTAL SYSTEM COST (15000€):

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KEY PART NAME: Mobile Base Pioneer 2 DX
PART NUMBER: 1
MANUFACTURER: Activemedia
COST: 2500€
WEBSITE: www.activerobot.com
DESCRIPTION/TIPS: Non Holonomic 2 wheels mobile base, equipped with a front sonar ring. Connection with the host through RS232 interface.

KEY PART NAME: Hokuyo Infrared Range Sensor PB9-11
PART NUMBER: 1
MANUFACTURER: Hokuyo
COST: 1500€
WEBSITE: www.hokuyo.jp
DESCRIPTION/TIPS: Infrared proximity range finder. 162 deg. Of spanning angle. RS232 connected; extremely noisy, but light and low power.

KEY PART NAME: Stereo Vision System
PART NUMBER: 1
MANUFACTURER: Videre Design
COST: 1200€
WEBSITE: www.videredesign.com
DESCRIPTION/TIPS: High quality stereo vision system.

KEY PART NAME: On-board embedded pc (VIA EPIA-M10000)
PART NUMBER: 1
MANUFACTURER: VIA
COST: 300€
WEBSITE: www.via.com
DESCRIPTION/TIPS: Cheap and low power barebone PC. It has approximately the same performances of an Intel Pentium 3 /800Mhz.

KEY PART NAME: Wireless 802.11 a/b/g access point (3COM OfficeConnect 3CRWE454A72)
PART NUMBER: 1
MANUFACTURER: 3COM
COST: 180€
WEBSITE: www.3com.com
DESCRIPTION/TIPS: Three band wireless access point. It works in master, client and bridge modalities.

KEY PART NAME: Mobile Base Pioneer 3 ATX

PART NUMBER: 1
MANUFACTURER: Activemedia
COST: 4000€
WEBSITE: www.activerobot.com
DESCRIPTION/TIPS: Holonomic 2 wheels mobile base, equipped with a front sonar ring. Connection with the host through RS232 interface.

KEY PART NAME: Sick LMS-291-S14 (Laser range finder
PART NUMBER: 1
MANUFACTURER: Sick
COST: 1500€
WEBSITE: www.sick.de
DESCRIPTION/TIPS: Accurate and powerful laser range finder. Scans up to 80m, with a resolution up to 0.25 deg. RS232/RS482 connection.

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WEBSITE: www.3com.com
DESCRIPTION/TIPS: Three band wireless access point. It works in master, client and bridge modalities.

KEY PART NAME: Contact less thermal infrared sensor with laser pointer
PART NUMBER: 1
MANUFACTURER: Rayomatic 40
COST: 1300€
WEBSITE: www.eurotron.it
DESCRIPTION/TIPS: Heavy, but accurate thermal sensor. RS232 connectivity.

KEY PART NAME: Home made pan-tilt unit
PART NUMBER: 1
MANUFACTURER: Tetsushi Kamegawa (an our past collaborator)
COST: 500€ (the cost includes only the parts)
WEBSITE: www.eurotron.it
DESCRIPTION/TIPS: A microcontroller based pan tilt unit. The actuators are made using servos which can be found in RC controlled toy cars.

## References:


1. G. Grisetti, C. Stachniss, and W. Burgard. Improving grid-based slam with rao-blackwellized particle filters by adaptive proposals and selective re-sampling. In Proceedings of International Conference on Robotics and Automation, Barcelona, 2005.

2. S.~Bahadori and L.~Iocchi. A stereo vision system for {3D} reconstruction and semi-automatic surveillance of museum areas. In Proceedings of Workshop Intelligenza Artificiale per i Beni Culturali (AI*IA-03), 2003.