SPQR RoboCup 2015
Standard Platform League
Team Description Paper

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1 Introduction

SPQR team[1] 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. Recently, our team won the first prize at the Iran Open 2013, the third prize at German Open 2013 and it succeed in passing the first elimination stage of RoboCup 2013 and 2014.

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.

This report describes the main achievements of the past years and research activities planned for the 2015 development.

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

2 Team Constitution and Robots

The SPQR is composed by two professors, two doctoral students and four master and undergraduate students. Currently, we own six robots: five NAOs V4.0 and one NAO V5.0.

3 Basic Abilities

3.1 Perception, Localization and Locomotion

Historically, SPQR developed a dynamic color segmentation method [2] that is able to provide robust and efficient color segmentation 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. The approach provides similar results with respect to complete image scanning, but it significantly reduces computation time. A benchmarking methodology for evaluating robotic soccer vision systems was also developed in [1]. We provided a public repository with data sets (with ground truth), algorithms and implementations that can be dynamically updated and a set of evaluation metrics, error functions and comparison results. Objects (ball, goal posts, field lines, and robots) were recognized through a combination of color and shape, using specific recognizers activated according to the game and player situation. For example, goal recognition and robot detection were disabled when the robot was tracking the ball and the ball was close to it, while ball recognition and tracking were disabled when the robot was static and it was looking for landmarks for localization. Since 2013, we are using another software architecture properly designed for the SPL league, the **B-Human** architecture [6]. This software easily communicates with the *low-level* of the robot allowing us to focus on our research topics.

3.2 Reinforcement learning

Goalkeeper dive handler - 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.

Approaches - The way a robot approaches the ball is of outmost importance during a game. In fact, a good positioning at the end of the approach-phase highly increases the chances of a more precise and powerful ball-kicking. Our goal for this year is to employ policy gradient techniques to improve the current ball-approach behavior and learn the best relative positioning of the robot with respect to the ball and the desired kick-angle.

3.3 Robot smart behavior generation

Since last year, we reshaped the behavior of each role in order to improve the effectiveness and robustness of our team playing strategies during SPL matches. Since RoboCup 2014 some major changes have been done: in the newest implementation each behavior strongly depends on the task the single robot has to accomplish on the field (e.g. support, score, defend, etc.) and the role assignment changes dynamically depending on the situation. In particular, thanks to the use of a new coordination module, we managed to make each behavior more flexible and efficient. Moreover, to further increase the effectiveness of our behaviors, we are trying to augment the internal knowledge of each robot regarding the environment and the overall status of the ongoing scenario.

4 Coordination module

One of the main focus of the SPQR is the development and the improvement of a new coordination system, the so-called *Context-Coordination system* [] . The key contribution of our approach consists in exploiting the rules governing the scenario and the combination of the robot actions and perceptions to enhance both single and collective behaviors. This method aims at "contextualizing" the environment in order to easily change over time the roles assigned to each robot and guide the entire team toward its goal. The contextualization module helps in avoiding inappropriate behaviors or actions that could be considered pointless in particular situations.
More specifically, our architecture includes two submodules: the *context* and the *coordination* system. The former influences the sets of roles and tasks according to the current context, and the latter, relying on utility estimations [3], keeps mapping the playing robots into the *context-aware* roles in order to improve efficiency.
Moreover, we are generalizing our definition of contextuality in other applications. For instance, we are exploiting the context-coordination developed within the RoboCup scenario in *multi-robot coordinated search and target localization.* The main idea is to deploy a coordinated team of robot to localize multiple targets (e.g. lost objects, control malfunction infrastructures, victim assessments) and to leverage the execution of the current robot tasks by exploiting any kind of information that can help the robots to specialize their search and to improve their performance.

5 Networking

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. Part of our efforts are focused on creating a more robust protocol that can adapt to the quality of the wireless network available. The new protocol must guarantee reliability while being able to discard *"untrustable"* packets and we want to make it as general as possible, so to be able to use it in different multi-robot environments.

6 Distributed Data Fusion

Distributed data fusion is the process that merges together multiple data and different perception of the same real-world provided from different agents. Eventually, the process will end up with a more accurate definition of the real-world model which will be used by the whole team of robot. This is exactly what we are trying to do, we developed a system capable to disambiguate the robot pose using the ball perception taken from all active robots by employing a state-of-the-art *particle filter tracker* [5]. This year, our intention is to improve and make our algorithm more stable involving in the disambiguation model also the position in the field of the teammates, i.e. robots sharing the same jersey color. In a regular match, it could happen that the pose of a robot is inverted or flipped. The algorithm, retrieving information from other robots, is able to correct the pose of the inverted player and redirect it toward the opponent goal.

7 Walk engine

In the past two years our team used the walk engine provided by B-Human in their yearly code release without any significant modification. This year, we are working 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. In particular, machine learning techniques will be employed to dynamically adjust the gait so to improve the walking balance and prevent the robots from falling, ensuring a reliable high-speed locomotion.

8 Software Architecture

During the development of many RoboCup teams (ranging from middle-size, to legged, rescue and @Home robots) we have gained a significant experience and developed a set of reusable modules. In the RoboCup2013 symposium our laboratory presented a substantially new project with the final aim to electronically refer an entire game among Nao robots. GNAO (Ground Truth Acquisition System for Nao Soccer Robots) [4] is an open source software for monitoring humanoid soccer robot behaviours aims at providing a simple and fast calibration set up, a foreground mask for each captured frame, a 3D information about each player on the field as well as the position of the ball, a multi-camera data fusion scheme and a set of the tracks representing the objects of interest. GNAO is conceived for registering ground truth data that can be used for evaluating and testing methods such as robot coordination and localization. The hardware architecture of the system is designed for using multiple low-cost visual sensors (four Kinects). The software includes a foreground computation module and a detection unit for both players and ball. A graphical user interface has been developed in order to facilitate the creation of a shared multi-camera plan view, in which the observations of players and ball are re-projected to perform the tracking task. This approach is robust to the presence of people on the field (e.g. referees), illumination changes, shadows, and unexpected noise in the background geometry (e.g. audience around the field).

References

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