# UChile Robotics Team
# Team Description for RoboCup 2015

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**Abstract.** This Team Description Paper describes the organization, publications, and new developments of the UChile Robotics Team for the RoboCup Standard Platform League 2015 in Hefei, China. For this year, we have presented 4 publications related to general and robot soccer-specific domains, as well as we have improved several characteristics of our software framework, in order to accomplish similar results to 2014. Also, we committed to participate in the main competition, drop-in player competition and technical challenges.

**Keywords:** RoboCup, SPL, Standard Platform League, 2015, Universidad de Chile

## 1 Introduction

UChile Robotics Team (UChileRT) is joint effort of the Advanced Mining Technology Center (AMTC) and the Department of Electrical Engineering of the Universidad de Chile in order to foster research in mobile robotics, computer vision and learning algorithms.

Our team was created in 2002 under the name UChile1, and we participated in the four-legged Standard Platform League since 2003. In 2007 we changed our name to UChile Kiltros, and in 2010 we collaborate with the SPQR Italian team. After the unsatisfactory results obtained in 2012 we carried out a restructuring process, where several changes and improvements have been implemented until now. As a result, we were within the top twelve teams in RoboCup 2013 (The Netherlands), and we reached the fourth place in RoboCup 2014 (Brazil). For RoboCup 2015 we have developed several changes according to the rule changes and the technical challenges. In addition, several improvements have been developed in both robot algorithms and strategy so as to maintain the results obtained the last years.

This paper is organized as follows: First, we present the team structure and members (Subsec. 1.1). Then, we introduce the main publications presented and accepted for the RoboCup Symposium 2015 related with the team activities (Sec. 3), followed by the developments and changes for 2015 (Sec. 4). Finally, in Sec. 5, we also acquaint the current research lines guided by the doctoral and master thesis projects of some members.

### 1.1 Team Members

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|---|---|
| **Team Leader:** | Prof. Dr. Javier Ruíz-del-Solar |
| **Team Captain:** | M.Sc. José Miguel Yáñez (PhD Student) |
| **Doctorate Students:** | Leonardo Leottau, Carlos Celemin |
| **Master Students:** | Pablo Cano, Matías Mattamala |
| **Undergraduate Students:** | Pablo Saavedra, Constanza Villegas, Kenzo Lobos, Gabriel Azócar, Nicolás Cruz |

## 2 Past Relevant Work and Scientific Publications

UChileRT has been involved in RoboCup competitions since 2003 in different leagues: Four-legged 2003-2007, @Home in 2007-2012, Humanoid in 2007-2009, and Standard Platform League (SPL) in 2008-2012. UChile's team members have served RoboCup organization in many ways: Javier Ruiz-del-Solar was the organizing chair of the Four-Legged competition in 2007, TC member of the Four-Legged league in 2007, TC member of the @Home league in 2009, Exec Member of the @Home league since 2009, and co-chair for the RoboCup 2010 Symposium. Among the main scientific achievements of the group are the obtaining of three important RoboCup awards: RoboCup 2004 Engineering Challenge Award, RoboCup 2007 and 2008 @Home Innovation Award. UChile's team members have published a total of 34 papers in RoboCup Symposium (see Table 1), 24 of them directly related with robotic soccer, in addition to many papers in international journals and conferences.

**Table 1.** Presented papers in the Robocup Symposium by year

| RoboCup Articles | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Oral | 1 | 2 | 1 | 1 | 2 | 3 | 2 | 2 | - | - | 1 | 1 | 1 |
| Poster | 1 | 1 | 1 | - | 3 | 2 | - | - | 2 | 1 | 2 | 1 | 4 |

## 3 Publications since RoboCup 2014

**Interactive Learning.** In [6], it is proposed COACH (COrrective Advice Communicated by Humans), an interactive learning framework that allows non-expert humans to shape a policy through corrective advice, using a binary signal in the action domain of the robot/agent. One of the most innovative features of COACH, is a mechanism for adaptively adjusting the amount of human feedback that a given action receives, taking into consideration past feedback. The performance of COACH is compared with other Interactive Machine Learning algorithms and an autonomous Reinforcement Learning agent in two learning problems: ball dribbling and Cart-Pole balancing. COACH outperforms the other learning frameworks in the reported experiments. Results show that COACH is able to transfer successfully human knowledge to agents with continuous actions.

**Layered Learning.** Layered learning is a hierarchical machine learning paradigm where a complex behavior is learned from a series of incrementally trained subtasks. We presented a publication [11] which describes how layered learning can be applied to design individual behaviors in the context of soccer robotics. Three different layered learning strategies are implemented and analyzed using a ball-dribbling behavior as a case study. Experimental results validate the usefulness of the implemented layered learning strategies showing a trade-off between performance and learning speed.

**White Goal Detection.** The main goal of this paper [5] is to present a simple, but robust algorithm for detecting white goals in the context of the RoboCup SPL (Standard Platform League). White goals will be used for the first time in the SPL competitions in 2015. The main features of the algorithm are a robust search strategy for detecting the goal posts, and the use of the Y channel image, instead of the color segments, for determining and characterizing the goal posts and the horizontal crossbar. This last aspect is crucial for detecting a white goal placed in a white background. The algorithm is validated in the real world (real robot in a SPL field), showing its ability to detect the while goals even when they are observed in a white background; please see our qualification video [20].

