Real MagiCol 99: Team Description

C. Moreno[1] , A. Suárez [1], Y. Amirat[2], E. González [1], H. Loaiza [1,3]

Université d'Evry Val d'Essonne, LAMI[1] – CEMIF[3],
Cours Monseigneur Roméro, 91025 Evry Courcouronnes, France.
{ moreno, suarez, gonzalez }@lami.univ-evry.fr, amirat@univ-paris12.fr,
hloaiza@eeie.univalle.edu.co,
Université Paris XII – LIIA
122, Rue Paul Armangot 94 Vitry S/Seine
Universidad del Valle - PAyRA. Escuela de Ingeniería Eléctrica y Electrónica,
Ciudad Universitaria, Cali, Colombia

Abstract. The hardware and software architectures of the Real MagiCol robots are presented. The hardware remains the same as the 1998 Robot Cup one, our research bearing on the cooperative architecture based on agent concept. The Real Magicol soccer players team for Robot Cup 99 is based on a *Behavior Oriented Commands* (BOC) architecture extension which combines reactive and deliberative reasoning by the distribution of the knowledge system into modules called behaviors.

1. Introduction

The middle size team "Real MagiCol" (Realismo Mágico [1] Colombiano) is a joint effort of institutions in France and Colombia. In addition to participating in RoboCup99, the robots will be used in the future for research and educational activities in Colombian universities and will be employed in a permanent exhibit of the interactive science museum "Maloka". In fact, we are the first Latin-American middle size team in RoboCup.

We decided to build our own robots for ROBOCUP 98. This allows a greater insight and a complete mastering of the robot's technology. We designed an open, easily reconfigurable PC based architecture in order to allow for future evolutions.

The Real MagiCol team features our hybrid software architecture called Behavior Oriented Commands (BOC) [2] [3]. It allows a soccer robot to plan complex deliberative actions while offering good reactivity in a very dynamical environment. BOCs provide a high level distributed intelligence model which is directly translated into a real time application.

This article presents the main aspects of the robots hardware and vision system, as well as their control architecture and the team strategy.

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2. Robot Description

The Real MagiCol team consists of five robots sharing the same hardware design. Each robot has an external diameter of 44 cm and a height of 18 cm (37 with the optional turret and vision system). Lineal speeds of almost 2m/s with accelerations of 1 m/s^2 are possible. The hardware architecture of the robots is shown in Figure 1. Figure 2 shows our goalkeeper in action.

