Fun2Mas: the Milan Robocup Team

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Abstract. We present Fun2maS, the Milan Robocup Team. In its implementation we have faced many aspects: hardware (electronics, mechanics), sensors (omnidirectional vision), behaviors (fuzzy behaviors management and composition), multi-agent coordination (strategy and tactics), and adaptation of the team behavior. We could fully exploit the characteristics of all the components thanks to the modular design approach we have adopted. All the modules have also been designed to be used in generic applications, and we have already adopted most of them for surveillance, mapping, guidance, and document delivery tasks.

1 Introduction

Fun2maS (*"[Let's] Fun to Multi–Agent Systems !!"*), the Milan Robocup Team, is born from the experience done with the Italian National Team (*ART* [1]) since 1998. In this paper, we summarize our results concerning: development of robot bases, omnidirectional vision [4][2][9][10], fuzzy behavior management systems [6], architecture for multi-agent coordination [8], and techniques to adapt the behavior of the team to that of the opponents [7].

2 Hardware

We have implemented both the mechanical and the electronic aspects of our robots. In 1998, we developed the robot base Mo^2Ro (*Modular Mobile Robot*), with two independent traction wheels on the front and a ball pivot on the rear. These robots (*Rullit* and *Rakataa*, first and third from the left in figure 1) weight about 30 Kg each, and can run up to 1 m/s. Due to inertia it is almost impossible to control faster robots with the same kinematics and mass distribution, so we have developed *IANUS*, a robot base with two independent, central traction wheels and most of the mass placed on them. The name comes from the Roman god with two faces, since this robot is designed to work indifferently in one of the two main directions. In the present implementation, *Roban* (the second from left in figure 1) can run up to 1.5 m/s. We have implemented on the same basic structure also *Ruffon*, our new goal keeper, unmounted in the picture. The last

Fig. 1. The Fun2maS team

robot on the right is *Roby(Baggio)*: it has two independent wheels each mounted on a rotating turret, so to obtain holonomic movement, which fully integrates with our omnidirectional vision system. All the robots are equipped with control and power cards developed in our lab, and a regular PC board, hosting low-cost frame grabber and wireless ethernet. One of the main concerns in the development of these robots has been the cost, which is as low as about 1,100 euros each. We are currently working to improve our mechanical and pneumatic kickers, mainly to obtain special kicking effects, differentiated also on the same robot, in the case of *Roban* and *Roby(Baggio)* which can kick from different sides. We are also working on a new low-level control architecture, based on a network of distributed microprocessors, that should replace the present ISA-bus cards.

3 Omnidirectional vision

Sensors play a crucial role for the performance of the robot and strongly influence its design [2]. We have focused on omnidirectional vision, where a camera pointed upward to a revolution mirror can provide a 360 deg image of the robot surroundings, whose characteristic depend on the mirror design. Our first mirror was conical with a spherical center, thus including in the image both distant and close objects. Our second mirror [10][9] is multi–part; we have: in the center the ground image without distortions (square angles appear as square angles), from the second part markers on the robots distant up to 11 meters, from the outer part the position of the ball and other robots when close by. This design exploits at best all the available resolution, and it also makes self–localization fast to compute. The color image is sampled in "receptors", small sets of 4 pixels (in cross configuration) whose color features are averaged, to obtain robust interpretation [4]. The number of receptors is much smaller than the number of pixels, so that computation is much faster than that needed by complete images, computing angular position and distance of all the elements on the field at 20 Hz. Moreover, each color is defined by collecting patches from the actual images, instead of defining a single interval for each color feature, thus providing a better characterization. We have adopted this approach also in other systems, operating in indoor environments, that can adapt the color interpretation according to the role the corresponding blobs have in the image.

