SPQR Real Rescue Team Description

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Abstract. In this paper we briefly describe the development of our team (SPQR) which participated in the Real Rescue RoboCup competition for the first year (7th position). Our team is composed of one Pioneer mobile base equipped with a fix color camera. Both the mobile base and the software framework (SPQR-RDK) have been previously used in the middle size soccer competition. Thanks to the flexibility of the SPQR-RDK framework, we have been able to adapt the basic behaviors of the robot, needed for the new application in a very short time (less than two months). In the following we will describe the method used to control the robot, the approach to the mapping and localization problem and the future development lines for our team.

1 Introduction

S.P.Q.R., is the group of the Faculty of Engineering at University of Rome "La Sapienza" in Italy, that has developed RoboCup teams in differant categories.*SPQR-Legged* plays in the legged soccer league, and *SPQR-Real-Rescue*, for the first time this year,in the Real Rescue league. In the past we have participated to the development of middle size robotic soccer teams: Azzurra Robot Team (ART) in 1998 and 1999, and*SPQR-Wheeled*in the Middle Size Team from 2000 to 2002. The SPQR-Real-Rescue Team has participated to the Real Rescue competition for the first year in RoboCup 2003 adapting the mobile platform previously used for the middle size league soccer competition. The two application domains obviously present several differences: in the Soccer league the environment is highly structured with colors precisely indicating different interesting features (the ball is red the lines are white and so on), moreover the geometry of the environment is relatively simple and a 2D representation of the environment is generally enough for all the tasks to be performed. On the other side, in the Real Rescue environment the geometry of the environment is complex and in some of the arenas (orange and red) the working scenario is deployed in different planes, with slopes and steps that has to be overtaken. Moreover, colors are of no use, the environment is not structured and several different materials are used in the arena. Therefore, the use of different sensors is required in order to have a clear perception of the scene and to identify the victims. The obstacles in the scene have a complex geometry and a 3D representation of the scene would be required for autonomous navigation. Finally, the map of the environment is not known and therefore to have a map of the environment that specifies the victims position inside the arena, which is one of the tasks required to the participating teams, some method of Simultaneous Localization And Mapping (SLAM) is required. We decided to participate to the competition, using a Pioneer 2 mobile platform equipped with a fixed color camera and a ring of sonars. The hardware set up constrained our team to participate only in the yellow arena (2D geometry of the environment). Moreover, we decided to teleoperate the robot adapting a graphic console previously developed for the soccer team (RConsole), exporting the image from the camera using a wireless network connection. Finally, for the mapping approach we used the information extracted from the sonar ring. Thanks to the high flexibility of our software framework developed in or group [3], we have been able to develop the basic skills needed by the robot for such a different application in a very short time. In fact, during the development of the robotic soccer teams, we decided to employ our experience in the development of tools that allow for an easy implementation of multi purpose mobile robots: the SPQR Robot Development Kit (SPQR-RDK). In the following section we provide a general description of the SPQR-RDK and focus on the specific modules that have been implemented on our robots.

2 Team Development

SPQR-Rescue Team is composed by the hardware previously used for a soccer robot. For obvious reasons related to the limited kinematics of the unicycle like kinematics, we decided to participate only in the yellow arena. The hardware of our robot is the following:

- ActivMedia Pioneer2-AT mobile base, with on board sonars;
- Sony camera;
- AMD-K6 400 class PC equipped with wireless lan, and PAL frame grabber.

The robot is remotely teleoperated using the image extracted form the camera as a feedback. The software architecture is based on the SPQR-RDK whose core is a middleware that provides the basic functionalities for the development of robotic applications. This middleware is composed by a minimum set of modules, common to all the applications that can be developed within our framework. The middleware is made up by the following modules, as shown in Figure 1:

- The **Robot Hardware Interface** is a library that defines an abstraction layer on the specific robot hardware, providing a common interface to the higher level modules.
- The **Task Manager** is a library that defines a template for all the user modules and provides both a set of services for dynamically loading the user modules in the application and a mechanism for data exchange among them.