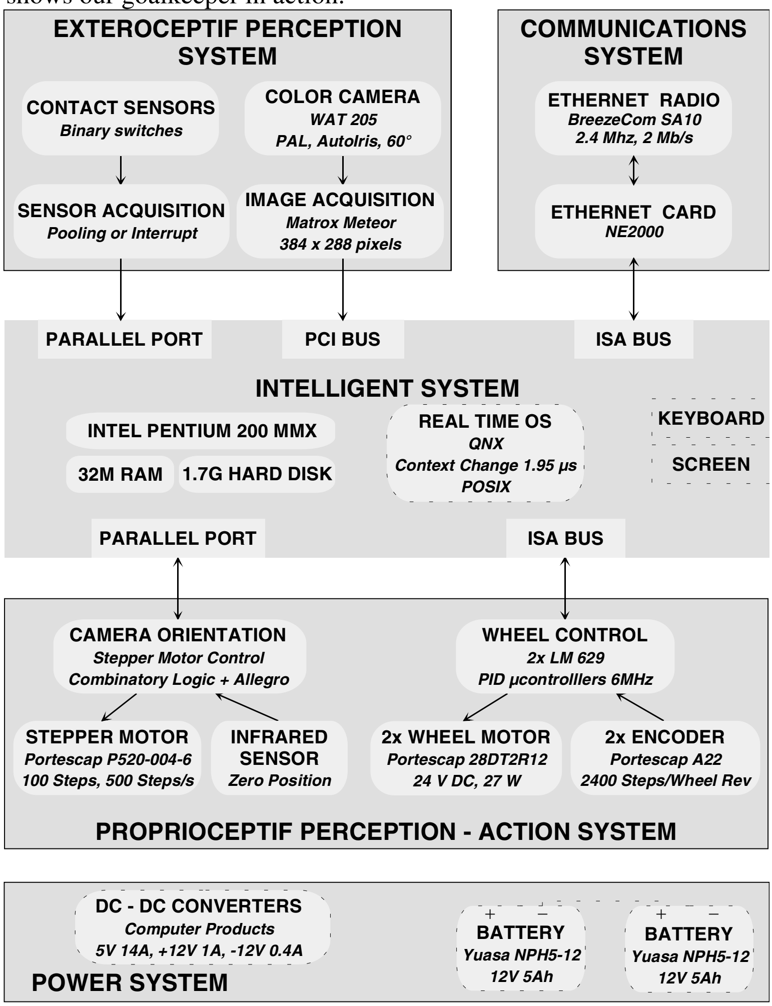

Fig. 1. Hardware Architecture of MagiCol Robots.

Fig. 2. General View of Robot and Ball

3. Local Vision System

Each robot possesses a color mini-camera with a 3.8 mm focal distance and a 51°(h) x 40°(v) vision field. The images are acquired in the RGB color model [4]. The detection algorithm of the elements (color-objects) of the terrain (ball, robot markers, goals, etc.) uses thresholded LUTs applied to the three color fields. A logical function between these images results in eight binary images, one for each color-object. A composed 8-bit image is obtained after bit-shifts and combination of the binary images. While performing the last step a LUT is applied to discriminate and label ambiguous pixels. A 9-level image is finally constructed.

The attributes of each color-object are obtained after segmentation of the 9-level image. For each detected color-object, the center of gravity, the surface and the enclosing window are calculated in image coordinates. Color-objects presenting a small size are rejected. The vision system was calibrated to carry out a 3D position reconstitution of the objects, taking advantage of the fact that the height of the ball, goals and robots are known to reduce the unknown variables in the camera model.

The *local map* is the set of objects recently seen by the robot. An object is characterized by its relative position, speed and uncertainty in local coordinates. The color-object information provided by the image treatment module and the odometer allows to estimate the position and speed of objects. Newly detected objects are incorporated into the map with an initial uncertainty value based on their distance and image surface. Objects re-detected in new images are updated. The uncertainty of undetected objects is increased until they reach the forget threshold.

The robot localization is carried out using objets known to be static. We plan to integrate the information from the local modules in the different robots into a *global map*, in order to improve the precision of the position and speed estimates of objects of interest.

We expect to improve the robustness by implementing an HSI (Hue, Saturation, Intensity) model based algorithm for the color-objets detection. These model could allow the color camera calibration under unstable illumination conditions.

4. Roles and Formations

In a soccer game robots need to be organised to play coherently [9]. Our robots incorporate the rules to execute individual actions depending on its role, team formation and game context.

A role assigns responsibilities and actions to a robot. The generic roles of goalie, defender and attacker are defined. The goalie stays parallel and close to the goal, trying always to be directly between its goal and the ball. The attacker moves to the ball trying to kick towards the opponent's goal; when the ball is in the attacking side it attempts to have a good non interfering attacking position. The defender maintains a good defending position between its goal and the ball/opponent, to move near the ball and pass it to the attackers; it also tries to place itself between the ball and its own goal when the ball is far [5][6]. We also define a new role, the *coach*. It performs global localisation, role and formation distribution, supervision activities, and manages external information.

The generic roles are specialised in sub-roles according to the robot playing region in the field and its attitude towards the game. The field is divided into three regions: left, right and central allowing to decline the roles as left-handed, right-handed and central. Robots can also play a role having different attitude towards the game, for example, a defender may be *prudent* (always staying in a defensive position) or *aggressive* (always trying to kick the ball). This specialisation by attitude allows to easily built teams playing different tactics without modifying its formation.

A formation is a team structure that defines a set of roles in a particular game [6]. A formation assigns a specialised role for each robot. The selection of the team formation depends on the game situation, particularly on the score and opponent's strategy. At start information concerning global team formation affects the way individual sub-role rules are interpreted which allows to have collective conscience.

