Artisti Veneti:
a New Entry in 2001 Middle-size League

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Abstract We illustrate our new team *Artisti Veneti* (The Venetian Artists) a new entry in the Middle-size league from The University of Padua (Italy). Our team has actually four robotics players based on Pioner1/2 Platforms. A fifth player is planned to be added to the team before end of April'01. *Bart*, *Homer*, and *Lisa* (based on Pioneer1) have yet played in the past with ART Italian Team. *Lisa* has an omnidirectional vision sensor. *Nelson* (a new player based on Pioneer2) is based on Pioner2. *Nelson* integrates also a directional vision sensor with its omnidirectional one. All players have a bi-directional kicker. 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. A balancing between reactivity and deliberativity is obtained by focusing the attention on robot's maps.

1. Introduction - A short history of our team

Artisti Veneti Team has been founded on 2001, to participate to RoboCup01 in Seattle, by Enrico Pagello, who have coordinated locally the Padua Branch of ART Team, on 1998, 1999, and 2000. The "human" members of our team include one new PhD student, plus all the six undergraduate students that participated to ART-2000, both in Amsterdam and in Melbourne.

The "robotics" members of our team include actually four players, *Bart*, *Homer*, *Lisa*, and *Nelson*. *Bart and Homer (*designed at our Lab. on 1999), have played very successfully 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, in Amsterdam, where they contributed to win the Second Place Cup of RoboCup-Euro2000, and unsuccessfully, due to coordination failure problems of ART Team, in Melbourne. This year, a new player, *Nelson*, has been added to our robotics team, and a *fifth player* is planned to be added to the team before end of April'01, to replace one of the older player.

2. Our four players: Bart, Homer, Lisa, and Nelson

Artisti Veneti has been conceived as an heterogeneous robot team. Our goal is having four different kind of robots. Actually, *Lisa, Homer* and *Nelson*, even if built upon a similar base (a Pioner 1 or a pioneer 2) have several differences, both in the mechanical structure. While *Bart/Homer* have two wheels in the front end, and one only directional camera, *Nelson* try to keep the wheel axis at the centre of gravity, and integrates two different cameras. *Lisa*, of course, being a goalkeeper, is different from the previous ones. To enhance the team, we are trying to add to our 4 robot team a fifth mechanical omnidirectional platform (or a clone of nelson) for Seattle'01 competition.

Homer & Bart use a Pioneer1 base. We installed a Motherboard ASUS TX97E with Intel P233 mmx processor, a 64 MB RAM, a 4 GB HD, a Graphicboard with 2MB ram, a BT848 FrameGrabber, and a Lucent Wavelan PCMCIA. The Robots actually receive 24V from a series of two 12V batteries or from an external power supply. This system allows a better yield and a better isolation between PC card and motors card. Batteries are positioned on the top of chassis, near the motor control board and the air tank. This position makes it very simple and fast to replace batteries. The internal of chassis is completely used for PC. The kicker used to catch the ball is pneumatic: two pistons, an air-compressed tank and two electronic valves make up the system. Pistons support an aluminium plate form by two pieces. Any piston can move independently from the other, so we can turn the shovel to the right or to the left. This system is strong, powerful and agile, but it frequent to get stuck with other robots or walls. The chassis is entirely built using aluminium plates of 1.5mm or 3mm (for the top). Mainboard is fixed on the top. Lateral protections are installed around wheels, so they never can block. We projected and realized a tripod support for camera. It's rigid and precise, it keeps the camera high and protected, moreover it includes an inclination system. If it become necessary it can be removed quickly.

Lisa use a Pioneer1 base. We installed a Motherboard Asustek P5A-B (ATX-baby), with AMD k6-3 500 MHz processor, a 64 MB RAM, a 1 GB HD, a Graphicboard with 2MB ram, a BT848 FrameGrabber, and a Lucent Wavelan PCMCIA. Lisa mounts a special kicker inspired by the Kicker used by Galavron, ART's Goalkeeper. It allows both front and lateral kicks. It has micro switches on the kickers, and allows three different type of control of the kick. Lisa use an omnidirectional vision sensor designed by ourselves.

Nelson is a new player realized using as base the Pioneer 2. We installed a -Motherboard Chaintech ATX-baby, with an Intel Pentium 800MHz, 64 MB RAM, a 1 GB HD, two different frame grabbers, a Graphic Board PCI with 8MB, and a Lucent Wavelan PCMCIA. It was developed improving our past robots Bart and Homer. We do not use the original chassis, because we need to have a minimal distance between kicker and wheel-axis, moreover the height of structure was excessive especially on the rear. The main difference between Nelson and the other our players are: -A new vision system based on two cameras: a front camera and an omnidirectional one. The second one will use a self-built conical mirror. -A new kicker. It add to the previous system a front shovel necessary to raise the ball. Nelson will be faster than Bart and Homer. Maximun speed is 2m/s.

Before end of April, we plan to introduce into our team a *fifth player,* to replace one of our older robots (Bart or Homer). We are exploring two alternative possibilities, or to build a *Nelson's clone,* either to add a *mechanical omnidirectional platform*. Administrative financial issues prevent us to state now which will be our choice. A final decision will be taken before end of April'01.