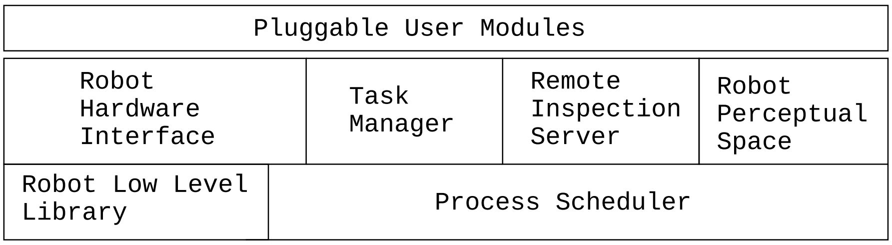

Fig. 1. Overview of the SPQR-RDK architecture

- The **Robot Perceptual Space** is an extensible knowledge base shared among all the user modules, holding the overall robot knowledge about the environment.
- The **Remote Inspection Server** is a library that allows for remotely monitoring the robot activities, by implementing a publish/subscribe mechanism for the data produced by the running modules.

The user modules, implementing the specific functionalities are loaded from the robot application as binary objects, and the SPQR-RDK core grants remote control and communication capabilities. One of the tools that has been developed to complete the RDK is RConsole, a remote client capable of controlling multiple robots, and of displaying the internal modules state using the RIS mechanism to minimize the network bandwidth requirement, which is one of the greatest constraint in wireless networks.

2.1 Localization and Mapping

One of the fundamental task that a rescue robot has to perform is to reconstruct the operating scenario, and to locate the inside victims. For successfully performing this task it is needed to correctly estimate both the unknown environment and the robot pose, in order to mark a given position in the map when a victim is detected . The problem of consistently estimating map and robot position is known as Simultaneous Localization and Mapping (SLAM), and it has been object of investigation for a great number of researchers since mid 80s.

In the Rescue Domain the problem of designing a consistent map is made hard by the materials of which the arenas are build, that goes from phonoabsorbing panels, to wood and glass. Each of those materials can be easily detected by one kind of sensor, but a device capable of detecting all of the rescue arena materials does not exist, i.e. the glass can be detected by sonars but not by laser range finders, as opposed to the panels, therefore the choice of heteroceptive the sensors that has to be used for map building is crucial, and multi sensor integration techniques has to be used. However, as said in the introduction we decided to adapt a robot designed for playing soccer, into a rescue robot, and at that time the sensors equipping the mobile base were only sonars and and spot camera, and the decision was to use only the sonars for mapping, since the spot camera cannot assess the range informations needed by the mapping process without strong assumptions on the environment structure. Anyway the adaption of a soccer robot to a rescue robot was made easy by our software architecture, that has been explained in Section 2.

The method we used for SLAM is shown in Figure 2: the achieved map is composed by lines, that are extracted from the accumulated sensor readings through the Hough line transform [2] while the position of the robot is estimated starting from the past position and the learned map part , through the use of an extended Kalman filter [6]. The position assessment process works as follows: given the global map and the local map, both represented in the Hough space, the association among features, given the robot position can be established according to the nearest neighbor principle, then for each feature pair a displacement along their normal segment is performed, as well as the angular correction, and the update step for the kalman filter is executed. When the robot moves the estimated position is updated according to the motion model, by the execution of the kalman prediction step, given the odometry readings. All the unmatched lines persisting for more than a given time will be introduced in the map, but the user can interactively remove the mapped lines that are not feasible.

