MINHO Autonomous Mobile Robot Football Team

Fernando Ribeiro, António Sampaio, Ivo Moutinho, Paulo Braga,
Pedro Silva, Jorge Monteiro, Victor Silva, Carlos Fraga
University of MINHO, Dep. Industrial Electronics, Campus Azurém, Guimarães
fernando@dei.uminho.pt http://www.robotica.dei.uminho.pt

ALGORITMI research centre

RoboCup Initiative

By mid-21st century, a team of fully autonomous humanoid robot soccer players shall win the soccer game, comply with the official rule of the FIFA, against the winner of the most recent World Cup.

History

- 1993 - Idea, objectives, initial rules
  to develop a robot soccer team which plays like human players.
- 1997 - Nagoya
- 1998 - Paris
- 1999 - Stockholm
- 2000 - Amsterdam (European)
- 2000 - Melbourne
- 2001 - Seattle
- 2002 - Fukuoka
- 2003 - Padova
- 2004 - Portugal

Field

The challenge - Chess x RoboCup

	Chess	RoboCup
Environment	Static	Dynamic
State Change	Turn taking	Real time
Info. accessibility	Complete	Incomplete
Sensor Readings	Symbolic	Non-symbolic
Control	Central	Distributed

ROBOT DESIGN

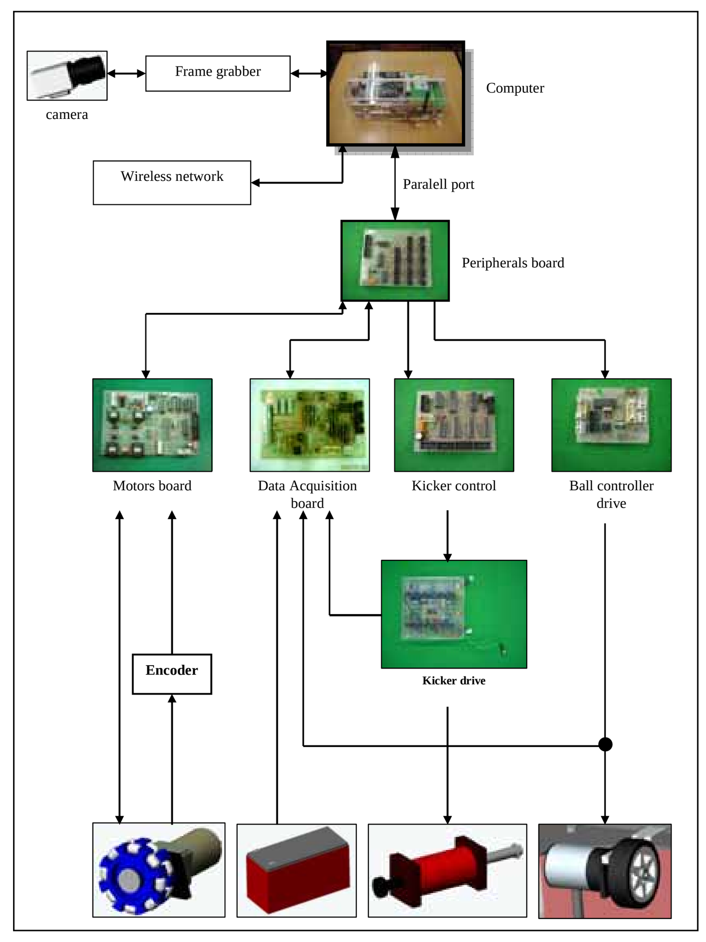
- Shape was designed/planned before implementation
- Conical shape to avoid hidden parts on the vision system and to protect main hardware from collisions
- Omnidirectional wheels at 120º were chosen to simplify steering and control
- The actual motors were chosen due to its characteristics: torque, speed, low consumption, 24V fed.
- The batteries and kick (heavy components) were placed at the bottom so that the gravitacional center was as low as possible.
- All the robot is divided in separated modules which can be easily and quickly replaced. Repairs are rare but very quick if needed. In most cases there are no screws only *velcro to hold things*.
- The PC is easily removable so the robot can be programmed at any place.
- The camera points upwards onto a spherical mirror facing down. This allows 360º vision allowing the software to react faster.
- The Kicker is very strong and feasible. It charges in aproximatly 5 seconds and can kick while charging.
- The ball handler controls minimaly the ball making it rotate while the robot is moving around searching for the goal.

Vision / Software

Robots Software

Remote system Software

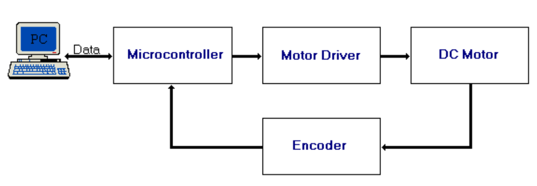
ELECTRONICS / HARDWARE



Computer:

- Motherboard: VIA EPIA M 933 mini-itx
- Microprocessor: Low consumption (VIA C3 933MHz)
- RAM Memory: 256MB (266MHz speed)
- 1 PCI Slot expandable to 2 (frame grabber + wireless networ board)
- WiFi: ACX100 (*Texas Instruments)* IEEE 802.11b compliant, 22Mbps
- Hard Disk: 256Mb IDE memory flash
- Power Source: 50W ATX fed at 12V
- Operating Sistem: Linux (Mandrake 8.2) text mode (150Mb only)
- Inputs/Outputs:
  - Composite Video (image capture)
  - Wireless LAN (Communications)
  - Parallel Port (Control)

Motor Control Board:

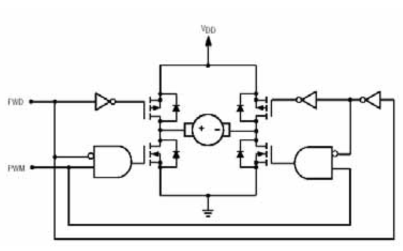


Microcontroller

The microcontroller (PIC16F876) handles all the commands for the robot. It controls the speed and direction of motors through the motor driver. The microcontroller tells the robot position via encoder output.

