Artisti Veneti: an Heterogeneous Robot Team for the 2001 Middle-size League

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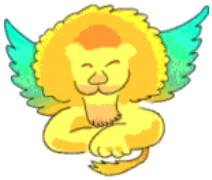

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Abstract. We illustrate our new team *Artisti Veneti* a new entry in the Middle-size league from The University of Padua (Italy). The team is composed of heterogeneous robots that use only vision as perception system. The vision systems have been designed separately for each robot. Our players are coordinated in the frame of ADE (Artisti Veneti's Development Environment), a multi-thread distributed real-time Environment working under Linux OS. Cooperative abilities, like exchanging a ball, can be achieved through the use of efficient collision avoidance algorithms using roles swapping triggered using an enhanced reactivity approach.

1 Introduction - A short history of our team

Artisti Veneti Team has been founded in 2001, to participate to RoboCup01 in Seattle, by Enrico Pagello, who have coordinated locally the Padua Branch of ART Team, in 1998, 1999, and 2000. The "robotic" members of our team include five players, *Bart*, *Homer*, *Lisa*, *Nelson* and Barney. *Bart and Homer (*designed at our Lab. on 1999), have played with ART'99, by scoring a total of 5 goals in 9 games. *Homer* won a Technical Challenge against Friburgh University. *Bart*, *Homer*, and *Lisa* (designed at our Lab. on 1999/2000), have played successfully with ART-2000, which won the Second Place Cup of RoboCup-Euro2000, and in Melbourne. This year two new players have been added to our robotic team: *Nelson* (based on a Pioneer2 basis) and *Barney*, a Golem robotic platform of Golem Robotics.

2 Our five players: Bart, Homer, Lisa, Nelson and Barney

Artisti Veneti has been conceived as an heterogeneous robot team [1]. *Lisa, Bart, Homer* and *Nelson*, even if built upon a similar base (a Pioneer 1 or a Pioneer 2)

[1] For a more detailed description of our team please refer to the web site *www.dei.unipd.it/∼robocup*, where you can download a longer version of this document.

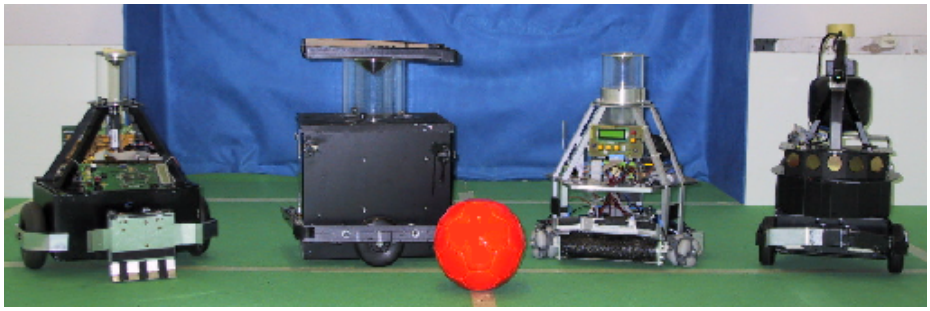

Fig. 1. Our heterogeneous robot team. (From left to right) Nelson, Lisa, Barney and Bart (its clone Homer is not displayed).

have several differences, even in the mechanical structure. In *Bart*, and its clone *Homer*, the lower part of the chassis is the original one of the Pioneer, while the chassis of *Nelson* and *Lisa* have being totally reshaped. Eventually, *Barney* is an omnidirectional robot, with a chassis with a circular symmetry..

Homer & Bart use a Pioneer1 base, Intel P233 MMX processor, 64 MB RAM, BT848 FrameGrabber. The kicker used to catch the ball is pneumatic: two pistons independently commanded allow to turn the shovel to the right or to the left. They mount standard perspective cameras.

Lisa uses a Pioneer1 base, AMD k6-3 500 MHz processor, 64 MB RAM, BT848 FrameGrabber. Lisa mounts a special kicker inspired by the Kicker used by Galavron, ART's Goalkeeper. It allows both frontal and lateral kicks. Lisa uses an omnidirectional vision sensor designed by ourselves [5].

