UChile Robotics Team

Standard Platform League Qualification Document - RoboCup 2018

1 Statement of Commitment to Participate in the RoboCup 2018 SPL

UChile Robotics Team has participated continuously in the RoboCup soccer competitions since 2003. With this document we state our intention to participate in the Standard Platform League 2018, assuming the compromise and responsibilities implied.

2 Team Information

Team Name:	UChile Robotics Team
Team Leader:	Prof. Dr. Javier Ruiz-del-Solar
Team Captain:	Gabriel Azócar
Master Students:	Nicolás Cruz, Rodrigo Pérez, Francisco Leiva
Undergraduate Students:	Gabriel Azócar, Ignacio Bugueño, Nicolás Aguilar
Affiliation:	Advanced Mining Technology Center (AMTC), Department of Electrical Engineering, University of Chile, Av. Tupper 2007, Santiago, Chile. uchilert@amtc.uchile.cl, `http://uchilert.amtc.cl`
Presentation Video:	`https://youtu.be/1I9q7b26swU`

3 Mixed Team

Due to the difficulties regarding the geographical location of our team and the number of current members, we will not participate in the mixed teams competition this year. Instead, we only commit to participate in the main competition for this RoboCup 2018.

4 Code Usage

Since 2013 we have used the BHuman[1] Code Release as the core library for our developments as a replacement of our deprecated self-developed library used for AIBO. This year we will use the BHuman 2017 Code Release[11] and we ported all our work from previous RoboCups into this release. We do not plan to use any other team's code. Starting from the BHuman framework, we have made several developments, some of which have been published, and we are pursuing new advances for this year.

4.1 Past Developments

Here we present the main projects we have developed since we adopted the BHuman framework. A complete history of recent related publications and contributions can be found in Section 6.

4.1.1 New Ball Model

The new ball featured for the RoboCups 2016 and 2017 possesses a non uniform mass distribution. This makes the prediction of the ball position and velocity much more difficult since the ball does not follow a straight line path. Considering this challenge a new ball model was developed to correctly predict the ball state. The new ball model is a diffuse interactive multiple model Kalman filter (IMMKF), where each model represents a different deceleration along the x-axis (parallel to ball velocity) and an acceleration along the y-axis (perpendicular to the ball velocity). Each model is weighted according to the Kalman filter innovation and finally the states are combined into a single prediction according to their weight. This allows us to predict curved ball trajectories.

4.1.2 Adaptive Color Segmentation

Last year we developed an adaptive color segmentation based vision system. Color segmentation is used since the computational sources available are scarce, and this approach has been widely used in the RoboCup SPL with great results. Since the SPL is moving towards a non-controlled environment and this approach fails against changing illuminations conditions due to the segmentation parameters being fixed, classic color segmentation alone is not enough. To address this issue several approaches have been reported, but our work is similar to the one published by HTWK [5], in which an YCbCr color cube is estimated using statistical information of the image. We proposed several improvements to overcome the problems of the HTWK approach, so as to segment in the HSV color space as well as two additional steps to detect the field and to filter the segmentation.

4.1.3 Automatic Camera Settings

In order to achieve robust and efficient artificial vision systems, dealing with changing lighting conditions is fundamental. In general, since solving this problem is expensive by software, we follow a similar approach to other SPL teams, by setting the hardware parameters online. We developed a real-time controller to automatically set the camera parameters such as gain exposure and white balance, that allowed us to overcome variable lighting.

4.1.4 Machine Learning-based Vision System

Pure machine learning-based vision systems are usually complex and due to the hardware constraints of the NAO, achieving real-time processing has been difficult if not impossible. We proposed an hybrid vision system, which uses color segmentation to detect objects proposals, and then performs a precise classification over the proposals based on efficient deep nets such as X-NOR nets or SqueezeNets [3].

