RoboIME : Team Description Paper for LARC/CBR 2012

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Abstract— **This paper describes the electronic, mechanical and software designs developed by RoboIME Team in order to join LARC 2012. All designs are in agreement with the rules of Small Size League 2012. This is the second RoboIME participation in a Latin America level RoboCup event, although the team was already challenged twice in Brazilian competitions in recent years.**

I. INTRODUCTION

RoboIME is a small-size league soccer robot team from IME, Rio de Janeiro, Brazil. This is the fourth time the team is taking part in competitions. The main result was in 2011 when the team achieved second place in RoboCup Brazil Open.

All students that work in this project are members of the Laboratorio de Robotica e Inteligencia Computacional at IME. The previous studies [1][4] provided the basis for the current structure of software and hardware team's. The current team structure is based on the design for participation in RoboCup 2012 [9]. This paper describes the current software modules, electronic and mechanical design.

II. SOFTWARE SYSTEM

The software system consists basically of five modules: AI, LogPlayer, Simulated World, Support Simulation and Transmission. The modules were implemented using the Microsoft Visual Studio 2010 IDE, that allows a single solution integrated of projects in different programming languages (e.g. CSharp, C++), making the project more flexible for other programmers giving continuity to the implementation.

We chose to adopt the fragmentation of the software project into modules to facilitating the implementation team. A UDP socket interface was adopted for communication between most modules giving independence to them. Some interfaces like between AI Module and Support Simulation Module, that need high performance, don't communicate using the UDP Socket interface. Figure 1 shows the block diagram of the software system.

A. AI Module

This is the largest and most complex software module. It is responsible for the following features:

- Collect, interpret and filter data from the Referee-Box, SSL-Vision, Transmission Module (real world or simulated), Support Simulation Module and Joystick;

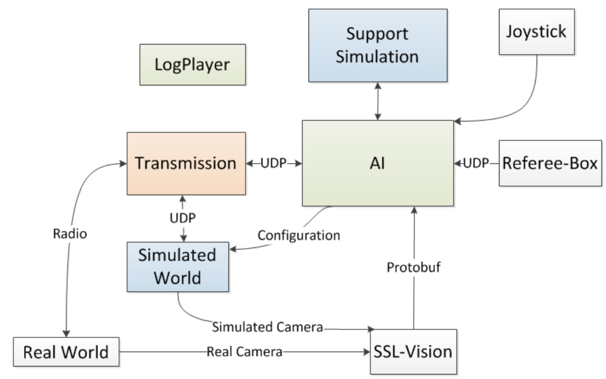

Fig. 1. Block diagram of the software system

- Take high level decisions to define the actions that robot should do (i.e., to find the position and orientation that robot has to reached, find the force to kick the ball, find the torque to dribble the ball);
- Use the Support Simulation Module to create a planning;
- Make a short future preview of the world (real or simulated) using data from the sensors (encoder, camera, infra-red);
- Make the configuration of the simulation environment Simulated World (setting bodies existing in the simulation);
- Control position and orientation of the robot defining which speeds the robot actuators (motor, kicker and dribbler) must reach. These speeds will be passed to Transmission Module to be sent to the World (simulated or real);

Among the many reactive behavioural control architectures, we have chosen STP (Skills, Tactics and Plays) architecture [2]. In order to create a plan, we use two algorithms: Minimax [6] and BK-BGT (Behavioural Kinodynamic Balanced Growth Trees) [7]. These algorithms works as Play on the STP architecture.

On the implementation of Minimax, the players agents are based on objective (assessed by an objective function) and the minimax algorithm is used to define which heuristics (Skills, Tactics and Plays) to use. The objective function consider several factors: distance from the ball to the opposing goal, distance from the ball to the goal together, distance from the ball to the opposing players, among others. The two algorithms use the Support Simulation Module to creating a

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Physics-Based Robot Motion Planning.

Extended Kalman Filter (EKF) [8] is used to offset the effects induced by time latency in that accumulates in vision systems, AI, communication and execution of commands for the robot.

B. LogPlayer Module

This module is important to debug the planning algorithms. AI Module creates a log file with all the information necessary to describe the tree planning, so using the LogPlayer Module we can play the log files to visualize all possible solutions present in the tree planning.