3. Our vision system

Our robots are fitted with heterogeneous vision sensors. The goalkeeper mounts an omnidirectional vision systems, two attackers mount a perspective camera vision system and the new attacker, *Nelson*, mounts an heterogeneous vision system composed by a perspective camera and an omnidirectional catadioptric system. Actually, our research interest is moving toward the multiple camera data fusion. The first step is the creation of an attacker robot fitted with a perspective camera and an omnidirectional camera. The omnidirectional camera mimics the peripheral vision of animals while the perspective camera represent their central vision.

The perspective vision system of the robots is composed by a Sony XC999P camera with a 106° field of view. Such a wide view angle permits to observe a wide area of the field of view but introduce a serious distortion, that is corrected by software. The cameras are the only sensors exploited by our robot to locate themselves, the ball and the opponents robots. The vision software and the graphical interface for the image processing are entirely developed by our team exploiting the Qt Linux library.

The low-level processing of the image is the same for all sensor. It is based on a colour segmentation of the image. 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 limits. First, the thresholds are set by hand, resulting in a skilful and time consuming process to obtain a good segmentation. Second, defining a lower and an upper thresholds for a colour, let say red, delimits a box in the colour space. Pixel inside the box are red, pixels outside are not. This box will exclude certain reddish pixels and include non-reddish ones. Consider a pixel out of a face of the box and a pixel within the box but in a corner. The former is not considered red even if it is more close to the centre of the box, i.e. is more reddish, than the latter pixel. To solve these limits, we propose a new way to associate a colour to a pixel. At the set-up stage, the operator select the region of the image containing the object and associate it a colour. The pixels of the objects are selected and mapped in the colour space. Here, they will form a cluster in the region of the colour space corresponding to the object's colour. The pixels too far from the cluster are rejected, they could be erroneously selected pixels. A convex hull is created in the colour space. The convex hull contain all the pixels of the object. The process is repeated for all the colours present in the field of play. To determine the colour to associate to every pixel, we map the pixels in the colour space and those inside the convex hulls are associated to the corresponding colour. This process is performed in real-time using a look-up table. The two main advantages of our approach are:

1. the convex hulls fit more closely the actual distribution of the image pixels in the colour space, with respect to the previously mentioned boxes;
2. the set-up process is much faster and reliable because the trial and error procedure in setting the thresholds is avoided;

To achieve a wider field of view, we adopted omnidirectional vision. First, on the goalkeeper and now on the new robot Nelson. The omnidirectional vision system is composed by a camera pointed upward, looking at a multi-part mirror. We designed the profile of the mirror especially for the Robocup competition. In [5] there is a detailed description of the goalie omnidirectional vision system. Where details are given on the design of the mirror and how a custom designed mirror permits to identify new effective behaviours. In [4], other ongoing work at IAS Lab of Padua University is illustrated, about a system where a custom designed omnidirectional vision sensor is exploited in a mapping task.

4. Our planning system

Limited global planning capabilities are obtained by balancing between deliberative and reactive capability using a Map Focusing approach, as described in [1]. At the reactive level, *Bart* and *Homer* were programmed by using a *behavior-based* approach, [3], to the aim of obtaining a robotics social organization. Three different robot roles has been introduced, according the definition of a role given in [6], by specifying a set of behaviors [2]. 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 Ethnos, used by ART [6].

ADE allows to create a set of processes structured as threads (Experts, according to Ethnos approach). Each expert can communicate through message passing with other threads of the same process and also with other processes running on other processors. ADE's messages can be fully personalized by identifying their nature, structure, and dimension, for all needs. Several processes can run simultaneously, in real-time, on the same machine. it is possible to subscribe to different message lists, in order to send a given message only to a selected process set. Experts are structured hierarchically. They are organized according several priority levels. Each process can be associated to its own kernel, that start its threads by setting their initial parameters. Each Expert has its own running time. It can be set dynamically by itself, or by other experts of higher priority. Each expert can allow or deny itself or other experts of lower priority. When a segmentation fault happens, it is possible to kill the expert that has caused the error, or to restart it with or without a new initialization. Each expert can be suspended for a while, and kept ready to be resumed later.

The *behaviors* of our players are based on collision-avoidance algorithms that use *field vectors* and generate *schema-based behaviors*. They use a *robot role-swapping* approach based on a set of three roles, to realize coordinated actions. A *measure of quality Q,* able to triggers the prop 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 shows 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]. An Obstacle Avoidance module implemented these motion planning algorithms as an expert in Ethnos, that now has become a thread in ADE.

In the Figure, *Bart* and *Homer* swap their roles, and succeed to *exchange the ball*, as an emergent behavior (*www.dei.unipd.it/~robocup)* during Stockholm'99 quarter-finals against the Universities of Ulm. In these games, a very effective emergent cooperative ability, was achieved by Bart and Homer through the use of efficient *collision avoidance algorithms* activated while they were mutually exchanging their play roles [9]. For our whole 4 robots team, we are now using the same approach, enhanced with some deliberative capability, according to [1].

5. Conclusions

We illustrated our new team *Artisti Veneti* (The Venetian Artists), actually based on the 4 players, *Bart*, *Homer*, *Lisa*, and *Nelson*. *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. A new player, *Nelson* has been added to the team. A *fifth player* is forecast to be added to the team before end of April. Our *vision system* rely on the omnidirectional vision, [4], [5], for both the goalkeeper, and the new player, Nelson. 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. Our robot team has also some limited reasoning capabilities based on balancing reactivity and deliberation [1].

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