Team Mexico RoboCup 2014 Humanoid KidSize Team Description Paper

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Abstract. We describe the *RoboCup KidSize* humanoid robots to be used by *Team Mexico* in the *RoboCup 2014* competition to be held in João Pessoa, Brazil. For this edition of the competition *Team Mexico* is integrated by three institutions: *ITESM*, *ULSA* and *UNAM*. We present *five* different robot architectures: Bogobot V2, Cyberlords T2, Cyberlords T3, *DARwIn-OP* and *NimbRo-OP*. The focus of this paper is on a proposed standard for humanoid robot collaboration on the *RoboCup* field. This standard is outlined in three parts: (1) the high-level state machines that define the basic roles for the robots, (2) the higher-level state machine that allows each robot to choose its role depending on the status of the game, and (3) the data packets required for the robots to exchange information and play collaboratively.

1 Introduction

Team Mexico is a multi-institutional initiative represented this year by *Instituto Tecnológico y de Estudios Superiores de Monterrey* (ITESM), *Universidad La Salle* (ULSA), and *Universidad Nacional Autónoma de México* (UNAM). Each of these institutions have previously competed in the *Humanoid KidSize League* of the *RoboCup World Championship* under the names of *Bogobots*, *Cyberlords La Salle* and *Pumas UNAM*, respectively. Several other institutions have expressed their interest in this initiative and may join for the next edition of *RoboCup*, among them: INAOE, ITAM, and UPAEP, the second one with experience in the *SPL* and *SSL* leagues, the other two with experience in the *@home* league.

The three institutions representing *Team Mexico* for this edition of *RoboCup* have a history of participation in the *Humanoid KidSize League* that dates back to 2008, both at the local and international levels.

Team *Bogobots* participated for the first time in the *Humanoid KidSize League* in *RoboCup 2008* in Suzhou, China [1–4], although they had previous international experience in the *RoboCup* four-legged league with Sony Aibo robots since 2002. In *RoboCup 2009* in Graz, team *Bogobots* reached the quarterfinals. They were runner-ups during the *RoboCup Mexican Open* in 2009 losing the final against *Darmstadt Dribblers*, and then went on to become mexican champions in the 2011 edition of the *RoboCup Mexican Open*. They were also runner-ups at the 2012 and 2013 editions of the *RoboCup Mexican Open*. Their research has been focused on humanoid robot locomotion, computational vision and localization [5–9].

Team *Pumas UNAM* had their debut in the *Humanoid League* in *RoboCup 2008* [10, 11]. They imported their accumulated experience from the *@home* league, where they participated in *RoboCup 2006* for the first time, and have continued to do so ever since. They were runner-ups at the 2008 and 2011 editions of the *RoboCup Mexican Open*. Their research in humanoid robots is tightly linked to that of their service robots in the *@home* league [10–12].

Team *Cyberlords La Salle* debuted at the *First RoboCup Mexican Open* in September 2008. Since 2009, the team has taken part in all editions of the *RoboCup World Championship* [13–17], and three *RoboCup Latin American Opens*. Team *Cyberlords La Salle* took the championship at the *RoboCup Mexican Open* in 2008 and 2012, and at the *RoboCup Latin American Open* in 2010 and 2011. Their research has been concentrated on software architectures for mobile robots with heterogeneous architectures, localization and computational vision [17–20].

Fig. 1. *Bogobots* and *Cyberlords La Salle* playing at the *RoboCup Mexican Open* 2012

2 Architectures

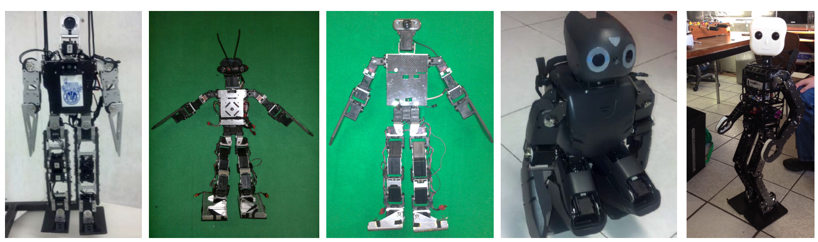
Team Mexico will compete at the *RoboCup World Championship* in 2014 with five different hardware architectures, all of which are depicted in Figure 2. Each of these architectures is briefly described in the following paragraphs. Further details can be found on the *Specification Sheets* submitted by *Team Mexico* for the competition.

