# FC Portugal 2007 – 2D Simulation Team Description Paper

Luís Paulo Reis[1,3], Nuno Lau[2,4], Luís Mota[1,3]

lpreis@fe.up.pt, lau@det.ua.pt, luís.mota@iscte.pt

[1]FEUP –Faculty of Engineering of the University of Porto, Portugal
[2]DET – Electronics and Telecommunications Department, University of Aveiro, Portugal
[3]LIACC – Artificial Intelligence and Computer Science Lab., University of Porto, Portugal
[4]IEETA – Institute of Electronics and Telematics Engineering of Aveiro, Portugal
http://www.ieeta.pt/robocup

**Abstract.** FC Portugal 2007 project intends to continue the research performed during the development of previous FC Portugal RoboCup simulation league teams. These teams have one of the best sets of results in previous competitions. FC Portugal won the simulation league in RoboCup2000 - Melbourne, got third in RoboCup2001 – Seattle, won two European championships (Amsterdam2000 and Paderborn2001). FC Portugal team also won the 2002 Coach Simulation in Fukuoka and achieved two second place awards in this competition (Padova, 2003 and Lisbon, 2004). In other leagues the team is presently European champion of RoboCup in two leagues: Rescue Simulation and 3D Simulation and is World Champion of RoboCup 3D Simulation league (scoring 77 goals without conceding any). This paper describes some of the innovations of our team for the last simulation league competitions, relating them with previous work developed by simulated RoboCup teams.

## 1. Introduction

The main research goal of FC Portugal team is the development of a formal model for the concept of team strategy for a competition with an opponent team having opposite goals, general enough to be instantiated to various dynamic competitive domains. The formal model enables the design of an agent architecture suitable for RoboCup simulation league agents and a world state model capable of storing the information needed for an intelligent agent to play soccer.

The project research focus is also concerned with developing general decision-making and cooperation models for soccer playing. Cooperation mechanisms include developments of the previously proposed Situation Based Strategic Positioning and Dynamic Positioning and Role Exchange Mechanisms. Communication languages and protocols, to convey the most relevant information at the right times to players have also been developed. Also, research is focused on intelligent control of players' sensors to achieve maximum coordination and world state accuracy. Online optimization has been used in order to develop a complete set of efficient low-level skills for soccer playing agents.

Coaching is an important research topic in RoboCup. We have proposed Coach Unilang – a general language to coach a (robo)soccer team. Our coach conveys strategic information to players, while keeping their individual decision autonomy.

FC Portugal is also very concerned with the development of agent evaluation tools like our offline client methodology; WstateMetrics that evaluates the accuracy of world states and Visual debugger used to analyze the reasoning of agents. Evaluation by domain experts using graphical tools is one of the methodologies that is being used. FC Portugal 2007 2D team builds upon previous research that has made the FC Portugal team one of the most successful teams that ever participated in RoboCup competitions.

The rest of the paper is organized as follows. Section 2 describes FC Portugal agent architecture and the knowledge structures used. Section 3, briefly describes some of the high-level decision and cooperation algorithms developed by the team. Section 4 describes some new work on a Strategical layer definition and flexible Setplays definition. The next sections deal with Intelligent Perception and Communication and Game Analysis and Coaching. Section 7 briefly introduces our Agent Analysis and Debugging Tools and the last section contains the paper conclusions.

## 2. Agent Architecture and Knowledge Structures

To enable a team to perform cooperative multi-agent tasks, like playing simulated soccer, in a partially cooperative, partially adversarial environment a lot of knowledge is needed. Also, agents must have a world state representation as updated and as accurate as possible.

Knowledge is essential to perform complex cooperative tasks in complex dynamic environments. Whenever the domain becomes more complex, knowledge importance is even greater. This is the case in multi-objective, partially cooperative and adversarial domains in which agents have limited perception and action capabilities. For this type of domains we argue that to correctly perform cooperative tasks, agents should include knowledge at three levels: individual action execution, individual decision-making and cooperation. Knowledge for executing actions is concerned with the specific commands needed to perform a given low-level action. Individual decision-making knowledge is concerned with the way agents choose the action to execute (from the available set of actions). Knowledge for cooperation is concerned with tactics, situations, dynamic formations, roles, dynamic plans and communication protocols [1]. Representation structures for this type of multi-level knowledge are one of our research goals.

The world state representation has only interest if it may remain updated and may be used to effectively decide the individual and cooperative actions to perform. The following methods are used to update our agent's world state information: visual perception analysis; communication; and action prediction.

## 3. High-level decision and Cooperation

In RoboCup past editions, teams with the best decision making mechanisms were very successful. In RoboCup 2001, the champions (Tsinghuaeolus [2] also champions in 2002) and vice-champions (Brainstormers [3]) did not use the coach agent and trusted mainly on their better low-level skills and well-tuned individual decision-making mechanisms. In RoboCup 2004 STEP won the competition mainly due to their fast dribbling ability. So, besides having a configurable strategy and

flexible coordination mechanisms [4], well-tuned individual decision making mechanisms are still very important in RoboCup simulation league. This way we focused on a new shooting approach based on evaluating goal scoring possibility based on Goalie Movement Prediction [11].

We are extending our Dynamic Positioning and Role Exchange mechanism (DPRE) [1] that is based on previous work by Stone et al [5]. How to define roles based on standardized agent behavior characteristics for the RoboCup simulated soccer domain is one of the problems to be tackled. To improve the flexibility of our team, agents are able to switch their relative positions (for a given formation) and roles (that define agent behavior at several levels), at run-time, on the field.

