New improvements of MINHO Team for RoboCup Middle Size League in 2003

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Abstract. Although this research group has started a robotic football team in 1998, MINHO team has been participating in RoboCup only since 1999. The robots were completely developed by the undergraduate team members (mechanics, hardware and software), due to budget reasons, and every year new improvements had been made. The team came to a point where new improvements would mean complete changes in the robot design, hardware and mechanics. Therefore, this year major changes have been implemented. Being all member of an Industrial Electronics department, our main research areas consist of general electronics, computer vision/image processing, and control. In this paper, the major changes implemented are described and some results assessed.

1 Introduction

Although many teams prefer to buy a standard off the shelf robotic platform and implement some changes in hardware/software or even some adaptations, Minho team builds their own platforms from scratch with undergraduate students as part of extra curricular work and with reduced budget. This continuous participation in RoboCup has led to many new developments in many fields. In previous years [1][2], the robots used poor and too complex mechanics, which meant that frequently problems would occur. A decision was taken of implement major changes in mechanics and hardware in the robots this year, and to improve the strategy/tactics and cooperation algorithms for next year when RoboCup will be held in Portugal.

2 Omni Wheels

It is of maximum importance for the robots to move as fast as possible towards the ball in order to control it sooner than the opponent team robots. With the use of Omni wheels (also known as Swedish wheels) there is no need to rotate the robot until it reaches the ball direction, since the robot can move in any direction. Therefore, the decision of using three omni wheels (as shown in Figure 1) was easily taken.

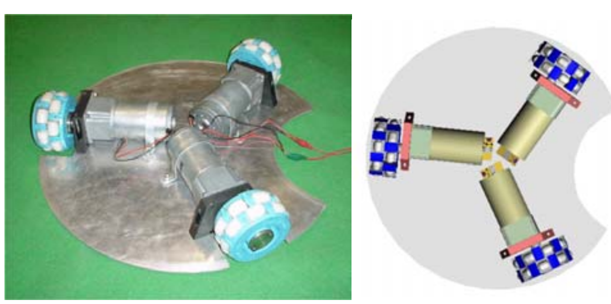

Figure 1 – Three-Wheel drive mechanical construction (physical and CAD design)

These wheels provide simple control and steering, allow extreme maneuverability and speed reaching the ball direction. However, this type of wheels also has brings up other problems

like traction and their facility of being pushed by opponents robots. This is the main reason why it is not advisable to use this type of wheels on a goalie.
Previous attempts had been made with this type of wheels and an example is the Artisti Veneti team which already uses an holonomic platform as described in [3].
The motor control is simple. The total platform displacement consists of the sum of three vector components (one per motor) and is represented as a vector in the platform body center.

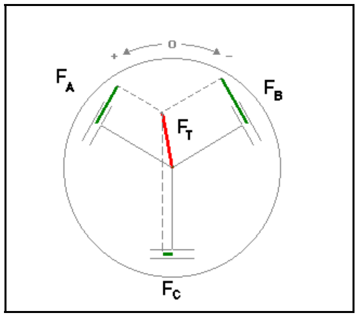

Figure 2 – Motor contribution vector representation for a certain desired movement

In Figure 2 it is depicted a vector representing the desired movement (F_T in the center); the angle represents the direction and the length represents the speed. In order to find out the three independent motor contributions, this vector is projected on A, B and C axis representing each wheel line of movement. The vectors can have a positive direction (to the left) or a negative direction (to the right) which represent the direction in which the motor has to move (forward or backwards respectively). Should angular movement only be required, identical contributions are given to the three motors.

3 New Platform Design

Since the wheels used were shorter (half the size of the old wheels), this allowed to lower the gravity centre. New stronger and lower consumption 24V motors were bought and they were directly coupled to the wheels, reducing mechanics (previous version had external gearbox with complex mechanics). Infrared encoders and respective electronic were developed by the team. They can read 24 different positions per crankshaft turn. As the ratio is 3.125 and the wheel radius is 50mm, that gives a resolution of approximately 4mm (in straight line, with no load and without slippery).
Also taken into consideration for this new robot design were reduction of the total weight, increase of battery autonomy, reduction of hardware and utilization of, as standard as possible, hardware. Figure 3 shows the new robot design.

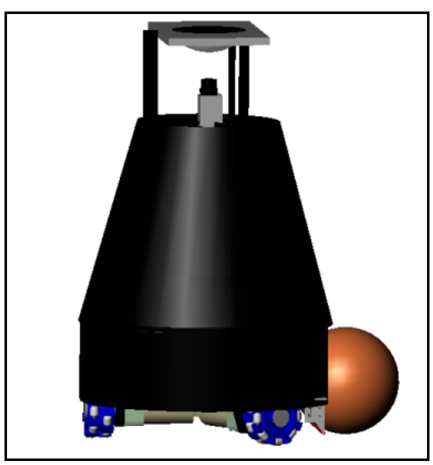

Figure 3 – New robot design (in SolidWorks 2001)

4 On Board Computer

A Low consumption computer motherboard VIA EPIA M + C3 running at 933 MHz is used, with 256 Mbytes of P266 memory and a 2.5” IDE Flash Drive with 256 Mbytes. This motherboard has a VGA board embedded, supports USB 2.0, it has 1 parallel port (from where the outputs are sent to the motor controllers), 1 serial port and a PCI slot. A two PCI raiser is used in order to connect the two boards (wireless Network board and the frame grabber). The operating system used is Linux Slackware 8.1, the Image processing software is written is Assembly (AT&T) and the game strategy is written in C language.