Bogobot V2: Mechanically designed and built by the *Robotics and Intelligent Machines* research group at *ITESM*. It is based on Dynamixel RX-28 and RX-24F servomotors, for a total of 18 DOF. It features a FitPC2 embedded computer. Two of these robots are available for the competition. The software for these robots has also been developed locally at ITESM.

Cyberlords T2 and T3: Based on the *Kondo KHR-3HV* humanoid robot, but heavily modified to provide them with autonomy. Both architectures use roughly the same kind of sensors, but feature different processing units. In the case of T2, the robot uses a *Roboard RB-110* and a *Kondo RCB4*, whereas the T3 architecture uses two *Gumstix Overo Fire COM* with *Summit* board. One robot of each of these two architectures is available for the competition. Both robots run applications based on *libCyberlords* developed at the *Mobile Robotics and Automated Systems* lab of *Universidad La Salle*.

***DARwIn-OP*:** This is the well known commercial robot offered by *ROBOTIS*. A yet to be determined number of *DARwIn-OP* robots will be available for the team during the competition. All three institutions representing *Team Mexico* have developed code for the *DARwIn-OP* and have used it during official competitions, a sample of which is shown on the team's qualification video.

***NimbRo-OP*:** This robot was designed and built at *Universität Bonn* [21, 22] by team *NimbRo*. It was recently acquired under a joint research grant in which five Mexican institutions are involved. In order to participate in the *Humanoid KidSize League*, the head of the robot is being re-designed so as to meet the height restriction of 90cm maximum. The robot is hosted at the *BioRobotics Lab* of *UNAM*, where its software is currently under development.



Bogobot V2 Cyberlords T2 Cyberlords T3 DARwIn-OP NimbRo-OP

Fig. 2. Five hardware architectures for *Team Mexico* in 2014 (not to scale)

3 Humanoid Robot Collaboration

As we approach the vision of the *RoboCup* initiative for 2050, more complex and expensive robots will be needed. We will soon reach a point in time when no single research lab will be able to build, maintain and transport around the world eleven humanoid robots to play either against a similar team of humanoid robots or against a team of humans. The *RoboCup Humanoid League* will have to evolve into an event in which researchers will meet to integrate a mix and match of different kinds of humanoid robots from different groups around the world, and these humanoid robots will have to collaborate in a soccer game in a seamless way.

During *RoboCup 2011* in Istanbul, Turkey, several teams in the *Humanoid KidSize League* took part in a demo game that intended to demonstrate the feasibility of 5 vs 5 matches. Since no single team could provide five robots for either side of the match, it was necessary to improvise and use robots from different teams. It became painfully obvious from this demo game that the league was missing a standardized communication protocol and a collaboration strategy that would allow robots from different teams to interact with each other.

Team Mexico is in essence a mix and match of humanoid robots that are not only brought in from different research labs, but which have notably different hardware architectures. It has then become a necessity for the team to establish a basis for humanoid robot collaboration on the *RoboCup* football field.

We are hereby proposing a standard that specifies three basic roles for the playing field, a strategy that will allow each robot to choose their own role depending on the status of the game, and a small data packet that robots must be able to produce and understand in order to exchange meaningful information with their peers. This proposed standard is outlined in the following subsections.

3.1 Playing Roles

Whichever standard that is proposed for humanoid robot collaboration in the *RoboCup* field must be specified only at the higher levels of abstraction, without reference to particular details of any specific hardware and/or software architecture. This will allow for robots from different research groups to be able to play football interactively while at the same time allowing sufficient freedom to each group to pursue their own research objectives.