5. BOC Implementation

A real time control architecture should be used to implement a soccer mobile robot that deals with a dynamic environment. Our robot control system is implemented using the hybrid architecture BOC, which combines reactivity and deliberative reasoning by the distribution of the knowledge system into modules called *behaviours*. A *BOC* is a service carried out by a set of cooperative associated behaviours (*ABs*) executing in parallel. The co-ordination of the *AB*s is performed by a control unit (CU) using synchronisation signals.

A general description of MagiCol robots using the *BOC* architecture was presented in our previous paper [3]. Figure 3 presents relevant aspects of the actual BOC model implementation of our goalie; ellipses and rectangles represent *behaviours* and *control units* respectively.

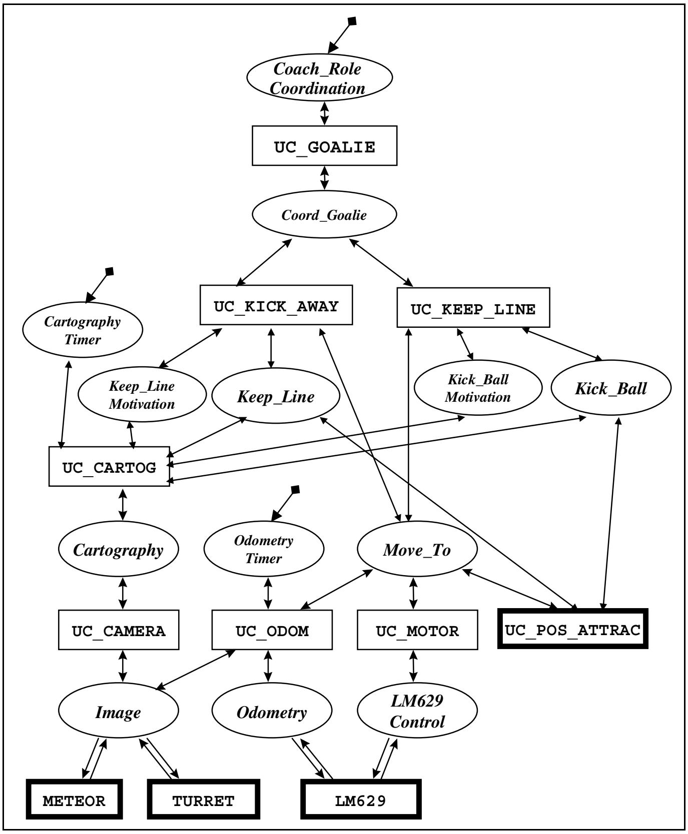

Fig. 3. BOC Model of our Goalie for RoboCup98.

The coach assigns roles by requesting a high level *BOC* to each robot. The command parameters include zone and attitude specialization attributes of the role. In our goalie, UC_GOALIE activates the *behavior Coord_Goalie*, which decides the next action to execute. Two possible high level goalie actions are defined: *Keep_Line* and *Kick_Away*. A request to the concerned *UC* is performed. When the action is finished an acknowledge is received, the state is modified and the next action to perform is selected using the control rules embedded in the *behavior*.

The execution control of the command `Keep_Line` is performed by UC_KEEP_LINE that activates three *ABs*. The behaviour *Position_Line* modifies the attraction point to make robot move to the best defensive position over its line (parallel to the goal entry). The *behavior Keep_Line_Motivation* monitors if the motivations for doing this action are still valid, when motivation falls under a threshold (specified by *Coord_Goalie*) an end signal is generated thus stopping all *ABs* and finishing the *BOC*. The third *AB Move_To* drive the robot to arrive to the attraction point specified by other cooperative *behaviors*. High level behaviors have access to sensors and actuators through low level commands.

6. Conclusions

The hardware and software architectures of the Real Magicol Robots were presented. These robots were built for the RoboCup competition, but future research in other subjects has also been considered.

The BOC architecture was used with few modifications and proofs to be well adapted to this kind of challenge, allowing a straightforward well structured real-time implementation of the proposed concepts.

In our current implementation, collective behaviours emerge as a result of role attribution and team formation. We plan to extend the task parallelism to the team as a whole by adding explicit communication between the players. The increased information exchange, should also allow our coach to detect specific strategy patterns from the opponent team in order to adapt our own strategy.

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