Nelson is a new player based on a Pioneer 2 base, Intel Pentium 800MHz, 64 MB RAM, BT848 FrameGrabber. The chassis has been totally rebuilt. Nelson mounts an omnidirectional vision system designed by ourseves [5]. The kicker is fitted with a third piston to raise the ball to perform lobs.

Barney, an holonomic platform with an omnidirectional vision sensor, has been borrowed from Golem Robotics. We have developed a new set of behaviours for the robot and integrated it in the heterogeneous team.

3 Our vision system

The goalkeeper, Nelson and Barney mount omnidirectional vision systems, Bart and Homer mount standard cameras. The cameras are the only sensors exploited by our robots to locate themselves, the ball and the opponents.

The omnidirectional vision system is composed by a camera pointed upward, looking at a multi-part mirror. In [5] we give details on the design of the mirrors and how a custom designed mirror permits to identify new effective behaviours.

The low-level processing of the image is the same for all sensors[2]. In the Robocup domain the colours of the objects in the field of play are precisely coded. Usually, to associate a colours to a pixel, the pixel value is confronted with a set of thresholds in the colour space. This approach has two shortcomings. First, the thresholds are set by hand, resulting in a skillful and time consuming

[2] Except for Barney that uses the original vision software of Golem Robotics.

process. Second, defining a lower and an upper thresholds for a colour, delimits a box in the colour space, that usually poorly describes the disposition of the object's pixels in the colour space. To overcome these problems, we propose a new way to associate a colour to a pixel. At the set-up stage, the operator selects the region of the image containing the object and associates it a colour. The pixels of the object form a cluster in the colour space. The convex hull containing these pixels is created. A colour is then assigned to a pixel only if this pixel is inside one of the convex hulls. This process is performed in real-time using a look-up table. Our colour segmentation algorithm presents two main advantages. First, the convex hulls fits more closely the actual distribution of the image pixels in the colour space, with respect to the previously mentioned boxes. Second, the set-up process is much faster and reliable because the trial and error procedure in setting the thresholds is avoided.

4 Our planning system

In our previous works, limited global planning capabilities are obtained by balancing between deliberative and reactive capability [1], whereas in our team we have used an enhanced reactivity approach. At the reactive level, our robots are programmed using a *behavior-based* approach. Three different robot roles [6] has been introduced by specifying a set of behaviors [2]. The three roles are: **attacker**, **midfielder** and **defender**. Each basic behavior is realized as a thread in ADE. ADE (Artisti Veneti's Development Environment), is a multi-thread distributed real-time Environment working under Linux OS. ADE has been inspired by the coordination environment used by ART [6].

ADE allows to create a set of processes structured as threads. Each thread can communicate, through message passing, with other threads of the same process and also with other processes running on other processors. Each thread can allow or deny itself to other threads of lower priority. When a segmentation fault happens, it is possible to kill the thread that has caused the error, or to restart it with or without a new initialization. Each thread can be suspended for a while, and kept ready to be resumed later.

A *measure of quality Q*, able to triggers the proper role, was introduced time ago, at IAS Lab. of Padua Univ., for evaluating how much work must be done by a robot to get the ball in the best position to score [2]. Our robots are able to show a cooperative action, like a *ball exchange*, by coordinating their basic behaviors through the dynamic assignment of the above three roles realized by a set of behaviors that exploit some smart collision-free motion strategies, based on the computation of field vectors [9]. During the 2001 Seattle competition, we had several situations in which the robots swap their roles, and succeed to *exchange the ball*, as an emergent behavior like it was in Stockholm'99 and Amsterdam'00.

5 Conclusions and Acknowledgements

We illustrated our new team *Artisti Veneti*, based on five players. *Bart*, *Homer*, *Lisa*, *Nelson* and *Barney*. *Bart* and *Homer* played together successfully with ART team at both RoboCup'99 and Euro-2000 competitions. *Lisa* played at Euro-2000 for the first time as a reserve goalkeeper. All the three have also played with ART at RoboCup'2000. Two new players, *Nelson* and *Barney* have

been added to the team this year. Our *vision systems* rely on omnidirectional vision, [4], [5], for both the goalkeeper, and the new players. Our team plays according to an Emergent Behavior Engineering approach [7], [8], implemented in the frame of ADE, a new multi-thread distributed real-time Environment.

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