

Enhancing the Artisti Veneti Team for RoboCup2003

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Abstract. We illustrate the progress in developing the RoboCup team *Artisti Veneti* of the University of Padua (Italy). The team is composed by heterogeneous robots which use only omnidirectional vision as a perception system. Each player realizes a suitable combinations of flexible motions and omnidirectional vision. Two goalkeepers are available: the former uses an old style two wheel-driven platform with a restricted motion, whereas the latter is based on a fully omnidirectional platform. The other robots of the team are realized as either omnidirectional or two wheel-driven platforms. The players are coordinated in the frame of ADE, a multi-thread distributed real-time Environment working under Linux OS, and they use a fuzzy-logic system for decision making.

1 Introduction

The Artisti Veneti Team of the University of Padua has been founded in 2001 to participate to RoboCup 2001 in Seattle, to continue the experience gained by the Paduan Branch of ART Team, in 1998, 1999, and 2000. The "robotic" members of Artisti Veneti 2003 now includes six players: *Argo*, *Barney*, *Bender*, *Fred*, *Lisa* and *Nelson*, after the *retirement* of Bart and Homer that have played successfully since RoboCup 1999 in Stockholm where with ART they won the Cup of the second place in the World competition [7].

Lisa, a two-wheels goalkeeper designed at our Lab in 1999, played successfully since RoboCup-Euro2000 where with ART-2000 won the Second Place Cup. In the year 2001, two new players were added: *Nelson*, based on a Pioneer2 basis, and *Barney*, a three-wheel holonomic platform built by the Golem Team. In the year 2002, a second Golem platform and a clone of Nelson were introduced. This year we introduce a new goalkeeper *Argo*, a new three-wheel holonomic

platform, inspired to Golem's architecture. We illustrate their main features and their software in the next sections.

The human team has 3 Staff members, and about 15 undergraduate students of the Faculty of Engineering. The Staff includes Enrico Pagello, a member of the Faculty of Engineering of the University of Padua, as the Team Leader, Emanuele Menegatti, a Post-Doc in Robotics, as the coordinator of the undergraduate students, and Antonio D'Angelo, a member of the Faculty of Science of the University of Udine, as an external collaborator.

For a more detailed description of our team please refer to the web site www.dei.unipd.it/~robocup.

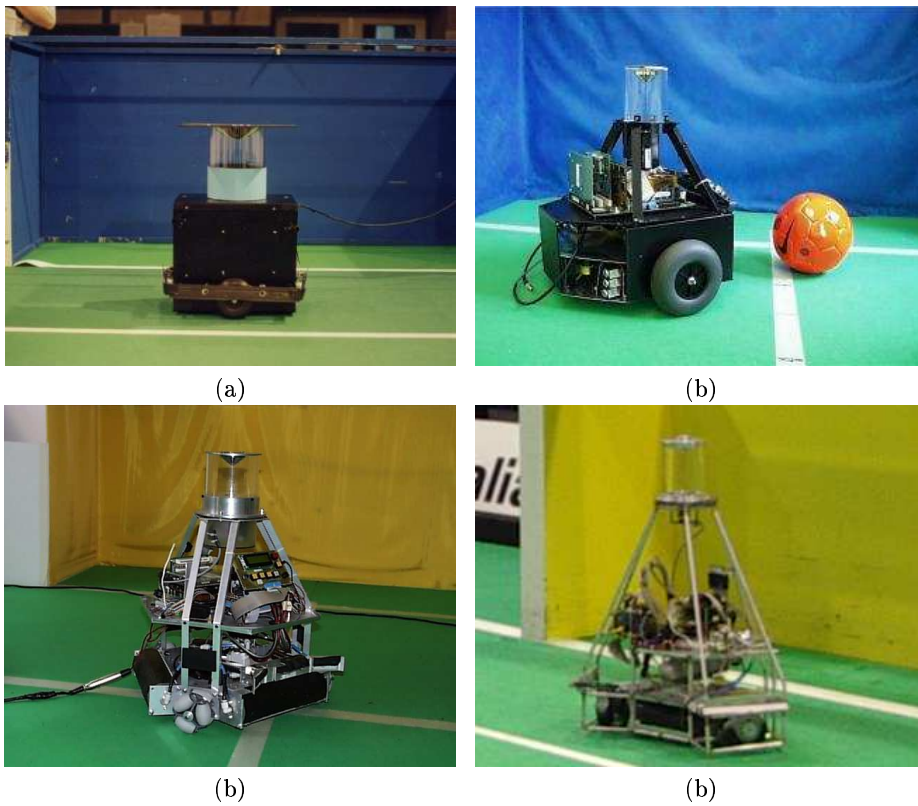


Fig. 1. Our robot's typologies: (a) 2-wheel goalkeeper *Lisa*; (b) 2-wheel *Nelson*; (c) 3-omniwheel *Barney*; (d) 3-omniwheel goalkeeper *Argo*