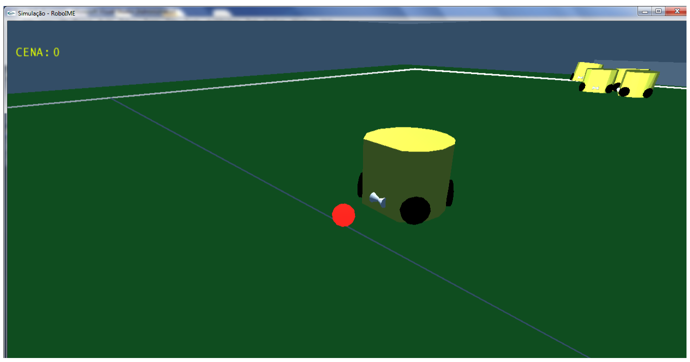

Fig. 2. Simulated robot.

C. Support Simulation Module

This module is part of F180 environment simulator. It simulates the physics of bodies presented in a match from the Small Size Robot League. Its also so possible to make the control of robot actuators (motor, kicker and dribbler).

The simulator was developed using the PhysX Engine, that enables high performance processing physics calculations in a GPU. Figure 2 shows the robot in the simulator. This module can provide long-terms predictions, in opposition to the Kalman Filter that provides a short-term prediction.

D. Simulated World Module

This module is also part of the simulator designed to F180's environment. But this module replaces the Real World, when it is not convenient to use it. Thus this module receives through UDP sockets the speeds that the actuators of the robot must reach, the simulator has an internal controller to calculate the torque required to be applied to the actuators to achieve the desired speed (like real robot).

The AI Module can configure the simulation environment of the Simulated World Module just sending an XML file, via UDP Socket, containing information for the construction of bodies in the simulator. This module has two simulated cameras which provide input to SSL-Vision, we use two OpenGL cameras and the images are sent through TCP sockets.

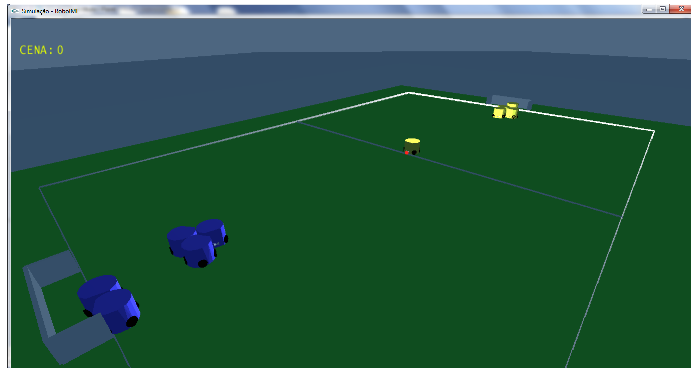

Fig. 3. Simulation environment of the F180.

E. Transmission Module

This module is responsible for delivery the speed to actuators and receiving status of the robot, such as real velocity of each motor, kick sensor status and power supply status, via radio in Real World or via UDP socket in Simulation World. This module is coded in CSharp language using the interface development Microsoft Visual Studio 2010 IDE.

III. Path Planning

Path planning algorithm is based on the theory of Artificial Potential Field [3], which has as its fundamental principle driving the robot in an artificial force field generated by obstacles and the target. The potential (gradient) should be continuous. The obstacles (other robots) and the target (certain objective local) generating fields of repulsion and attraction, respectively, obtaining a movement by which avoids obstacles and possibly reach your goal.

IV. Electronic Project

RoboIME electronics consist of seven boards: (a) the Main board, responsible for communication between the other boards; (b) the Stamp board, responsible for the embedded computation; (c) the Kicker board, responsible for maintaining the high voltage to activate the kick shoot; (d) four motor controller board which are responsible for robot's motion control. These boards are described in details in this section.

A. Main Board

The Main Board features a socket to plugin the boards: kick's sensor, dribble's motor, four wheel's motor, four encoders and the power supply. There is a RFM12b SMD embedded which is a wireless transceiver operating in the 434 MHz band, set as up to 115.2 kbps, fully in agreement with with FCC and ETSI regulations.

