SPQR SPL Team

Team Description Paper 2018

V. Suriani, T. Manoni, V. Di Giambattista, M. Cecchini, D.D. Bloisi, D. Nardi

Department of Computer, Control and Management Engineering "Antonio Ruberti"
Sapienza University of Rome
Via Ariosto 25, 00185 Rome, Italy

1 Team Information

- **Team name:** SPQR Team - Sapienza University of Rome (Italy)
- **website:** `http://spqr.diag.uniroma1.it`

SPQR is the group of the Department of Computer, Control, and Management Engineering "Antonio Ruberti" at Sapienza University of Rome (Italy). SPQR Team 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: Prof. Daniele Nardi served as Exec, Trustee, President of RoboCup Federation from 2012 to 2014 and was RoboCup Symposium co-chair in 2004; Prof. Luca Iocchi is Exec member of RoboCup@Home, Trustee and was RoboCup Symposium co-chair in 2008. SPQR team members published a total of 18 papers in RoboCup Symposia (including best paper awards in 2006 and 2015 [2]), in addition to many other publications about RoboCup-related activities on International Journals and Conferences in Artificial Intelligence and Robotics (including IROS RoboCup Best Paper Award in 2016 [4]).

1.1 Team Members

The team is composed by 11 people: 1 Full professor, 1 Associate professor, 1 Assistant professor and 8 master students (MS).

- **Supervisors**: Prof. Daniele Nardi (Team Leader), Prof. Luca Iocchi, Dr. Domenico Daniele Bloisi;
- **Members**: Vincenzo Suriani (Team Leader), Emanuele Antonioni (MS), Matteo Cecchini (MS), Tiziano Manoni (MS), Marco Paolelli (MS), Valerio Di Giambattista (MS), Jose Maria Salas (MS), Luca Di Giammarino (MS).

2 Main Contributions

Before 2013, SPQR used its own framework, called *OpenRDK*[1]. From 2013 onward, SPQR Team has chosen the *B-Human Team* framework as base for developing its code, adding its own modules about *perception, coordination, and decision making*. Furthermore, the behaviors are completely implemented by us. We want to acknowledge the B-Human team for their great contribution and work in the SPL league. In RoboCup 2018, SPQR Team will adopt the B-Human 2017 framework, modified in the features listed in our 2018 Qualification Report.

Perception. From 2017, SPQR Team is using as replacement of the B-Human Ball Perceptor a newly developed machine learning approach inspired by our deep learning work on NAOs [1]. This allows us to play outdoor without color and camera setting calibrations (see details in [5, 7]). We forked the B-Human 2016 repository adding our Ball Perceptor code (`https://github.com/SPQRTeam/SPQRBallPerceptor`). The main limitation of our approach was the computation amount required in the cascade phase. This lead us to a reshaping of the whole pipeline and we moved in a different color space in order to reduce the computation load. In the current implementation, we do all the image processing in the Y channel on the YCbCr and we optimize the search space in order to extract patches that have higher probability to contain objects of interest.

SPQR Team has its own modules for data fusion in replacement of the B-Human TeamBallLocator and the TeamPlayersLocator. In particular, our modules are based on the *P-Tracking* library [5] to achieve a distributed multi-robot object tracking.

Coordination. From RoboCup 2015, we have an algorithm that exploits the high level information about game situations to obtain a specific behavior in response of multiple environmental stimuli. The aim is to create a more effective way of perceiving the World. This coordination module models the context features of a specific environment, such as RoboCup, and integrates different coordination techniques for a team of robots. More in detail, our approach relies upon two well-known methods for coordinating a team of robots: distributed task assignment and distributed world modeling, by combining the robustness of them. This work achieved the IROS RoboCup Best Paper Award in 2016 [4].

To use our coordination in a real playing scenario, we have developed a tool for testing the network communication in presence of a large number of packets, which can create delays in the coordination. This tools has been used to develop our own adaptive networking module, which is in addition to the B-Human networking infrastructure. Our communication system can adapt to the external network conditions and can provide more stability to the coordination module, even under network unreliability. This enhances the coordination process in high

