ART'00 - AZZURRA ROBOT TEAM FOR THE YEAR 2000

Giovanni Adorni [1], Andrea Bonarini [2], Giorgio Clemente [3], Daniele Nardi [4], Enrico Pagello [5], Maurizio Piaggio [6]

[1] DII-Università di Parma, [2] DEI-Politecnico di Milano, [3] Consorzio Padova Ricerche, [4] DEI-Università di Padova, [5] DIST-Università di Genova, [6] DIS-Università di Roma "La Sapienza"

1 INTRODUCTION

Robotic soccer is a challenging research domain that can be used to explore new problems and test new techniques/ solutions in the fields of Artificial Intelligence and Autonomous Robotics, as well as for training and educational purposes.

Azzurra Robot Team (ART) is a national project launched in 1998 in the framework of RoboCup Initiative with the aim of education and training of students in the fields of Artificial Intelligence and Autonomous Robotics as well as developing and testing new research ideas useful for indoor robotics. ART is the result of a joint effort of several Italian research groups. The goal of the project is to exploit the expertise and ideas from different research groups around Italy in order to build a team where players have different features, both hardware and software, but retain the ability to coordinate their behaviour within the team. Therefore, ART is an heterogeneous team where each player synthesizes experiences/solutions of different research laboratory.

ART achieved the second place in RoboCup '99 in Stockholm, and ranked second, first among the European teams, in the First European RoboCup Championship held in Amsterdam in May 2000. In this paper we describe the main characteristics of ART'00, the team participating in the RoboCup Initiatives during the year 2000. More precisely, next section describes some features of the players; section 3 discusses the problem of coordination among the team; section 4 presents a card for each player participating in RoboCup 2000; and last section thanks all the ART-ists involved in this project.

2 ROBOT FEATURES

Each player differs from its team mates in many ways: mechanics, sensors, computer hardware, control software and, most of all, design. The design in particular is not only different (each research group develops its own robot) but also operates in a substantially independent way. Presently, we are using different robotic bases, all of them characterized by a conventional PC, wireless high bandwidth connection, low cost frame grabber(s), CCD camera(s), odometry and kicking device.

P. Stone, T. Balch, and G. Kraetzschmar (Eds.): RoboCup 2000, LNAI 2019, pp. 559-562, 2001.

The vision systems, the most important sensor of ART'00 players, rely on three different camera setups: omnidirectional, binocular, single (fixed or pan-tilt) camera. Omnidirectional vision systems consist of an upwards-oriented camera that acquires the image reflected on a concave mirror hanging above it, obtaining a field of view of 360 degrees. In single camera systems the field of view is quite narrow, limiting the distortions introduced by the lens and making object localization in the acquired image quite reliable. If pan-tilt devices are present, the camera motion can compensate for the limited field of view. Multi-camera vision provides a wide field of view with little distortion requiring no moving devices. However, either as many frame grabbers as the number of cameras or a multi-input frame-grabber is required. Camera calibration may be critical as it must ensure that information coming from different cameras is homogeneous and not contradictory in the regions where the camera fields of view overlap.

Vision algorithms (VAs) have been designed to tackle: object detection, obstacle avoidance, player self-localization. In light of the different geometry of the vision systems, VAs have one class independent of the acquisition system, concerning object and landmark detection, based on fast segmentation techniques by means of adaptive thresholding in the color space. A second class, device-dependent, has to take into account the different geometry in the interpretation of distances and orientations of the objects as they appear in the acquired image. In that case, VAs may involve not only vision but also vision/control interaction. In omnidirectional vision setups, object/landmark detection can be done all around the robot with the analysis of a single frame. In pan-tilt camera systems, the robot control system has to drive two systems, the robot and the camera, and has to analyze their relative motion in real time and accurately enough to follow the ball motion at any time. Finally, in binocular systems, even if it is possible to acquire images from all cameras at the same time, real-time constraints suggest that only the relevant ones be processed. Therefore, VA must include some kind of spatial reasoning to choose the right buffer to process.

3 TEAM COORDINATION

Coordination of players in ART'00 is particularly challenging because of its significant heterogeneity. A first level of coordination (low-level communication framework) is strictly related to the chosen software architecture (ETHNOS) and its message based communication protocol (EIEP - Expert Information Exchange Protocol); a library has been also developed to allow the communication with other architectures (i.e., SAPHIRA). The EIEP deals transparently both with inter process communication within a single robot and with inter-robot communication. In the EIEP the different robots are allowed to subscribe to communication clubs in which messages are exchanged with a publish/subscribe technique. Whenever a message is published ETHNOS transparently and dynamically distributes the messages to the appropriate subscribed receivers.

In ART'00 we are allowing the robots to communicate in a single club (the team) and with an external monitoring station (the coach) which monitors the activity of all the players for displaying and debugging purposes during a match. In this club robots can be added and removed dynamically without explicit programming. A second level of coordination is related to the role the players: goalkeeper (role_0), main attacker which demands ball possession (role_1), helping attacker which supports the main attacker in the action (role_2), defender which attempts to recover the ball (role_3). Three field zones are associated to a specific role. The zones generically describe the regions in the field (attack, defense, field center) in which the respective role identified behaviour should be carried out. Two utility functions are used in the robot/role association. The goalkeeper is always associated to the designated robot unless a malfunction forces another robot to temporarily act as a substitute. For the remaining (MF-Middlefield) players the role/player association based on the above structure is: ≪ Every cycle (100 ms) each robot transmits a message containing the computed value for the two utility functions based on its relative perceptions of the external world. Every robot also subscribes to the utility value message type and therefore also receives the utility values of all the other robots in the field. Every cycle each robot compares its first utility value with the one of the other robots. The robot with the lowest value takes role_1. The remaining two robots compare the second utility value. The one with the lowest value takes role_2, the remaining takes role_3≫.

