S.P.Q.R. Wheeled Team

Luca Iocchi, Daniele Baldassari, Flavio Cappelli, Alessandro Farinelli,
Giorgio Grisetti, Floris Maathuis, and Daniele Nardi

Dipartimento di Informatica e Sistemistica
Università di Roma "La Sapienza"
Via Salaria 113, 00198, Roma, Italy
<lastname>@dis.uniroma1.it
http://www.dis.uniroma1.it/∼wheeled

Abstract. This paper presents the design and implementation issues that have been addressed for the realization of the S.P.Q.R. Wheeled team of soccer robots. The team is formed by "senior" soccer robots that have participated to previous RoboCup competitions as well as by new robots developed for completing the team. By exploiting our previous experience in designing and developing soccer robots, we have developed innovative techniques for vision, localization, planning and coordination.

1 Introduction

S.P.Q.R. is the group of the Faculty of Engineering at University of Rome "La Sapienza" in Italy, that is currently involved in developing two RoboCup teams: the **S.P.Q.R. Legged** team [6] in the *Sony Legged League* and the **S.P.Q.R. Wheeled** team in the *Middle Size League.*

The S.P.Q.R. Wheeled team is formed by three "senior" soccer robots that have participated at previous RoboCup competitions within the ART team [7], by a Golem robot, and by a new robot that has been designed and built within our group for the role of goalkeeper. The main feature of our team is the design approach we have adopted for developing cognitive soccer robots, that can be programmed by using a high-level specification of their capabilities, the environment and the task they can execute. The layered architecture we have realized allows for sharing the same high-level modules within both the Legged and the Wheeled teams.

2 Team Development

Team Leader: Luca Iocchi.
Team Members: Daniele Baldassari, Flavio Cappelli, Alessandro Castaldo, Alessandro Farinelli, Giorgio Grisetti, Floris Maathuis, Daniele Nardi, Giampaolo Pucci, Davide Troiani.
Country: Italy.
Sponsors: Facoltà di Ingegneria, University "La Sapienza" and NETikos Web Mobility.

A. Birk, S. Coradeschi, and S. Tadokoro (Eds.): RoboCup 2001, LNAI 2377, pp. 669–672, 2002.
© Springer-Verlag Berlin Heidelberg 2002

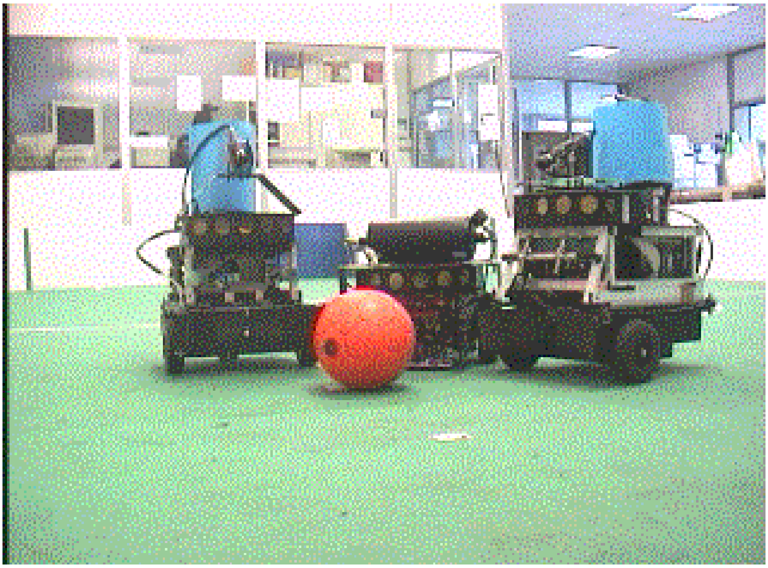

Fig. 1. S.P.Q.R.-Wheeled team

3 Robotic Bases

The robots of our team are based on different mobile platforms. Three of the players are modified Pioneer1 or Pioneer2 [1] robotic bases, equipped with a fixed CCD color camera and with a kicking system formed by two independent air-pressure driven kickers that allow for directional kicks. One of these robots has a kicking system that can raise the ball from the ground. The fourth player is a Golem robot[2] with omnidirectional motion system and omnidirectional vision system obtained by a mirror especially designed for the RoboCup environment. The goalkeeper is a new robot that has been designed and built within this project. Motor control is based on a self-made board connected to the on-board PC on the ISA bus. In this way, the control of the robot is performed by the same CPU (currently a Pentium III 800 MHz) used for high level processing. This has been possible by using the real-time extension of the Linux operating system and by the implementation of a motor control driver that run in real-time mode and thus it is guaranteed to be scheduled every 5 ms. The vision system of our new robot is formed by a moving stereo vision camera and a digital camera with an emisperical lens having field of view greater than 180 degrees. By putting the digital camera on the top of the robot looking downwards, the goalkeeper is able to see 360 degrees for about 5 meters (to the half of the field form the goal line). Image quality is very good both for the use of a digital camera and for the lack of a mirror that always introduces some kind of distortion.

