SPQR
RoboCup 2016 Standard Platform League Qualification Report

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1 Team Information

SPQR [1] is the group of the Faculty of Computer Engineering at Sapienza University of Rome in Italy.

It has been involved in RoboCup competitions since 1998 in different leagues: Middle-size 1998-2002, Four-legged 2000-2007, Real rescue robots 2003-2006, @Home in 2006, Virtual-rescue since 2006 and Standard Platform League (SPL) since 2008.

SPQR team members have served RoboCup organization in many ways: Daniele Nardi served as Exec, Trustee, President of RoboCup Federation from 2012 to 2014 and was RoboCup Symposium co-chair in 2004; Luca Iocchi is Exec member of RoboCup@Home, Trustee and was RoboCup Symposium co-chair in 2008.

SPQR team members published a total of 16 papers in RoboCup Symposia (including a best paper award in 2006), in addition to many other publications about RoboCup related activities in other international journals and conferences in Artificial Intelligence and Robotics.

The SPQR Qualification Video 2016 is available at
https://youtu.be/Q1omw7txKRY

1.1 Team Members

The team is composed by two professors, PhD and Master students.

[1] http://spqr.dis.uniroma1.it

Advisors: Luca Iocchi, Daniele Nardi;

Team leaders: Vincenzo Suriani, Francesco Riccio;

Members: We are in a preliminary step and the list of students is not yet official.

2 Robot Information

Currently our team owns 6 robots:

- 1 NAO V5.0,
- 5 H25 NAOs V4.0.

3 Preference

The SPQR Team is willing to compete in the outdoor competition for the first round robin (1). Thus, we are going to participate in the *Outdoor challenge*, and also in the *Drop-in player competition* (2).

4 Code Usage

Historically, SPQR deployed its own framework entirely written in C++, named OpenRDK. It allows for an easy formalization of the robotic system in all its components. Specifically, one of the key feature of such a framework is the design of robot behaviors through *Petri Net Plans* [4]. Such a formalism is suitable for creating complex behaviors both for a single robot and the entire team by exploiting a theoretical background on *Petri Nets*. Within the OpenRDK framework, our team contributed in developing a method to perform color segmentation [3] with very little calibration effort, as well as a hierarchical approach for examining the image pixels using a set of sentinel pixels that are non-uniformly spread on the image. Moreover, we provided a benchmarking methodology for evaluating robotic soccer vision systems [2]. It is accessible via a public repository with data sets (with ground truth), algorithms and implementations that can be dynamically updated.

Since 2013 the SPQR Team is using the soccer-dedicated software architecture developed and released by the *B-Human Team*. We want to thank the team for their great contribution and work in this league. This software easily communicates with the *low-level* of the robot, allowing us to focus on our research topics that are more centered in high-level coordination and distributed environment reconstruction.

5 Past History

SPQR Team joined the RoboCup competition since 1997. Lately, in 2013 the SPQR participated in two Open competitions: the IranOpen, winning the competition, and in the GermanOpen competition, obtaining the third place. In RobotCup 2013, in Eindhoven we passed the first round robin, and we achieved the second place in the second round robin. In RoboCup 2014, in João Pessoa, we passed the round robin phase in the group D. Last year, in RoboCup 2015 in Hefei, our team competed in different challenges and in the main competition. The team did not manage to pass the first round robin stage.

6 Impact

The Ro.Co.Co. (Cognitive Cooperating Robots)[2] laboratory has been always interested in participating in RoboCup. We aim at transferring the achievements of our research in machine learning, behavior formalization and coordination in the RoboCup competition. We believe that our work, in these research areas can contribute in developing a more reliable soccer team and pursuing the goals of our league (1).

Our university, and in particular our department, strongly supports our work in RoboCup competitions. In fact, such competitions are an excellent testbed for validating our work. Furthermore, we are the only laboratory that tries to address problems such as multi-robot coordination, and robot learning. Moreover, the *Petri Net Plans (PNP)*[4] framework is now our official system for behavior design and formalization, thanks to the work done in RoboCup experience (2). Lately, we started exploiting our knowledge on vision and dynamic walking engine to better govern the Nao platform and employ such a robot in other applications.