[1] `http://openrdk.sourceforge.net/`

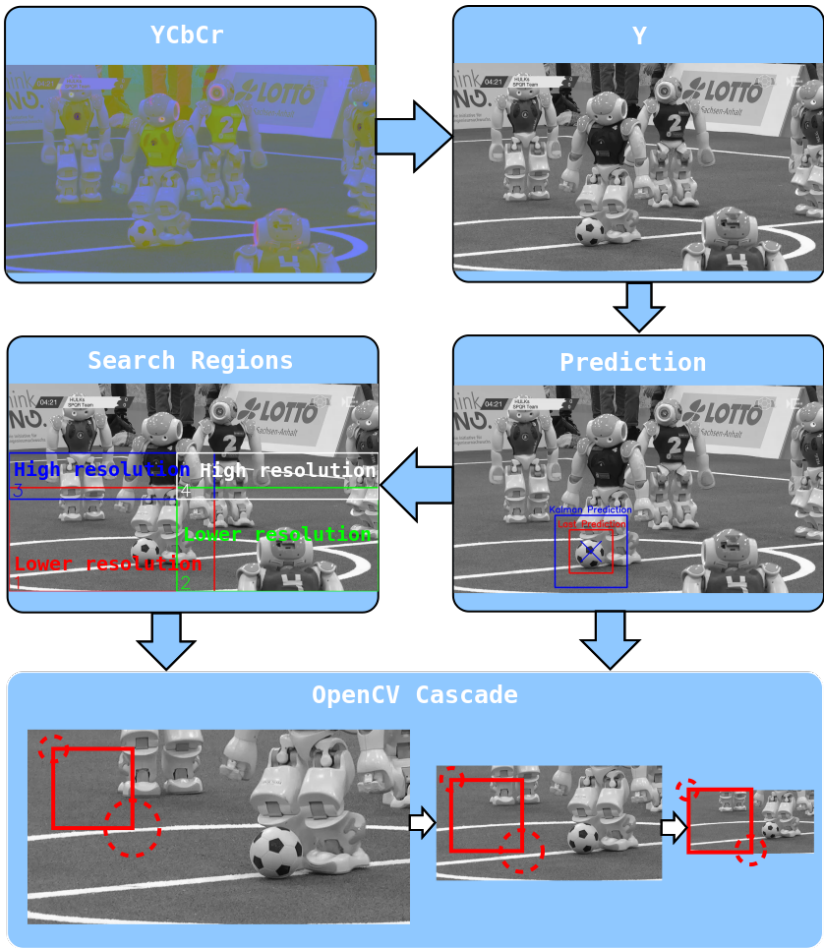

Figure 1: From a YCbCr we extract only the Y component. From the Y channel, we create our regions of interest based on Kalman predictions and global and local ball positions. For the chosen regions, we compute the min and max ball diameter. With this information and this regions of interest we run the Cascade Classifier.

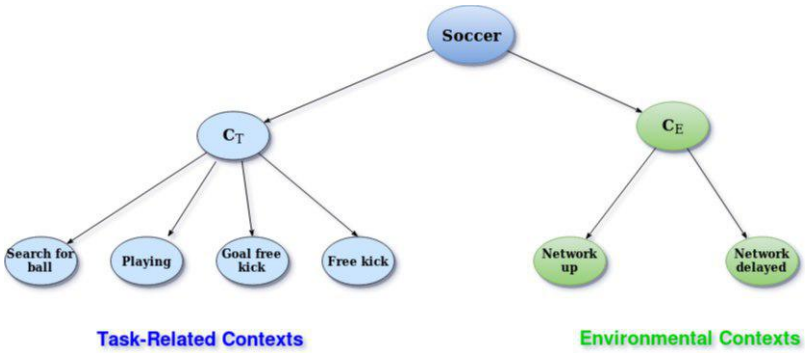

Figure 2: SPQR Coordination contexts for RoboCup 2018.

network traffic conditions. The details about our networking pipeline can be found in [4, 8]. To validate our approach, we have developed a tool to influence the network reliability during regular matches in the SimRobot simulator. This year, we modified the network modules provided by B-Human 2017 code (i.e., TeamData and TeamMessageHandler) and we extended the TCM in order to plot additional debugging information. To adapt the actual coordination to the new rules, we extended the contexts to incorporate also new game situations, such as the free kicks, the goal free kicks and the foul. The new contexts perfectly fit the architecture already built and allow to choose properly the coordination strategy in each game context.

Particular attention has been paid to the matters of defining the best strategies in peculiar playing phase that this year are allowed from the rule book.