2 Robot Hardware

Artisti Veneti has been conceived since the beginning as an heterogeneous robot team. All our robots mount an omnidirectional vision sensor, the only one exploited by our robots to self-localise in the field, to locate the ball and the opponents. The omnidirectional vision system includes an upward camera, looking at a customly designed multi-part mirror, see Fig. 2, whose design is detailed in [11].

Lisa, Fig. 1a), is fitted with a self-made control board, AMD k6 processor, and a PAL Sony camera. *Lisa* mounts a special kicker inspired by the Kicker used by Galavron, ART's Goalkeeper. It allows both frontal and lateral kicks.

Both *Nelson* and its clone *Bender*, Fig. 1b), have been built on a Pioneer 2 platform. They use Intel PIII and PIV boards, and PAL Sony cameras. The two-wheels are balanced with respect of the center of gravity, in order to get semi-holonomic motions. The kicker is able to control the direction of the ball, as in the original ART's kicking devices.

The two Golem platforms (*Barney* and *Fred*), Fig. 1c), were upgraded to a PC-104 with a PIII CPU and using new omnidirectional wheels. Three driven omnidirectional wheels at 120° , one to the other, enable the holonomic motion of the Golem platform. The three motors driving the omni-wheels are controlled by a self-made board. The omnidirectional vision sensors are equipped with PAL Hitachi cameras.

The new goalkeeper, *Argo*, Fig. 1d), is an holonomic platform inspired to the Golem's design, but with some improvements to enhance the performances. Its frame, made by Alluminium pipe to be sturdy, has been enlarged to include stronger motors and larger wheels (12 cm instead of 8 cm). The motors are controlled by a PC-104 board from Mesa, the omnidirectional vision system uses a Firefly IEEE 1394 camera. Carefully considering the experience of *Lisa*, we realised that a goalkeeper robot should be holonomous in order to be able to easily manouever in the goal area that often is cluttered of robots, but should have a preferential motion direction to be able to oppose to the attacking robots. We found the best option for the robot is to move on a semicircle centered on the goal center and to be able to resist to pushes toward the goal, as explained in [11].

The communication among the robots and with the external monitoring computers is performed via wireless LAN IEEE 802.11b. For mass storage, the robots are fitted with flash card memories which are more robust against vibrations than conventional hard disks.

3 Robot Software

Our software runs within the frame of ADE (Artisti Veneti's Development Environment), a multi-thread distributed real-time environment working under Linux OS [1]. Ade has been inspired by the coordination environment ETHNOS used by ART [2]. ADE allows to create a set of processes structured as threads. Each

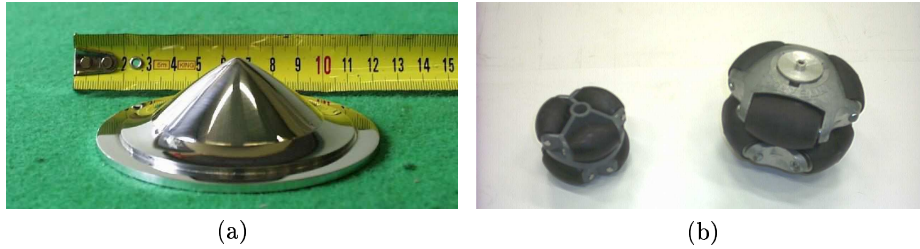


Fig. 2. Hardware's details: (a) multi-zone mirror; (b) 8cm and 12 cm omnidirectional wheels

thread can communicate, through message passing, with other threads of the same process and also with other processes running on other processors. When a segmentation fault happens, ADE can automatically either kill the thread that has caused the error, or restart it with or without a new initialization. ADE can suspended every thread for a while, and kept ready to be resumed later.

3.1 Vision

The omnidirectional sensors of our robots are tailored on the role of the robot and on the chassis of the robot and this result in different mirror profiles. Despite this heterogeneity, the low-level image processing routines are the same for all robots, only the mapping between pixel coordinates and world coordinates is different.