5 Kicker

A new magnetic impelled kicker was developed, similar to the previous one but stronger and faster charging. It uses an electric coil, in which a current passes through and attracts a cylindrical iron core. At the other end, a cylindrical shape nylon piece is attached to the metallic core and pushes the ball away.

Table 1. Kicker Characteristics

Characteristics	
Max. charging time	1.5 seconds
Equivalent capacitance	833 μF
Coil inductance	55 mH
Coil resistance	6 Ω
Max. energy consumption by kick	54 Joule
Weight	2 Kg
Ball distance	50 meters (approx.)

6 Vision

Although the same parabolic mirrors are used, they are placed in a different orientation. The new robot design allows the camera to face upwards and the mirror to face downwards. In previous versions the mirror and the camera were in a similar position but pointing slightly to the robot’s front, since the back of the robot would cover part of its field of view.
With this new orientation real Omni vision is now achieved, being possible to see at a distance of about 8 meters. The image is also centred which simplifies the software build up.
New image processing routines were developed and these allow most of the setup without the need to re-compile the software. Users without much programming knowledge can easily add virtual sensors to the game strategy, just by editing a parameters text file. The main routines are *Histograms*, *Areas* and *Colours*. Parameters like the window coordinates, the threshold and the required colour are only examples.
Football field Lines detection is carried out as first step to find the location of each robot as described in [4]. This technique uses a co-linearity detection algorithm after applying a convolution mask to the image.

7 Motor Control

A new motor control board was designed and developed by this team. One board per motor is used (3 per robot) and it consists of a Microcontroller which, after a computer output, defines the motor direction and speed by generating the PWM through a control algorithm on the microcontroller.
It also receives the infrared encoder reading which when compared with the required speed, generates the error and is then fed to the speed control algorithm.

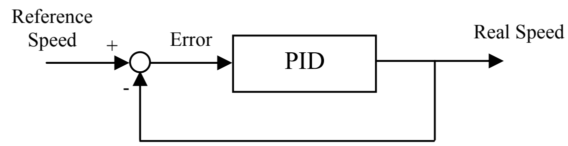

Figure 4 – Algorithm of the motor control boards

An electric current sensor is also embedded on the circuit board which detects and limits high currents (when a wheel is stuck for example). When that happens, the motor power supply is cut. This avoids the motor to break down and avoids also strong collisions with opponents' robots.

8 Conclusions

A new robot design was created with Omni wheels, which allows easier control and maneuverability. The robot's gravity center was lowered and the weight reduced. New low consumption and strong motors are used and directly coupled to the wheels reducing mechanics complexity. High speeds are reached although some slippery exists.
Unlike our previous robots, each motor and respective encoder is controlled by a PIC16F87XA, leaving the computer processor free for the image processing and game strategy. The kicker is strong, it charges completely in about 1,5 seconds and it uses very little energy. The computer motherboard used runs at a 933MHz speed and controls the game strategy and wireless communications. Linux operating system is used and that permitted a reduction in code of about 80%. The robots were completely designed and developed from scratch by the team members.

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[1] C. Machado, I. Costa, S. Sampaio, e F. Ribeiro, "Robotic Football Team from MINHO University", in RoboCup-99: Robot Soccer World Cup III", M. Veloso, E. Pagello, H. Kitano (eds), Springer-Verlag, Berlim, Alemanha, 2000.
[2] Fernando Ribeiro, Carlos Machado, Sérgio Sampaio, Bruno Martins, "MINHO robot football team for 2001", in "RoboCup 2001: Robot Soccer World Cup V", Andreas Birk, Silvia Coradeschi, Satoshi Tadokoro (eds), Springer, LNAI 2377, Berlim, 2002, page 657-660.
[3] E. Pagello, M. Bert, M. Barbon, E. Menegatti, C. Moroni, C. Pellizzari, D. Spagnoli and S. Zaffallon, "Artisti Veneti: An Heterogeneous Robot Team for the 2001 Middle-Size League", in "RoboCup 2001: Robot Soccer World Cup V", Andreas Birk, Silvia Coradeschi, Satoshi Tadokoro (eds), Springer, LNAI 2377, Berlim, 2002, page 616-619.
[4] Fernando Ribeiro, Gil Lopes, "Real Time Game Field Limits recognition for robot self-localization using collinearity in Middle Size League RoboCup Soccer", Revista Robótica, N.º 50, 1º trimestre 2003, ISSN: 0874-9019, pág. 28-30.