[1] `http://www.activrobots.com/`
[2] `http://www.golemrobotics.com/`

Therefore we have different robots with different capabilities to use according to the situation at hand (e.g. the characteristics of the opponent team). All these robots use: 1) a conventional PC for on-board computing; 2) a wireless high bandwidth connection for communication and coordination among the robots during the game, and as a development tool that allows the programmer operating on a standard platform to obtain accurate information about the situation on-board; 3) high quality CCD color cameras with a resolution 380 TV lines and a low-cost PCI frame grabber based on the BT848 and one digital camera with IEEE1394 interface.

4 Software Architecture

In order to realize a robotic team with heterogeneous platforms three main components have been developed: a heterogeneous and asynchronous layered architecture allowing for an effective integration of reasoning and reactive capabilities of the robot; a high level representation of the plans executed by the robots; a formal account of the system for generating and verifying the plans. The use of a high-level specification has provided significant advantages also from a practical viewpoint. First of all we are able to share the high-level of our architecture among different platform (including the Sony legged robots that compete in the Legged League). Second, we are able to effectively program our players in a very flexible and effective way. All our robots share the same software architecture in which the main components, that are perception, localization, navigation, planning and task execution, and coordination, are described in the following paragraphs. We have also realized a new development tool (based on global vision) that is used for monitoring the behavior of the robots during a match or an experiment, and thus for evaluating the implemented techniques for localization, navigation, and coordination.

Perception. The perception of our robots is mainly based on color cameras used as vision based range sensors, that are able to acquire range information for the objects that are in the environment. The use of a vision system is very important since images are the richest font of information that a robot can acquire from the environment, however, with respect to other range sensors (such as sonars and laser range finders), it requires an additional effort for calibration and the implementation of routines for color segmentation, feature extraction and world reconstruction. In addition to the image processing procedures, that were already developed (see [5]), we have designed a new easy-to-use tool for calibrating the vision system: internal and external parameters and color filter.

Localization. Localization in RoboCup is an important aspect for effective task accomplishment and Hough Localization [5] has proved to be very effective in this environment. We have extended our previous method with the implementation of a probabilistic extension of the Hough Localization [4] that, by using an Extended Kalman Filter, has provided good improvements in the integration of the map matching process with odometry data.

Navigation. A new navigation system has been implemented for our robots. We have defined a new global navigation function that takes into account moving objects and it is used for generating the trajectories for the robot. By taking into account direction and speed of moving objects our path planner is able to generate more effective trajectories for avoiding them. For instance, in situations in which another robot is crossing the robot's trajectory the path planner usually chooses to pass behind it or even to stand still until the other robot is passed.

Planning and Task Execution. A central issue for our research in robotics is the design of cognitive mobile robots, where a deliberative layer including an explicit representation of the robot's knowledge on the environment is added, with the aim of increasing the robot's performance in accomplishing complex tasks. We have developed both a set of primitive actions to provide the robots with individual basic skill and a framework [2,3], for high-level description of the environment, automatic plan generation and verification, and monitoring during task execution.

Coordination. Coordinating a team of heterogeneous robots is an important research issue, and the highly dynamic, uncertain and noisy RoboCup environment provides for an interesting testbed for experimentation of distributed approaches to multi-robot coordination. Coordination among the robots in our team has been designed on a distributed coordination protocol [1], that is implemented on every robot of the team and allows for the exchange of a few data containing information about the status of every robot. The protocol deals both with roles (*GoToBall*, *Defend*, etc.) and with strategies (defensive, offensive). While roles are dynamically assigned to the various players during the game, depending on the configuration present on the field, the strategic level was demanded to an external selection (the human coach).

References

1. C. Castelpietra, L. Iocchi, D. Nardi, M. Piaggio, A. Scalzo, and A. Sgorbissa. Coordination among heterogenous robotic soccer players. In *Proc. of International Conference on Intelligent Robots and Systems (IROS'2000)*, 2000.
2. Giuseppe De Giacomo, Luca Iocchi, Daniele Nardi, and Riccardo Rosati. A theory and implementation of cognitive mobile robots. *Journal of Logic and Computation*, 5(9):759–785, 1999.
3. L. Iocchi, D. Nardi, and R. Rosati. Planning with sensing, concurrency, and exogenous events: logical framework and implementation. In *Proc. of KR'2000*, 2000.
4. Luca Iocchi, Domenico Mastrantuono, and Daniele Nardi. A probabilistic approach to Hough Localization. In *Proceedings of the IEEE International Conference on Robotics and Automation (ICRA2001)*, pages 4250–4255, 2001.
5. Luca Iocchi and Daniele Nardi. Self-localization in the RoboCup environment. In *RoboCup-99: Robot Soccer World Cup III*, pages 318–330, 1999.
6. D. Nardi, C. Castelpietra, A. Guidotti, M. Salerno, and C. Sanitati. S.P.Q.R. In *RoboCup-2000: Robot Soccer World Cup IV*. Springer-Verlag, 2000.
7. D. et al. Nardi. ART-99: Azzurra Robot Team. In *RoboCup-99: Robot Soccer World Cup III*, pages 695–698. Springer-Verlag, 1999.