In the following sections, we report contributions generalized in other application domains that impact our laboratory research.

6.1 Context-Coordination System

We developed an algorithm that exploits the high level information of occurring situations to obtain a specific behaviors in response of multiple environmental stimuli. The aim of this work is to provide a high level of knowledge about the current state of the world, allowing the team of robots to have a more effective way of perceiving the environment and the entities in it. This coordination system models the context features of particular environment and integrates two different methodologies for *Multi-Robot Systems*: distributed task assignment and distributed world modeling. In fact, in order to perform the task assignment, we rely upon utility estimations exchanged within the team during their mission. More in detail, we dynamically change the *utility functions* according to the current status of the *distributed world model* and the *context* the team

[2]http://www.dis.uniroma1.it/ labrococo/?q=node/6

is in. Such an adaptation of the utility estimation is the key insight of our coordination system and allows our robots to specialize their behavior to any environmental requirement. We are generalizing such a coordination framework to the case of Non-adversarial target localization in indoor scenarios. The main idea is to deploy a coordinated team of robot to localize multiple targets (e.g. lost objects, moving person, victim assessments) and to leverage the execution of the current robots' tasks by exploiting any kind of information that can help the robots to specialize their search and to improve their performance.

6.2 Networking

In Multi Robot System (MRSs), one of the biggest problems is represented by network constraints. In the last few years the SPQR team had issues with the communication between robots. The use of a point-to-point network protocol for exchanging packets has often generated problems, mainly caused by the non robustness to packets loss. In order to overcome these issues, we developed a communication system able to adapt itself to the external network conditions. Indeed, in this work we aimed at formalizing a coordination system, focusing on the problem on the connectivity among robots. We provide more stability to the coordination module, even under network unreliability, and contribute to enhance the coordination framework in critic scenarios.

6.3 Walk Engine

Until RoboCup 2014, our team used the walk engine provided by B-Human in their yearly code release without any significant modification. In the last year, we worked on a new version of this walking engine, still based on the 3D-Linear Inverted Pendulum model, using the previous walking engine as a starting point.

Machine learning techniques has been employed to dynamically adjust the gait so to improve the walking balance and prevent the robots from falling, ensuring a reliable high-speed locomotion. In fact, legged robots suffer an impact with the ground at heelstrike and lose energy as a result. In case of bipedal locomotion, it is important to notice that there is a trade-off between stability and walking speed. The more we want to increase the frequency of the walking cycle, the easier is to lose balance and fall. Our work aimed at improving the walking performances of a widely adopted biped robot platform in terms of speed and stability. These improvements give the ability to walk faster and on a wide variety of heterogeneous terrains, without falling or deviating from the desired path.

7 Other

In this section, we want to list other contributions and work done in the RoboCup scenario.

7.1 Reinforcement Learning

In RoboCup 2014 SPQR team participates to the Open Challenges introducing a reinforcement learning technique to improve the timing behavior for a goalkeeper robot. The goal was to increase the number of saved balls by optimizing its dive times. As any reinforcement learning formalization, the agent iteratively learns an optimal policy which maps every possible state in a consequent action and adjusts its training parameters evaluating the gained rewards. Our team implemented and compared two different learning algorithms: one based on policy gradient techniques and another one on genetic algorithms.

7.2 Multi-Agent Multiple Object Tracking

We devise a novel method, called *PTracking* [5], based on Distributed Multi-Clustered Particle Filtering. The algorithm is divided into two phases, namely a *local estimation* phase and a *global estimation* phase. Each sensor performs the local and global computation, sharing the obtained results in order to achieve a better representation of the current scene.

The novelty of the proposed approach is in the integration of the following three main features: (1) a new clustering technique that keeps track of a variable unknown number of objects ensuring a limited distribution in the space of the particles, (2) the approximation of the particle distribution as *Gaussian Mixture Models* (*GMM*) to improve robustness and reduce the network overload and (3) an asynchronous approach to improve the flexibility and the robustness of the entire system (e.g., robustness to communication failures, dead nodes and so on). Such an approach has been also presented in the *OpenChallenge* of RoboCup 2013 in Eindhoven.

References

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