The communication protocol used between the Stamp Board and the transceiver was Serial Peripheral Interface Bus (SPI), that is a synchronous serial data link standard that operates in full duplex mode.

B. Stamp Board

This board is responsible for performing all the logic functions. It is like a brain of the electronic system. There is a embedded micro-controller STM32F103, that has ARM Cortex M3 as main CPU, 512 k RAM memory, working in 72 MHz, that was programmed with C language using the interface development CoIDE.

C. Kicker Board

This board is responsible for controlling the kick strength. There is only one kind of kick, the kick shoot. Two capacitors 1000 μF, 250 V are used to raise voltage in a boost circuit. The charge is discharged in a solenoid and depending on the PWM signal the kick device is activated, it is possible to control the kick velocity.

D. Motor Controller Board

The idea of the RoboIME electronic is to modularize the electronic project. So, there is controller module board for each wheel's motor. If one of them burns out, it is possible to change quickly. Each board has two TC4427 (MOSFET driver) and two IRF7319 (half H bridge). These ICs create a H-bridge, allowing velocity control in both directions.

V. Mechanical Project

In compliance with the SSL rules, the height of the robot is 148 mm, the maximum percentage of ball coverage is 15% and the maximum projection of the robot on the ground is 175 mm.

With the aid of CAD software (Computer Aided Design) and CAM (Computer Aided Manufacturing) a new robot has been developed based on a former RoboFEI team model, with some adjustments and changes. Figure 4 and 5 shows mechanical 3D view and real view of the robot. In relation to the shelf that had been used, this allows movement omnidirectional and has a greater torque that couples the fourth motors (one for each wheel) for the movement.

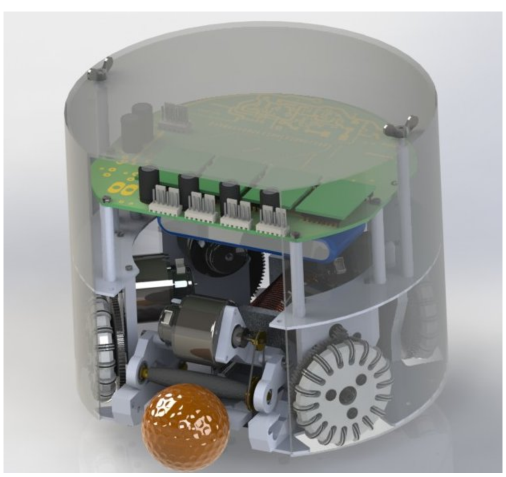

Fig. 4. Mechanical 3D model view.

The changes in the original design of the RoboFEI model provided a lower weight to the robot, such as: changing the

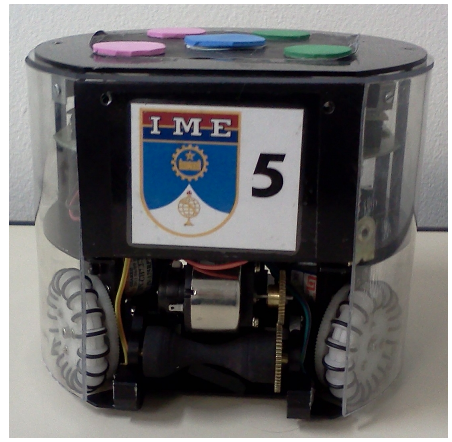

Fig. 5. Real robot view.

steel shaft by a shaft of high-strength aluminium wheels and replacement of aluminium by plastic wheels Polytec 1000. This new design also enables more devices to be shipped. It presents a diameter of 175 mm and an upper base with holes which give versatility to the coupling. The fairing of the robot was made from polyvinyl plates.

VI. CONCLUSIONS

The development of the LARC 2012 mechanical project was recently concluded, based on the one we created for RoboCup 2012. The six robots have already been manufactured, with only a few parts still needing rework. Some electronic prototypes were made, yet stabilizing efforts are still ongoing. The five modules of the AI system have already been implemented but they still need to be brought to perfection.

To the October competition, following goals are being sought: rework the remaining parts on the mechanical project such as making improvements on the coiling of the solenoid coil; stabilize the electronic project, including robot feedback and conclude the implementation of planning algorithms to be used in support decision making.

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