4.2 Current Developments

Several works are being developed for this competition. Most of them are based on active vision and machine learning algorithms, inspired by the success of our previous contributions related to these fields [2, 3, 8].

4.2.1 Machine Learning-based Vision System robot detector

The introduction of new lighting conditions (varying illumination in particular) has proven to be very challenging to the standard color segmentation algorithms used by the team. Indeed, these algorithms tend to fail under unexpected lighting conditions. To solve these problems a convolutional neural network-based robot detector that is able to run in real-time in a NAO robot has been developed. A proposal is generated using classical color-based algorithms which are then fed to the neural network. The network is able to process a robot proposal in ~ 0.65 ms and achieves a detection rate of $\sim 98\%$, eliminating most of the false positives generated by the region proposal algorithm. These in turn results in an improved world modeling since false obstacles are accurately discarded. This work was proposed by our team in [3] and won the Best Paper Award for Engineering Contribution in 2017.

4.2.2 Machine Learning-based Vision System Ball Perceptor

We are developing a mixed vision system for realistic ball detection, which performs a proposal generation for balls on gray scaled images, and then uses a convolutional neural network (based on [3]) to classify them. This perceptor achieves a very high hit-rate and precision, while being able to run in real-time on the NAO. A paper explaining these developments will be submitted to the RoboCup Symposium 2018.

4.2.3 Generalized, Frequency Independent Whistle Detector

A new robust whistle detector was developed, which processes audio data from the robot sensors using a statistical classifier. Using this approach combined with a voting system, the robot team can detect the signal to start the game with an extremely low false positive rate, even in environments with high noise levels.

4.2.4 Interactive Dribbling Training in Real World Environments

Recent changes in the robots environment and actuation have increased the reality gap between simulated and real world physics. In consequence, a dribbling mechanism with a good performance in the simulator does not translate to a good operation on the real field. To tackle this shortcoming, an interface for fine-tuning the dribbling mechanism in the synthetic grass field using COACH [2] has been created. With this, it is possible for a human trainer to give feedback to the robot using a remote control while it dribbles in the real field, correcting the errors that result from the training in the simulator.

4.2.5 Search Ball using Active Vision

We developed a new behavior to search the ball using active vision. The method initially conducts a search in the regions where the ball is most likely to be, for example in the position predicted by the ball model or around the feet of the robot that had the ball before it was lost. If the initial search does not return any positive result, then a new search process is undertaken by using all the field players. Together, the robots maximize the field coverage by exploring the field in a coordinate manner, thus minimizing the time needed to find the ball.

4.2.6 Ball Confidence Interval

Last year we developed a fuzzy based ball model. However, while this model was able to predict the complex trajectory of the ball to a certain extent, more information regarding the uncertainty of the prediction was needed. To account for this, prediction intervals have been developed by taking the acceleration as a fuzzy parameter and integrating this uncertainty in the fuzzy model. This results in an upper and lower estimation of the position of the ball that represents the range in which the ball is expected to be, with a certain probability. The information obtained from this process is later used in our behavior system.

4.2.7 Robot Orientation Detection

Based on [10], we are developing an improved Vision-Based Orientation Detection, for SPL League. Analyzing the lower silhouette of each robot (using the NAO cameras), we estimate and elaborate orientation lines. Incorrect line estimations are discarded using RANSAC. In order to determine the class of each line, a line classifier is implemented, based on convolutional neural networks [3], which is able to classify the orientation lines into four classes (right, left, front, back) in real-time. Then, a projection is made from visual space to three-dimensional space, to estimate the orientation angle associated with the opponent robots.

5 Past History

Subject to the funds available to the team, we intent to participate in the U.S. Open competition. In Table 1 the results from the RoboCup competitions of the last 4 years are shown.