4 BRIAN & SCARE

BRIAN (*Brian Reasonably Implements an Agent Noddle*) [6] is the fuzzy behavior management system that we have implemented. To each behavior are associated two sets of fuzzy predicates representing its activating conditions (*CANDO conditions*), and motivations(*WANT conditions*). These last may come from evaluation of the current situation, or from our distributed planner, and are used to weight the actions proposed by behaviors. We have developed reactive behaviors (such as `GoToGoalWithBall`) reaching a good performance in a context where agents operate most of the time selfishly. In order to achieve coordinated behaviors we are providing our robots with a set of general basic behaviors which can be instantiated by *SCARE* into higher level behaviors for the whole team, by considering *strategies* and *roles*.
SCARE (*Scare Coordinates Agents in Robotic Environments*) [8] implements all the relevant aspects of the multi–agent cooperation. Agents are assigned to *jobs* defined in a multi–agent task structure (*schema*). This makes it possible to perform coordinated actions such as ball-passing and opponent blocking (*doubling*). The job assignment is done by meta–agents which evaluate *opportunity* and *necessity* of undertaking actions, and consider the respective *predisposition* of agents. Meta–agents are dynamically distributed in the robot network, by taking into account quality of communication and available computational resources. If communication works fine, and one computer has enough resources, the control can be centralized on that computer, whereas, if the network is partitioned, each sub–net (at worst, each robot) has its own specialized, coordination meta–agent. This architecture enables the dynamical reconfiguration of the distributed planner, thus increasing robustness of the whole system.
To support communication among *SCARE*, *BRIAN* and the other components of the multi–agent system, we are substituting *ETHNOS*, the real-time communication system used in ART [1], with *DCDT* (*Device Communities Development Toolkit*) an event–driven middleware that gives to any module (including the low level controllers) the capability to exchange messages with any other, in a peer-to-peer setting.

5 Adaptation

We have worked on adaptation in Robocup since last year, when we obtained our first results in a simulated environment [5][3]. The team having even a single robot adapted to a new environment (e.g., opponents with different strategies) was able to score more goals, conceding less. The reinforcement learning algorithm we have implemented evolves populations of behaviors associated with WANT conditions. It tests different motivations for each behavior in different situations, and evaluates the contribution of each behavior to the global action.

We are now working on another adaptation mechanism to be implemented at the SCARE level, so that the team behavior can change dynamically, by changing the mentioned weighting parameters in SCARE, according to alterations in environmental conditions, opposing strategy, faults, etc. Also in this case, we have defined a reinforcement learning algorithm, currently under extensive test.

6 Conclusion

We have briefly summarized our activities in the development of a Robocup team, which span from hardware to adaptation. We adopted an the integrated and modular approach to the an effective team. We also made an effective effort to develop general tools usable in most multi–robot domains. We have adopted modules implemented for Robocup in other applications. In some cases the solutions found for Robocup have been extended to face different aspects of the problem (e.g., person detection). In other cases, results obtained in different domains have been applied also to Robocup; for instance, adaptation to different floor types, implemented for navigation tasks in DEI-Polimi building, can help to automatically tune the vision system also in Robocup.

References

1. G. Adorni, A. Bonarini, G. Clemente, D. Nardi, E. Pagello, and M. Piaggio. Art'00 - azzurra robot team for the year 2000. In M.Veloso P.Stone, editor, *RoboCup 2000: Robot Soccer World Cup IV*, Berlin, D, In Press. Springer Verlag.
2. A. Bonarini. The body, the mind or the eye, first? In M. Asada M. Veloso, E. Pagello, editor, *RoboCup 98–Robot Soccer World Cup III*, pages 695–698, Berlin, D, 2000. Springer Verlag.
3. A. Bonarini. Evolutionary computing and fuzzy rules for knowledge acquisition in agent-based systems. *Proceedings of IEEE*, In press, 2001.
4. A. Bonarini, P. Aliverti, and M. Lucioni. An omnidirectional vision sensor for fast tracking for mobile robots. *IEEE Trans. on Instr. and Meas.*, 49(3):509–512, 2000.
5. A. Bonarini, C. Bonacina, and M. Matteucci. Fuzzy and crisp representation of real-valued input for learning classifier systems. In P. L. Lanzi, W Stolzmann, and S. W. Wilson, editors, *Learning Classifier System: new directions and concepts*, pages 107–124. Springer-Verlag, Berlin, D, 2000.
6. A. Bonarini, G. Invernizzi, T. H. Labella, and M. Matteucci. A fuzzy architecture to coordinate robot behaviors. *Fuzzy Sets and Systems*, Submitted.
7. A. Bonarini and M. Matteucci. Learning context motivation in coordinated behaviors. In *Proceedings of IAS-6*, pages 519–526, Amsterdam, NL, 2000. IOS Press.
8. A. Bonarini and M. Restelli. An adaptive architecture for the implementation of cooperative strategies for heterogeneous agents. *IEEE Transactions on Robotics and Automation*, Submitted.
9. P. Lima, A. Bonarini, C. Machado, F.M. Marchese, C. Marques, F. Ribeiro, and D.G. Sorrenti. Omni-directional catadioptric vision for soccer robots. *Journal of Robotics and Autonomous Systems*, Submitted.
10. F. M. Marchese and D. G. Sorrenti. Omnidirectional vision with a multi-part mirror. In G. Adorni and W. Hoeke, editors, *Proceedings of EuRoboCup 2000"*, Amsterdam, NL, 2000. On CD-ROM.