**Active Vision.** We presented an efficient active vision system[15] which separates static information obtained offline from the map, and dynamic information from mobile objects, such as the ball and other players. Both types of information are mapped and handled in a simplified structure called *action space*, which assigns scores to each possible action of the robot's head; scores also consider the movement constraints of the robot's head. The system is able to run in real-time, requiring less than 1 ms. Results shown several improvements compared to a passive vision system.

# 4 Developments and Changes for RoboCup 2015

## 4.1 Vision

Regarding vision, several changes have been developed according to the rule changes for this year. In Section 3 we already presented a solution for the white goals rule. On the other hand, given that it is expected that realistic balls will be adopted in the near future and the SPL already issued a challenge concerning about the detection of realistic balls [7]. We developed a new ball perceptor in order to solve this problem. Whereas the old ball perceptor used the detection of an orange region and then checked for changes in the gradient of color, the new ball perceptor accepts all non green regions as possible ball regions. These regions are analyzed in order to check circularity conditions and obtain the pose estimation on field. This new perceptor was checked using different color balls and patterns, obtaining satisfactory results.

Since the SPL has also included a rule about changing lightning conditions, we formulated a semi-automatic color calibration system able to adapt in real-time. We used the hand-calibrated color table, which is updated using the prior information from the known objects.

## 4.2 World Modeling

The robot self-localization is estimated by using an Unscented Particle Filter method [21], which corresponds to a common particle filter but where each particle is an Unscented Kalman Filter (UKF). In addition, following the previous work we presented in the Open Challenge the last year [23] that consisted of a localization dis-ambiguity solution based on histograms, we are improving this approach by using fast local descriptors (Sec. 5), such as [12], and [18].

## 4.3 Decision Making

According to the new changes in world modeling and obstacle detection, we have improved and corrected the behaviors and strategies used in RoboCup 2014. In addition, we committed to participate in the Corner Kicks Challenge [7], so we have developed an strategy to solve this challenge as well.

## 4.4 Motion

Motivated by the Many Carpets Challenge [7], and following the work explained in Sec. 5, we have improved our robot gait in order to solve the challenge requirements as well as to enhance stability during the games.

We are also developing an automatic joint calibration based on [9], which uses a checkerboard attached to the NAO's feet. We already finished the first steps related with corner detection and transformation estimation as well as implemented some further routines.

### 4.5 Software Architecture

We updated the old core to support C++11, following the changes included in the BHuman Code Release 2014 [16], as well as to be compatible with the new versions of OpenCV.

## 5 Current Research Lines

**Reinforcement Learning** This line of work is part of the doctoral thesis of one of the team members. It is proposed to generate a methodology for implementing a decision making system, defining a state space according to specific game configurations, taking into account positions and probable team actions, and training recurrent and relevant game situations.

This work includes three main stages: *i)* the implementation or learning of tasks such as dribbling, intercepting the ball, kicking, going to strategic positions, and other similar basic behaviors; *ii)* the identification of specific game settings, and recurrent and relevant playing situations; *iii)* the reinforcement learning of high level behaviors based on a state-space transformation according to an specific game setting.

**Interactive Machine Learning** This line of work is part of the doctoral thesis of one of the team members. It is proposed to develop strategies for maximizing the information subtracted from the human feedback signals, in frameworks of Interactive Machine Learning wherein a person works as a teacher. It could be in paradigms either of Learning from Demonstrations (LfD) [3][2], in which the feedback is in the actions domain, or of IRL [10][22], in which the human feedback is in the evaluative domain. Some soccer robotics problems are being part of the sets of tested problems for evaluating all the proposals.

**Humanoid biped gait** This line of work is also part of the doctoral thesis of one of the team members. It is proposed to develop a methodology for designing a humanoid biped gait based on Dynamic Movement Primitives (DMP)[8, 19], developing a robust walking adaptive to some physical robot conditions (gear wear, encoders offsets, etc.). The trajectory generation are performed by using DMP instead of analytical models based on inverted pendulum or ZMP, trying to minimize its extensive required parametrization. The base leg trajectories are learned by imitation from other already implemented gaits and optimized with reinforcement learning. Because this initial knowledge taken from imitation, it is possible to reduce the number of epochs. So, it is able to implement reinforcement learning process in a real robot maximizing exploitation over exploration.

**Self-localization supported by natural landmarks** This line of research is part of a starting master thesis, motivated by several changes included into the SPL rules, such as goals of the same color and white goals. That changes require a robust self-localization system which leaves out the frequently used landmarks (goals, corners, center circle). At present, it has been researched several methods of feature extraction and description, such as FAST[17], ORB[18], BRISK[12] and KAZE[1] in addition to widely known SIFT [13] and SURF[4]. Furthermore, we have an implementation of FAST running in real time (faster than 30Hz), enhanced with memory-oriented optimizations. Next works will focus on other extraction methods on the NAO, such as BRISK [14], and a visual-SLAM implementation.

## Acknowledgments

This research is partially supported by Fondecyt project 1130153.

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