RoboCup 2014	
First Round Robin	
BHuman - UChile	7:0
Berlin United - UChile	2:1
RoboCanes - UChile	2:2
Philosopher - UChile	0:2
PlayIn Round	
UPennalizers - UChile	0:4
Quarter Finals	
NaoDevils - UChile	1[1]:1[4]
Semi Finals	
Nao Team HTWK - UChile	5:4
3rd Place	
BHuman - UChile	7:0
Tournament position	4/20

RoboCup 2015	
First Round Robin	
Northern Bites - UChile	0:4
Cerberus - UChile	0:3
SPQR - UChile	1:4
Nao Devils - UChile	1:3
Quarter Finals	
UT Austin Villa - UChile	0:2
Semi Finals	
UNSW Australia - UChile	6:1
3rd Place	
Nao-Team HTWK - UChile	3:1
Tournament position	4/20

RoboCup 2016	
First Round Robin	
UChile - HULKs	1:2
UChile - UPennalizers	2:0
UChile - Bembelbots	5:0
Second Round Robin	
UChile - SPQR Team	4:1
UChile - MRL-SPL	5:0
UChile - Berlin United - Nao	3:0
Quarter Finals	
UChile - Nao Devils	1[3]:1[2]
Semifinals	
UChile - B-Human	1:6
Third Place	
UChile - Nao-Team HTWK	1:4
Tournament position	4/24

RoboCup 2017	
First Round Robin	
UChile - Nao Devils	0:7
UChile - UNSW Sydney	0:2
Play-In Round	
UChile - JoiTech	4:0
Second Round Robin	
UChile - B-Human	0:7
UChile - HULKs	0:6
Tournament position	12/24

Table 1: RoboCup results since 2014. Penalty results are shown inside brackets.

6 Impact

At present, we are the only South American team that has participated every year in the SPL in both main and challenge competitions since 2003. After being able to position ourselves within the top four teams of the league in 2014, 2015 and 2016, our performance decreased sharply in the 2017 competition. This was the consequence of several factors, mainly the replacement of the field's which severely hindered the walk stability of our NAOs and the renewal of the members of our team. We are currently working hard to achieve better results.

Our participation in the RoboCup is an acclaimed activity by our University and the Chilean media. Last participations have been widely covered by press and television, giving us the chance to present our work in several ways. Some of the most remarkable media appearances of our team are interviews in the main national newspapers and television. Our team has also participated in all versions of the "Congreso del Futuro" the most important science fair in Chile as well as most versions of the "Robotics Week", a fair made each year in order to spread knowledge about robotics to the general public. Another one of the team's contributions in this area consists on regular presentations to school children in our laboratory as well as traveling to schools throughout the country.

UChileRT has been involved in RoboCup competitions since 2003 in different leagues: Four-legged 2003-2007, @Home in 2007-2017, Humanoid in 2007-2009, and Standard Platform League (SPL) in 2008-2015. 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, Executive 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 five important RoboCup awards: RoboCup 2004 Engineering Challenge Award, RoboCup 2007 and 2008 @Home Innovation Award, Best Science Paper Award in RoboCup 2015 [2] and the Best Paper Award for Engineering Contribution in 2017 [3]. UChile's team members have published a total of 42 papers in RoboCup Symposiua (see Table 2), 31 of them directly related with robotic soccer, in addition to many papers in international journals and conferences. A brief summary of our publications and past relevant work is listed below.

Table 2: Presented papers in the RoboCup Symposia by year, since 2004

Articles	2003 - 2010	2011	2012	2013	2014	2015	2016	2017
Oral	14	-	-	1	1	1	-	2
Poster	8	2	1	2	1	4	2	3

6.1 Open Source Contribution

Tutorial - ROS Cross-Compiling and Installation for the NAO V4: UChileRT has uploaded to the ROS community, a detailed tutorial to build, install and run ROS natively onto the NAO V4 [7]. To the best on our knowledge, this was the first tutorial that provides a step-by-step guide to build, install and run ROS embedded onto the Atom CPU of the latest NAO V4 robot.