Non-deterministic Decision Making. In 2016, we presented a method based on a combination of Monte Carlo search and data aggregation (MCSDA) [3] to adapt discrete-action soccer policies for a defender robot to the strategy of the opponent team. By exploiting a simple representation of the domain, a supervised learning algorithm is trained over an initial collection of data consisting of several simulations of human expert policies. Monte Carlo policy rollouts are then generated and aggregated to previous data to improve the learned policy over multiple epochs and games. For RoboCup 2018, we worked on these procedures to learn collective team strategies with MCSDA.

SPQR Nao Image Dataset. As mentioned in Section 2, SPQR Team has adopted its own ball perceptor for detecting the realistic black and white ball currently in use in the RoboCup SPL. The detector is based on a supervised approach and it is compatible with the B-Human framework. It consists of an LBP based cascade classifier trained on real images from the *SPQR Team NAO Image Data set*. The SPQR Ball Perceptor can be used not only for ball detection, but it is possible to extend the classifier also to different tasks; e.g., teammate recognition, field lines, landmarks detection. Our approach is a

robust starting point for the implementation of high-level functions to be used in the future outdoors competitions, where external light changes can strongly affect the recognition tasks.

In Robocup Symposium 2016, we presented [1] a novel approach for object detection and classification based on Convolutional Neural Networks (CNN)[1]. Quantitative experiments have been conducted on a dataset of annotated images captured in real conditions from NAO robots in action. The used dataset was made available for the community. It can be downloaded at `http://www.dis.uniroma1.it/~labrococo/?q=node/459`.

Impact in University/Community. Our University, and in particular our Department, strongly supports our work in RoboCup competitions, which are an excellent testbed for validating our research results. We are the only laboratory in our Department that tries to address problems such as multi-robot coordination, and robot learning. This year we carried out a tournament in our lab involving the AI course students to test strategies and to find the most suitable one for the RoboCup scenario. Moreover, the Petri Net Plans (PNP) framework has become our standard tool for robot behavior design and formalization, after to the work done in RoboCup experience. In the last two years, we started exploiting our knowledge on vision and dynamic walking engine to better govern the NAO platform and deploy NAO robots in other applications.

We promoting the research in AI and Robotics through several types of media channel to disseminate our research results. In order to pursue this goal, we have a YouTube Channel[2] and a Facebook Page[3] rich in contents about RoboCup. We reached more than 11,000 visualizations with a video on our YouTube channel showing our RoboCup 2016 highlights. The video has been transmitted by two Japanese National TVs (Nippon TV and Fuji Television Network). This effort is pursued also by participating in Italian Tv shows ("I Fatti Vostri", "Laudato sii' ", "Tg2 insieme") and in relevant exhibitions that take place in Italy (IAB Forum, Wired Next Fest, Blue Fest, Unirete, RomeCup, MakerFaire).

References

[1] D. Albani, A. Youssef, V. Suriani, D. Nardi, D. D. Bloisi. A Deep Learning Approach for Object Recognition with NAO Soccer Robots. RoboCup 2016: Robot World Cup XX - pages 392-403

[2] G. Gemignani, M. Veloso, D. Nardi. Language-based sensing descriptors for robot object grounding. 19th Annual RoboCup International Symposium, 2015. *Science Best Paper Award*.

[3] F. Riccio, R. Capobianco, D. Nardi. Using Monte Carlo Search With Data Aggregation to Improve Robot Soccer Policies. Proceedings of the 20th International RoboCup Symposium, 2016.

[2] `https://www.youtube.com/channel/UCRboLHM75uGB4TQH7s1APUg`
[3] `https://it-it.facebook.com/SPQRTeam`

[4] F. Riccio, E. Borzi, G. Gemignani, and D. Nardi. Multi-Robot Search for a Moving Target: Integrating World Modeling, Task Assignment and Context, 2016. International Conference on Intelligent Robots and Systems (IROS'16). *IROS-RoboCup Best Paper Award*.

[5] D. D. Bloisi, F. Del Duchetto, T. Manoni, V. Suriani. Machine Learning for RealisticBall Detection in RoboCup SPL. arXiv:1707.03628

[6] F. Previtali, D. D. Bloisi, L. Iocchi. A distributed approach for real-time multi-camera multiple object tracking - Machine Vision and Applications, pages 1-10, 2017.

[7] F. Previtali and G. Gemignani and L. Iocchi and D. Nardi. Disambiguating Localization Symmetry through a Multi-Clustered Particle Filtering, 2015, IEEE International Conference on Multisensor Fusion and Integration for Intelligent Systems, pages 283-288.

[8] E. Borzi. Multi-robot coordination under unreliable network conditions. 2015, Master thesis.