To avoid role association oscillations a double threshold mechanism has also been introduced to facilitate role keeping by the robots in the presence of similar utility values. The type of roles in the structures and the utility functions used determine the personality of the team and can be changed from match to match.

4 THE PLAYERS

#1 *Galavrón*(Goal Keeper) by DII - Università di Parma: Self made base, frontal/ lateral pneumatic kickers, motors in central position with four spherical wheels keeping the robot in balance, home developed control and power cards, binocular vision to allow 220 front view and perform geometric reasoning for self-localization, back/lateral infrared sensors, ETHNOS environment.

#2 *RonalTino* (MF Player) by DIS-Università di Roma"La Sapienza": Pioneer 1 base, pneumatic kicker allowing for left/right kick, Pioneer 1 microcontroller card with modified basic control hw and sw, monocular vision, sonars and infrared sensors, SAPHIRA environment.

#3 *TotTino* (MF Player) by DIS-Università di Roma"La Sapienza": Replica of Ronaltino with pan/tilt camera to reduce the time to locate the ball and to improve precision and speed of the actions approaching the ball.

#4 *Bart* and #5 *Homer* (MF Players) by DEI-Università di Padova: Pioneer 1 base, pneumatic kicker with an effector allowing for frontal/lateral kick, Pioneer 1 microcontroller card, home developed power card, monocular vision, ETHNOS environment.

#6 *Relé* (MF Player) by DIST - Università di Genova: Pioneer 1 base, pneumatic kicker with lever system able to lift the ball, Pioneer 1 microcontroller card with modified basic control hw and sw, monocular vision, ETHNOS environment.
#7 *Rakataa* (MF Player) by DEI-Politecnico di Milano: Self made base, two independent traction wheels, mechanical kicker, home developed control and power cards, omnidirectional vision, ETHNOS environment.
#8 *Lisa* (Goal Keeper) by DEI - Università di Padova: Modified Pioneer 1 base, pneumatic kicker with an effector opening two lateral wings while moving ahead, motors in a central position with two spherical wheels keeping the robot in balance, Pioneer 1 microcontroller card, home developed power card, omnidirectional vision, ETHNOS environment.
#9 *NakaTino* (MF Player) by DIS-Università di Roma"La Sapienza": Pioneer 2 robot prepared as RonalTino.

5 ART-ists

Team Leader: Giovanni Adorni (adorni@ce.unipr.it)
Dept. of Computer Engineering, Università di Parma
Parco Area delle Scienze 181A, 43100 Parma, Italy

Team Members:
M.Airoldi, D.Baldassarri, M.Barbon, M.Bellini, C.Bernardi, M.Bert, E.Bocelli, A.Bonarini, A.Brambilla, M.Bresciani, S.Cagnoni, F.Cappelli, M.Carletti, A.Castaldo, C.Castelpietra, M.Cefalo, R.Cipriani, G.Clemente, G.Colombo, E.Corbetta, U.Cugini, D.Daniele, A.Farinelli, C.Ferrari, G.Franceschini, L.Garbarino, M.Giardino, A.Gilio, M.Grillo, G.Invernizzi, T.H.Labella, L.Luminari, F.Marando, A.Marangon, F.Marchese, D.Mastrantuono, M.Matteucci, E.Menegatti, P.Meriggi, M.Mordonini, C.Moroni, D.Nardi, E.Pagello, C.Pellizzari, M.Piaggio, G.Pucci, G.Remondini, C.Rota, A.Scalzo, A.Sgorbissa, D.Sorrenti, D.Spagnoli, S.Suriano, M.Tamburini, R.Zaccaria, S.Zaffalon, M.Zoppi

Web page http://RoboCup.CE.UniPR.IT/ART2000/

References

G.Adorni, S.Cagnoni, M.Mordonini, M.Piaggio, Team/goal-keeper coordination in the RoboCup mid-size league, *In this Volume.*
C.Castelpietra, L.Iocchi, D.Nardi, M.Piaggio, A.Scalzo, A.Sgorbissa, Communication and coordination among etherogeneous mid-size players, *In this Volume.*
M.Piaggio, A.Sgorbissa, R.Zaccaria, A programming environment for real time control of distributed multiple robotics systems, *Advanced Robotic J.*, 14, 2000.
A.Bonarini, P.Aliverti, M.Lucioni, An omnidirectional sensor for fast tracking for mobile robots, *Procs. IEEE Instr. & Meas. Tech.Conf.*, Piscataway, 1999.
E.Pagello, A.D'Angelo, F.Montesello, F.Garelli, C. Ferrari, Cooperative behaviors in multirobot systems through implicit communication, *Robotics and Autonomous Systems*, 29(1), 1999.