The information extracted by the omnidirectional images are the position of the ball, the position of the goal posts and of the corner flags and the position of other robots. The image interpretation is based on color segmentation and on the RoboCup color coding where each object has a different colour. For colour segmentation, we designed a set of tools to speed-up the choice of the correct thresholds in the HSI colour space. Each triple of RGB values obtained from the camera is mapped in the HSI colour space and the corresponding RoboCup color is stored in a look-up table. In order to be able to analyse 25 frame per second on the limited hardware resources of our robots, we perform simple vision tracking algorithms of the objects of interest on the omnidirectional images.

To overcome the limitation of the single omnidirectional sensor, we are realizing a distributed vision system for our team. All the sensory information gathered by each robot are forwarded to the teammates, which use this information to enlarge or improve thier perception of the world. For more details please refer to [4] [9].

3.2 Localization

Our self-localization system uses robot's odometry and the position of few landmarks (the goal posts and the corner flags) obtained from the images. The sensor

inputs are matched to a model of the field and the position so achieved overwrites that one maintained by odometry. Self-localization failures are filtered out according with old localizations.

3.3 Decision and Coordination

In the past, our team developed an enhanced reactive approach starting from a behavior-based approach. Three different robot roles [2] was introduced by specifying a set of behaviors [3]. The three roles are: **attacker**, **midfielder** and **defender**. This approach has led to the realisation of complex behaviours, like ball exchange behaviour between the robots seen several times during the competitions [8], some clips can be found at <http://www.dei.unipd.it/robocup/resources/Video/>.

This year we have introduced a new fuzzy-deliberative system (*ArtiFACT*, Artisti Fuzzy Agents Control Toolkit) based on hybrid deliberative-reactive architecture. The classic deliberative paradigm (sense-reason-act) has been evolved reinforcing reactive behaviours. As Fig. 3 shows, there is a direct link between the *sense* block and the *act* block that speeds-up the reactive response of the robot, but that can be overwritten by the deliberative stage.

Artifatct's reasoning system works with logical expressions that represent conditions. Depending on results obtained by the evaluation of these conditions, a certain action is selected.

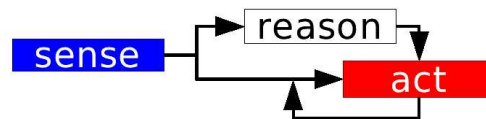


Fig. 3. ArtiFACT architecture: deliberative conditions (*reason* block) can be bypassed for certain inputs (*sense* block) which need more reactive behaviours

The *conditions* are defined as fuzzy functions. When they are evaluated a value in the $[0,1]$ range is returned, depending on how strongly the condition is met. The *actions* are the robot's basic behaviours. The connections that tie a set of condition to an action and its evaluation are programmed through a new own-developed high level scripting language.

Team coordination is obtained by incorporating some conditions depending on messages coming from other robot (e.g. *"IHaveTheBall"*, *"IWantToPass"*, etc.) in the evaluation of the conditions. This method was inspired by our previous work on *Emergent Behaviour* [3] and resulted to be effective during the games and especially during the challenge where our robots showed a cooperative action, ranking second in the free challenge trial. To see the movie of the challenge, please have a look at the URL: www.dei.unipd.it/robocup/resources/Video/

4 Analysis of performance at RoboCup-2003

After the RoboCup 2003 World Cup games we can draw some comments on the state of our team:

- Robotic platforms older than two or three years have severe hardware reliability problems;
- The new robot *Argo* was not tested before RoboCup-2003, due to lack of time, and resulted to be unstable and to have motor problems;
- The vision system of the robots probably needs a new color segmentation approach, but generally it proved to be reliable;
- The self-localization algorithm usually fails when robot is close to the corners of the field. We are working on a probabilistic approach to robot localisation, using a Monte Carlo Localization technique [5] [6] with an innovative omnidirectional vision sensor [10].
- Our ADE networking and multi-threading environment proved to be robust, powerful and scalable to new approaches (despite we changed all the software controlling the robot, we did not need to change anything in ADE);
- The new fuzzy-logic system for decision making on the robot proved to be very effective during the challenge competition, because in few minutes we were able to code a complex behaviour with just few lines of code. Unfortunately, it was developed too late to be effective during the competition;

5 Conclusions

We illustrated the Artisti Veneti-2003 team, composed of a goalkeeper, a new second goalkeeper, two two-wheels based players and two Golem platforms. The only sensors used by our robots are their omnidirectional vision systems. Our team plays according to a new selecting behaviour system based on fuzzy-logic, called ARTIFACTS. The robot communication and thread scheduling are implemented through ADE (Artisti Veneti Development Environment) suite.

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