ROS Node - Motion Module: Currently, UChile Robotics Team is using the B-Human walking and motion engine [4]. That motion module has been isolated, integrated as a ROS node, and shared as open source code. It is described in [6].

New Ball Perceptor: The ball was updated for the the RoboCup 2016, as such, the team had to update the ball perceptor to comply with the needs. UChileRT has uploaded a repository with the used code[12], along a wiki document that contains useful information about the algorithm and usage.

NAO Backpack: We developed a novel open-source add-on for the NAO that allows us to prototype new algorithms and solutions in a portable way. The backpack increases the computational capabilities of the robot by using an ODROID XU4 as main platform. We provide the specifications to build the hardware, as well as the accompanying software in GitHub [9].

References

[1] B-Human Team. B-Human Official Web. http://www.b-human.de.

[2] Carlos Celemin and Javier Ruiz-del Solar. Interactive Learning of Continuous Actions from Corrective Advice Communicated by Humans. volume 9513, pages 16–27, 2015. Best Scientific Paper Award.

[3] Nicolás Cruz, Kenzo Lobos-Tsunekawa, and Javier Ruiz-del Solar. Using Convolutional Neural Networks in Robots with Limited Computational Resources : Detecting NAO Robots while Playing Soccer. In *RoboCup 2017: Robot World Cup XXI Lecture Notes in Computer Science*. Springer.

[4] Colin Graf and Thomas Röfer. A Center of Mass Observing 3D-LIPM Gait for the RoboCup Standard Platform League Humanoid. In Thomas Röfer, N.Michael Mayer, Jesus Savage, and Uluc Saranl, editors, *RoboCup 2011: Robot Soccer World Cup XV*, volume 7416 of *Lecture Notes in Computer Science*, pages 102–113. Springer Berlin Heidelberg, 2012.

[5] Nao-Team HTWK. https://github.com/NaoHTWK/HTWKVision.

[6] David L. Leottau, Jose M. Yáñez, and Javier Ruiz-del Solar. Integration of the ROS Framework in Soccer Robotics: the NAO Case. In Ven Behnke, Manuela Veloso, Arnoud Visser, and Rong Xiong, editors, *Lect. Notes Comput. Sci. Vol. 8371, 2014 Rob. 2013 Robot World Cup XVII*, pages 664–671. Springer-Verlag Berlin Heidelberg, Eindhoven, The Netherlands, 2014.

[7] Leonardo Leottau. ROS Fuerte Cross-Compiling and Installation for the NAO V4. http://wiki.ros.org/nao/Tutorials/Cross-Compiling_NAO-V4, 2012.

[8] Matías Mattamala, Constanza Villegas, José Miguel Yánez, Pablo Cano, and Javier Ruiz-del Solar. A Dynamic and Efficient Active Vision System for Humanoid Soccer Robots. In *RoboCup Symposium 2015*, Hefei, China, 2015.

[9] Olave Gonzalo González Clayder Hasbún Nicolás Mattamala, Matías and Javier Ruiz-del Solar. The NAO Backpack: An Open-hardware Add-on for Fast Software Development with the NAO Robot. 2017. Available online: https://github.com/uchile-robotics/nao-backpack.

[10] A. Muhlenbrock and T. Laue. Vision-based Orientation Detection of Humanoid Soccer Robots. In *RoboCup 2017: Robot World Cup XXI Lecture Notes in Computer Science*. Springer.

[11] Thomas Röfer, Tim Laue, Yannick Bülter, Daniel Krause, Jonas Kuball, Andre Mühlenbrock, Bernd Poppinga, Markus Prinzler, Lukas Post, Enno Roehrig, René Schröder, and Felix Thielke. B-Human Team Report and Code Release 2017, 2017. Only available online: http://www.b-human.de/downloads/publications/2017/coderelease2017.pdf.

[12] UChile Robotics Team, 2016. Available online: https://github.com/uchile-robotics/nao-ball-perceptor-2016.