Golem Team in Middle-Sized Robots League

Golem Team
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Abstract. Golem is an holonomic robot designed to be compliant with Robocup regulations for the middle-sized league. The project consists in three parts: mechanics and hardware, vision system and software. We adopted the universal three wheels model to achieve a great freedom of movement. In order to take advantage of this particular feature, the vision system has to give a full sight of the environment. This objective is achieved by a mirror mounted on the mobile base. Decision making and planning are based on the knowledge of the relative prosition of all objects in the field (ball, walls, robots, goals) and especially on the recognition of teammates and opponents. Every robot can play as goalkeeper, defender or attacker.

1 Introduction

Golem Team is a team compounded by some students of University of Padua who participated to Robocup 1999 World Cup, held in Stockholm, as members of ART - Azzurra Robot Team. After this important experience we have decided to start this new project that tries to cover all parts of a robot building process from the mechanics to the high level software.

In this paper we analyze these some main topics. In the following section we give an overview of this holonomic mobile base focusing on the mechanics and hardware. In the third section we describe the vision system from the point of view of the hardware and software. In the fourth section we explain how the software is embedded in the system and in the last we conclude with some general consideration about our team.

2 Mechanics Architecture

The motion unit consists of three universal wheels placed at the vertexes of an equilateral triangle. A brush motor drives each wheel. Our group designed a controller, based on the Hitachi H8/3334, to calculate and adjust the speed of each wheel. An optical shaft encoder is mounted on every motor and its resolution is such that one pulse represents 0.18 degrees of wheel rotation. Linear and rotational velocities may be independently

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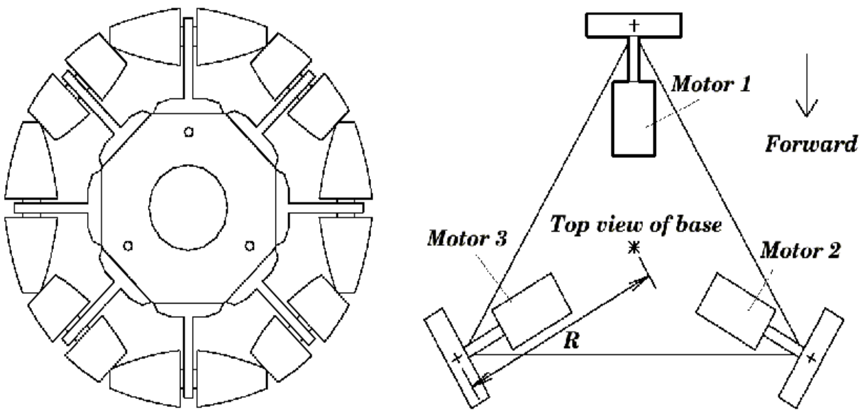
set by means of the mechanical architecture adopted, which allows the robot to follow the desired path without any constraint on its orientation, simplifying the playing algorithms.

Let r be the wheel radius, R the distance between a wheel and the center of robot and ω_1, ω_2, ω_3 the angular speeds of wheels; it follows that :

$$V_x \quad \frac{1}{3}\; r \;\; \omega_3 \quad \frac{1}{3}\; r \;\; \omega_2$$
$$Vy \quad \frac{1}{3}\; r \;\; \omega_3 \quad \frac{2}{3}\; r \;\; \omega_1 \quad \frac{1}{3}\; r \;\; \omega_2$$
$$Jog \quad \frac{r}{3\,R}\;\; \omega_3 \quad \frac{r}{3\,R}\;\; w_1 \quad \frac{r}{3\,R}\;\; \omega_2$$



We observe that if $\omega_3 \quad \omega_2$ and $\omega_1 \quad 0$ then $V_x \quad 1\;15 \;\; r \;\; \omega_3$ that is greater than the velocity which could be achieved by a unicycle robot.

Every robot is equipped with a pneumatic kicking device which can be used to kick in different directions and to dribble the opponents.