We have proposed and continually developed Situation Based Strategic Positioning (SBSP) mechanism [6, 1] that may be used to dynamically spatially position a team using different flexible formations for different situations. This mechanism is based on the distinction between active and strategic situations [1]. If an agent is not involved in an active situation then it tries to occupy its strategic positioning that change according to the situation of the game. Situation is a concept on a high-level analysis of the game (attacking or defending for example). SBSP was one of the main innovations of FC Portugal and is now used directly or as the base for the positioning systems of many simulated soccer teams.

## 4. Strategical Coordination Layer and SetPlays

Based on our previous work on strategical modeling we have developed a multi-purpose, adaptable, strategical coordination layer that allows the management of heterogeneous teams, for both centralized and decentralized environments, with reduced use of communication [13]. The model uses a multi-level hierarchical approach. In the first, lower level, the concept of roles is used to reflect the agent's usual activities. The second level introduces a sub-tactic that aggregates agents with various roles to solve partial objectives [13]. On top of the sub-tactics, the use of formations is employed to distribute available agents throughout the sub-tactics. A higher, tactical level then uses a hybrid method to switch formations. This method is based on a combination of events, situations and precedences [13]. On top of the previous levels a strategical level is defined that allows the commutation between tactics according to scenario conditions.

We have also developed a framework for high-level setplay definition and execution, applicable to any RoboCup cooperative league and similar domains. The framework is based in a standard, league-independent and flexible language that defines setplays which may be interpreted and executed at run-time [14].

These methodologies were applied for both RoboCup Soccer distinct leagues and RoboCup Rescue and tested in real competitions and controlled experiments, achieving excellent results [13, 14]

## 5. Intelligent Perception and Communication

Communication model of the simulated league is restricted by the available bandwidth and uncertainty of message delivery. In 2002 the communication rules have changed: bandwidth has been constrained (messages with maximum length of

10 bytes), but uncertainty on delivery can now be reduced. Also, a new form of visual communication (enabling players to point to regions of the field) has been introduced. We identify four potential research areas in the definition of a communication protocol: What to communicate? When to communicate? Who should be heard at each time? and How received messages will affect player's behavior?.

Previous approaches have used message contents, mainly, to share world state knowledge between players [7], to communicate useful events/opportunities [8] and to enhance cooperation [6]. With the reduction in message size, teams must carefully select which information should be conveyed. We have extended our ADVCOM principle: "Communicate only when you have something important so say" [6] with "Communicate only what is important", measuring the importance of each piece of information through utility metrics based on the current situation and on estimated teammates knowledge. This idea was also been extended with a Situation Based Communication framework [12]. In RoboCup simulation league, if two or more players talk in the same simulation cycle, the simulator delivers only one of the messages to the other players. Teams have dealt with this restriction either by assuring that only one player talks in each cycle or by allowing several players to talk [6]. We believe that the first approach is not sufficiently flexible and reliable and thus have used the second approach [6]. In our protocol every player estimates the importance of his knowledge to the rest of the team through utility measures and only communicates when its communication utility his higher than the others or is above a threshold.

In the simulation league agent's visual perception is obtained through controllable sensors. Players may control their visual quality, the sensibility angle and the position of their neck relatively to the agent's body. We have developed intelligent perception mechanisms, namely, on our intelligent perception mechanism, SLM - Strategic Looking Mechanism [6]. SLM decides the direction a player should look, in each cycle, maximizing the predicted world state update value from that perception.

## 6. Game Analysis and Coaching

In RoboCup simulation league, the online coach agent has a global vision of the field (without errors) gathered from the soccer server [9]. The coach agent is able to analyze the game and send high-level commands to his team in order to improve the team global behavior.

In previous work [10] we have explored different ways of implementing the coach agent. Different coaching architectures have been implemented and compared, including the division of the coach agent into one assistant agent (capable of gathering game statistical information and opponent modeling information) and a principal coach (that uses the information provided by the assistant coach in order to decide the best tactic to be used by the team at each moment in the game). Other coaching architectures were also explored, including the subdivision of the coach functions by the players in order to have a completely distributed coaching behavior.

Coaching is an important research topic in RoboCup. We have proposed Coach Unilang – a general language to coach a (robo)soccer team [2, 3]. The development of translators from Coach Unilang to Clang has provided us with a very useful tool to test team behaviors and to participate in the Coach Competition.

## 7. Agent Analysis and Debugging Tools

FC Portugal is also concerned with the development of agent evaluation tools like:
- Offline client methodology;
- WstateMetrics that evaluates the accuracy of world states;
- Team Designer that enables the graphical definition of soccer strategies;
- Visual Debugger used to analyze the reasoning of agents [1, 3].

Evaluation by domain experts using graphical tools is another methodology that will be used to fine tune our team for Atlanta 2007 tournament.

## 8. Conclusions

FC Portugal 2007, as its predecessors, is a team with a beautiful, fast, "real soccer like" way of playing simulated soccer. The improvements performed during this year make the team even more flexible and adaptable to different types of opponent strategies. The team achieved $5^{th}$ place in RoboCup 2006 simulation 2D league. However FC Portugal won Bremen RoboCup 2006 Simulation 3D league scoring 77 goals without conceding any, using exactly the same high-level coordination methodologies.

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