Moreover, in order to be able to play collaboratively each robot must be able to predict, at least to some degree, the behavior of its teammates. For this to happen, this standard proposes three basic roles for humanoid robot football players: *goalie*, *defender* and *striker*. These three roles are specified as state machines that have several states in common. Table 1 shows the proposed set of behaviors that must be implemented for each of the three roles, and the information that the robot would require to obtain from its teammates in order to complete each behavior successfully.

Depending on its role, each robot will have to evaluate several high-level conditions that will trigger specific transitions on the corresponding role state-machine. Table 2 lists the set of high-level conditions in this proposed standard. Some conditions require external information in order to be evaluated, either from teammate robots or from the game controller.

Based on the definition of each behavior and condition, the state machine for each of the three roles can be reduced to the transition tables shown on Table 3. It is important to notice that each behavior on these state machines may in turn be implemented as lower-level state machines. For example, the “block the ball” behavior for the goalie could in turn be a choice of a dive, a leg extension to one

Acronym	Description	Goalie	Defender	Striker	Required external information
GU	get up	yes	yes	yes	
POG	position autonomously in front of own goal	yes	no	no	
PSH	position autonomously in south half of field	no	yes	yes	(own-loc) from teammates
GIPP	get in position for pass	no	no	yes	(own-loc) from teammates
BB	block the ball	yes	no	no	
CB	clear the ball away from own goal	yes	no	no	
FB	find ball	yes	yes	yes	(ball-loc belief) from teammates
SBNC	find ball without changing position	yes	no	no	(ball-loc belief) from teammates
WTB	walk towards ball	yes	yes	yes	(prox-to-ball) from teammates
KBTG	kick the ball towards goal	no	no	yes	(prox-to-ball) from teammates
KBTN	kick the ball towards north half of field	no	yes	no	(prox-to-ball) from teammates
OA	obstruct adversary	no	yes	no	(prox-to-ball) from teammates
PB	pass the ball	no	yes	no	(own-loc and clear-for-pass status) from teammate strikers
GOTW	get out of the way of the ball	no	no	yes	(preparing-kick status) from teammate strikers

Table 1. Set of high-level behavior states for autonomous football players

Acronym	Description	Goalie	Defender	Striker	Required external information
RF	robot fallen	yes	yes	yes	
KTGD	kick towards goal detected	yes	no	no	
BC	ball is close	yes	yes	yes	
CPOG	positioned in own goal	yes	no	no	
SB	see ball	yes	yes	yes	
CPSH	positioned in south half of field	no	yes	yes	
CPFP	positioned for pass	no	no	yes	
BOF	ball on feet	yes	yes	yes	
BOSH	ball on south half	yes	yes	yes	
BONH	ball on north half	yes	yes	yes	
AC	adversary is close	yes	yes	yes	
ICTB	I am closest to ball	yes	yes	yes	(proximity-to-ball) from teammates
TICP	teammate is clear for pass	no	yes	no	(clear-for-pass status) from teammate strikers
TATK	teammate about to kick	no	no	yes	(preparing-kick status) from teammate strikers
GCP	game controller in PLAY	yes	yes	yes	(game status) from game controller

Table 2. Set of high-level conditions for autonomous football players

side or simply remain put, based on the direction and strength of the kick. How each behavior is implemented will largely depend on the hardware and software capabilities of the particular robot.