3 Vision System

To take advantage of the physical structure of the mobile base, we adopted an omnidirectional vision system. The hardware solution consists of a camera looking at a custom-made mirror. In this way we obtain a 360 degree perception of the field in a single image. The loss of resolution, typical of this kind of structure, is balanced by its efficiency in the tracking of evolution of the game.

The camera is a commercial product, the Hitachi VK-C78ES, an high-resolution camera whose lens gives a visual of 45 degrees; it is set up vertically pointing to the overlooking mirror.

The mirror was designed by Golem Team and was optimized for Robocup applications. It has a convex surface consisting of three different curves each dedicated to a particular kind of information, creating in this way three different zones of analysis. The inner zone reflects the whole view of the field: the profile of mirror is designed to minimize the reflected robot image. The middle zone is tailor-made to allow searching of markers placed on robots; the teammates recognition is a fundamental step to obtain a coordinated game and it is performed considering the color of the marker worn by the players. The middle zone of the mirror reflects the objects located between 30cm and 80cm of height from the field plan. The external zone, finally, is dedicated to the analysis of objects in proximity to the robot. A good ball control is possible only knowing its exact position, so the mirror shape increases the resolution of the image in this part of the visual area.

The equations of the curves composing the mirror were calculated upon a maximum acceptable error, function of the distance from the focus of the camera system.

The camera sends an S-video signal to a frame grabber based on the Conexant BT848 Chip. This is a simple and cheap system to capture high quality images from a camera.

The main problem to solve was the good real-time extraction of information from the frames captured. Every kind of object (ball, robots, field components) needs a dedicated approach to be recognized. Some data are needed with high frequency, while others can be refreshed less frequently. In order to reduce the computational load of the CPU, the vision software spawns several processes each of which evolves in parallel with its own frequency. For instance, we need to know the position of the ball with the highest possible frequency, so the searching process must be quick since it has to work at a frame rate of 25fps but, moreover, it must be robust in order to extract the ball position in a noisy environment. On the other hand walls do not move too far in the entire game, thus we can sporadically track them. This architecture let us use heavy algorithms blended with simpler ones yielding a system more flexible and capable to adapt to the on-board computer computational resources.

4 Planning and Behavior-Based Control

The whole set of software modules for controlling the players has been developed over the ETHNOS' [1] kernel. ETHNOS is a real-time programming environment which exploits the LINUX RT multithreaded operating system and provides communication facilities. It provides support for the real-time execution of periodic and sporadic tasks (called Experts).

Vision Experts, Planning Experts and the Arbitration module are realized as periodic Experts while each behavior is a sporadic Expert. At every decision step the Arbitration Expert activates a single basic behavior (such as 'kick ball' or 'intercept ball' or 'follow teammates' , etc.). Every behavior tries to perform its task according to planning directives (for instance the preferred direction to avoid an obstacle). Communication of raw data is not used. Every robot communicates 10 times per second the value of a function (Q function) which quantifies its priority in the action. Q is a function of ball distance and velocity, relative positions of ball, robot, goal and precedent results in performing the action. The hierarchy introduced by Q prevents a robot from interfering with the action of a teammate which could be carrying the ball.

[1] ETHNOS : Expert Tribe in a Hybrid Network Operating Systems developed by DIST of University of Genoa, Italy. http://www.ethnos.dist.unige.it

Since players have the same planning system, they can make assumptions on teammates intentions. This is a fundamental capability for obtaining an effective coordination without using a global positioning system or explicit communication. Every robot can play as defender or attacker, according to situation, score and its own disposition.

5 Conclusions

In this paper we presented the Golem Team for Robocup 2000 contest and we described the hardware and software of the robots. In our opinion this mobile base permits to perform a good play in the field and enhances coordination possibilities.

It should be clear that we want to reduce the explicit communication of information, let any single robot to act only using information obtained from the vision system that is the main sensor of these players.

From the point of view of the high level software, that rapresents the reasoning module of the robot, it can be considered as a layered module where the internal layers are the basic behaviors. Our work is now focused on the external layers that allows to improve the general capabilities of this kind of autonomous systems.

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