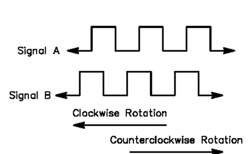
Motor Driver

The motor driver consists mainly of two PMOS and two NMOS power transistors connected in an H-Bridge fashion. This configuration allows the output voltage to be of either polarity, thus allowing the motors to turn in both directions. The input voltage controls the speed of the motors by PWM, which is handled by the microcontroller.

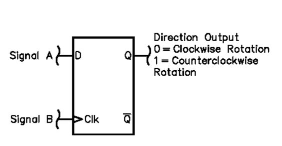


Encoders

When it comes to digital rotation sensors, the idea is to develop digital signals that indicate both direction and rate of rotation. The most common arrangement is a pair of digital signals in quadrature. That is, two digital signals having a 90° phase relationship (Figure). When the shaft is rotating in one direction, signal A leads signal B; when rotating in the opposite direction, signal B leads signal A.



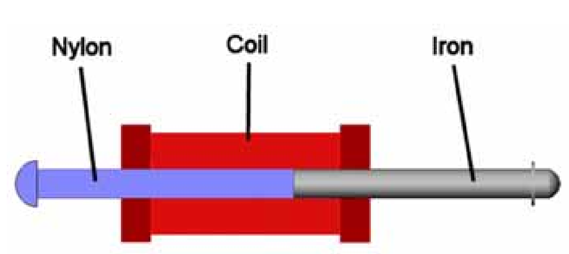
It is easy to determine the direction of rotation using an edge-locked D flipflop (Figure). Applying signal A to the flip-flop's clock input and signal B to its data input, signal B is low at signal A's rising edge when rotation occurs in the opposite direction; it is high when rotation is in the opposite direction. The flip-flop's output signal, Q, therefore indicates the direction of rotation. Such a direction signal, combined with the rate of one of the signals, A or B, yields the direction and speed of rotation.



KICKER

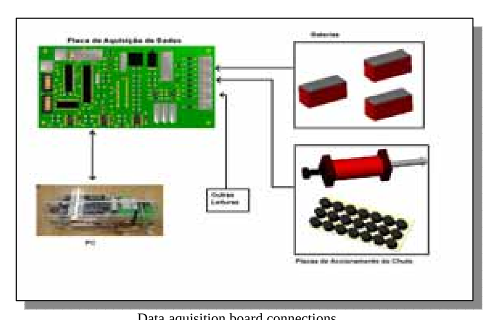
The kicker consists basically of an electric coil with a movable core made up with two different materials: one length of iron and one length of nylon. The iron part is mostly outside the electric coil and the nylon is mostly inside the coil void.
When electric current is applied to the electric coil, the core is pushed towards the nylon side so that the iron goes inside the coil, and it is the nylon part that will push the ball. The core force is proportional to the electric current on the coil, and also proportional to the amount of iron used in the metallic core.

Characteristics	
Max. charging time	12 seconds
Max. voltage discharge	400 Volts
Equivalent capacitance	4,3 mF
Coil inductance	55 mH
Coil resistance	6 Ω
Max. energy consumption by kick	174 Joule
Weight	2 Kg
Minimum discharging time (weak kick)	1 ms
Maximum discharging time (strong kick)	25 ms
Ball distance	50 meters



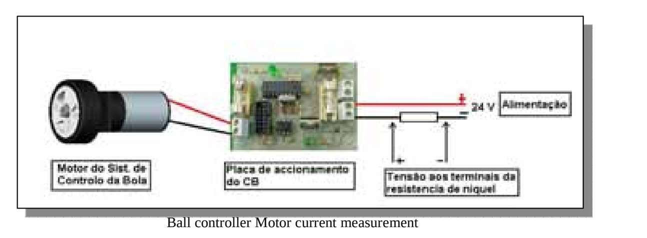
Data acquisition board

The robot uses 4 batteries 12V 7Ah, one for the computer and the others three to power the motors, kicker and more electronics.



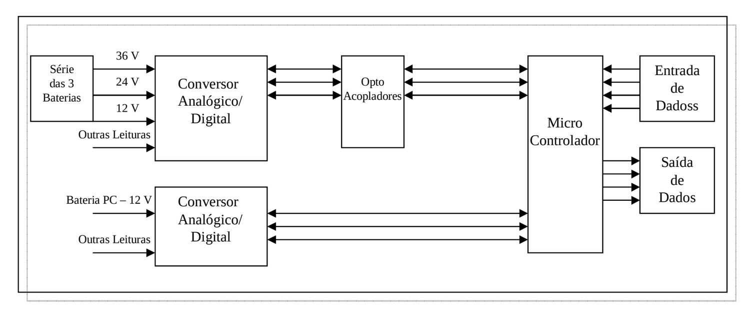
Data aquisition board connections

This board not only measures the batteries voltage but also the current on the ball controller motor in order to detect the presence of the ball.



Ball controller Motor current measurement

The board uses two analog/digital converters, to translate the voltage, the opto-couplers to isolate the earths and one microcontroller to interface between the converters and the PC. The microcontroller works as a logic unit which receives orders from the PC and controls the analog/digital converters



Data acquisition board block structure