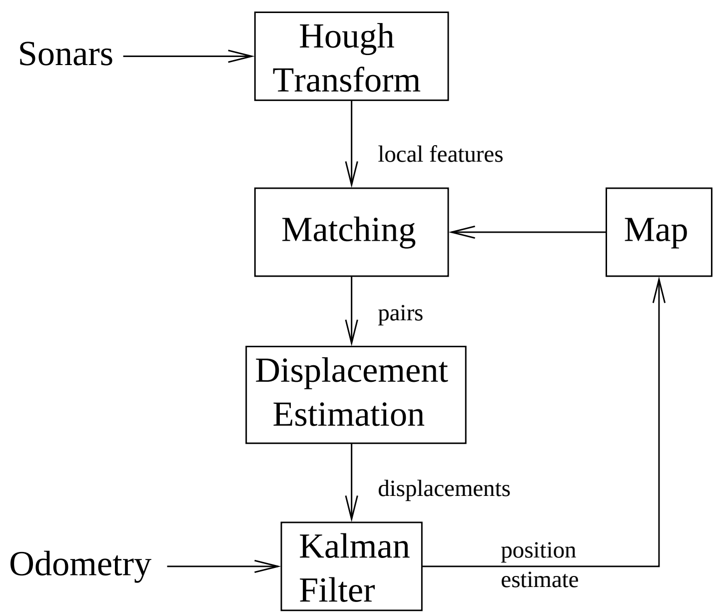

Fig. 2. The Mapping data-flow of our algorithm

2.2 Human Body Detection

In order to detect a human body, an autonomous robot must be equipped with a set of specific sensors that provide information about the presence of a person in the environment around.In 2003 Padua RoboCup competitions we started to study the methods and problems of Human Body Detection in a Rescue scenario [9] and we try to finilize this experiments and use them for the RoboCup2004 competitions. Each of these sensors is suitable to detect a specific characteristic of human bodies, such as shape, color, motion, IR signals, temperature, voice signals, CO_2 emissions, etc. In the first part of our experiments for Autonomous HBD we decided to use the visual information. In fact among the sensors that may be used for detecting human bodies, most of the research works in the literature make use of vision systems. The main reason is that cameras are commonly used in robotics and of course in computer vision and images are rich source of information, that are usually used also for other tasks, like localization, mapping, obstacle avoidance, etc. In fact, human body detection (HBD) by visual information has been studied also in different application fields that are for example autonomous vehicle navigation for detecting the people and pedestrians for autonomous navigation [7], surveillance [1], human motion capture for virtual reality [8], etc. Since, we are mainly interested in research of autonomous rescue robots, it is fundamental to devise effective methods for HBD. In the way of detecting an object in an image frame there are several methods. In particular, human body detection is generally addressed by using a three step method. The first step is to find the margins of each object in an image (*Segmentation*): in this phase we can individuate the existence of generic objects that are simply represented as set (or clusters) of connected pixels. In the second step such clusters of pixels are distinguished and classified on the basis of some predefined classes, representing the various parts of the human body (*Classification*). Finally, in the third step the classified components are composed in order to match a human body model (*Modeling and recognition*)[9]. Consider that the second and third steps can be used in an iterative cycle in order to detect the body with better effectiveness and reliability.

3 Conclusions and Future Works

In the future we plan to build a couple of ad-hoc heterogeneous rescue robots, and the experience of this year allows us to devise a more valid team for the real rescue competition, as well as to produce valid scientific results. The two robots equipment is the following:

- *Robot 1*: A Pioneer2 mobile base, high precision range finder, and spot camera, all connected to a portable PC, equipped with an 802.11b wireless network.
- *Robot 2*: A PioneerXX mobile base, low precision range finder, a stereo camera,Ir pattern detector all connected to a portable PC, equipped with an 802.11b wireless network .

The tasks of the two robots are different: the first has to build the environment map,while the second explore the map for navigating the environment, using one of the many dense sensor mapping technique, such as [4] or one of its variations.eventually synthesizing a joint perception module that integrates both sonars and lasers; The operator completely controls the first robot through a joystick, by looking at the camera images, that will be sent through a non locking network protocol (as UDP), and seeing the map under construction in a separate tool. Also we try to provide a semi-autonomous HBD algorithm to localize and detect the human body using the sensorial information(Stereo-Vision,IR-Image Patterns,Gas-Detectors). In order to experiment coordination and cooperation techniques we want the second robot to use the map built from the first one, and to autonomously search in the mapped area for human presence. Obviously the operator can suggest in which region the second robot has to look for human presence

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