Goalie		Defender		Striker	
Condition	Behavior	Condition	Behavior	Condition	Behavior
RF	GU	RF	GU	RF	GU
KTGD	BB	¬SB	FB	¬CPSH&¬GCP	PSH
BC	WTB	ICTB&BOSH	WTB	TATK	GOTW
BOF	CB	BOF	KBTS	¬SB	FB
¬SB&¬CPOG	FB	AC&¬ICTB	OA	ICTB&BONH	WTB
¬CPOG	POG	BOF&TIC	PB	BOF	KBTS
default	FBNC	*default*	PSH	*default*	GIPP

Table 3. Role state-machines

3.2 Role Selection

Each individual robot will be given a specific role by default. However, depending on the circumstances of the game it might make sense for a robot to change its role. For example, if only the goalie remains on the game (for whatever reason) and there are no opponents attacking it would make sense for the goalie to attempt to score. Rather than specifying complex state machines that will allow the goalie to incorporate all behaviors from the striker, we believe it is better to specify simple and concrete state-machines for each role but allow each robot to switch role when the circumstances are appropriate.

This is controlled by a *role-selection state-machine* in which each of the three roles is a state. The decision to switch is made locally by each robot, but requires information both from teammates and the game controller.

Another kind of "intelligent" behavior that could be incorporated from this strategy is for example: everyone turn into a striker if we are losing, the ball is on the opposite side and the time remaining is less than a minute.

A full specification for this *role-selection state-machine* is under development.

3.3 High-level Communication

We believe that rather than exchanging numeric data between robots and have each robot interpret the information received from each of its peers, it is preferable to have each robot interpret its own numeric data and communicate it to the rest as high-level semantic information. For this purpose, this proposed standard partitions the *RoboCup* field into 20 regions and each one is referred to with a name in stead of a coordinate, as depicted in Figure 3. For this standard, the "north" is defined as the direction from the own-goal to the opposing team's goal. In order to communicate its own location, each robot is responsible for generating its best estimate regarding which of the 20 regions it is currently located at and in what orientation with respect to the field. For example, a striker may be located at W4 and facing in the SE direction. This would be a good choice to wait for a pass.

In the case of proximity of the robot to the ball, distance is also expressed semantically. It makes sense to do it this way rather than in precise centimeters because depending on the speed of the robot the distance to the ball may be close or far. If this information is going to be used to decide who gets to walk towards the ball then it makes sense to base the decision on who will get there sooner. Also, by sharing the perceived location of the ball, the team will enhance its ability to find the ball after losing sight of it.

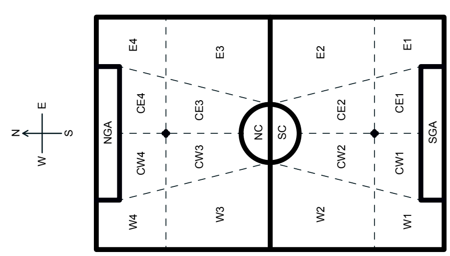


Fig. 3. Semantic Partition of the RoboCup Humanoid Field

A first draft for the data packet that each robot in the team would be expected to broadcast periodically is shown on Table 4.

Description	Field	Confidence	Field	Confidence
own-location	region-of-field	1-100	orientation	1-100
ball-location-belief	region-of-field	1-100		
proximity-to-ball	very-close/close/far	1-100		
own-battery-level	1-100			
clear-for-pass status	true/false			
preparing-kick status	true/false			
walking-towards-ball status	true/false			

Table 4. Data packet for autonomous football players

4 Conclusion and Future Work

We have outlined a proposed standard for humanoid robots playing collaboratively in the *RoboCup* field. *Team Mexico* will have its first chance to fully test this standard during the *6th RoboCup Mexican Open*, three months before *RoboCup 2014*. We do encourage other teams in the *Humanoid League* to try our proposed standard and to contribute with feedback. A "C" header definition of the data packet is under review and should be released soon.

Future work on this standard should incorporate communication between robots by means other than the wireless network, such as audible and visual cues.

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February 20th, 2014

Humanoid League Technical Committee,

I hereby express the full commitment of *Team Mexico*, which I formally represent, to participate in the 2014 edition of the *RoboCup World Championship* to take place in João Pessoa, Brazil, on July 19^{th} – 24^{th}.

I also express the full commitment of the team to provide at least one team member with sufficient knowledge of the rules to act as referee during the competition.

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