

## **STOx's 2011 TEAM DESCRIPTION PAPER**

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**ABSTRACT:** This paper presents an overview of the design and construction of the team of small size robot league of Santo Tomas University. This team was reunited to participate in the Latin American RoboCup Open 2010 and it's also supported by the result of several years of research and development. The development is show in two main parts: the design and construction of the robot and the development of artificial intelligence system for the team. The improvements to the team this year are the correction of errors in mechanical and electronic design, the addition of a parabolic kicker, the enhanced multi-agent system and the implementation of a simulator.

### **1. INTRODUCTION**

Our team was assembled inside the group of research and development in robotics GED, attached to the Faculty of Electronical Engineering of the Santo Tomas University, in order to join the RoboCup global initiative. In 2010 we participated for the first time in the Latin American RoboCup Open held in Sao Paulo (Brazil) in October; we played the final versus team RoboFEI thus obtaining the second place.

The robot team is composed by two main components: the robot and artificial intelligence system. The robot has mechanical and electronic control systems, configuration and debug system. The AI system is a software that gives the strategies, roles and tasks to each one of the robots depending of the position information and orientation of themselves and the ball, as well as predictions made with this information.

This year the team's main advances are: the design error's correction to make the platform even more reliable and robust, the incorporation of a parabolic kicker device, the improvement of the artificial intelligence system by the incorporation of new strategies, and the implementation of a game simulator with the purpose of decrease the development and the strategies times.

### **2. THE ROBOT**

Our equipment initially consists of five identical robots built in 2010; currently we anticipate the construction of three more robots. The design of intelligence of these robots won't be significantly changed, but we will correct the evidenced issues and we will add the ball's

parabolic kicking system. The robot measures are 178 mm in diameter and 145 mm high. The driving system (dribbler) covers the ball by 18%, complying with the competition rules. The real robot and 3D model of the robot are showed at Fig. 1 and Fig. 2 respectively.

## 2.1 MECHANICAL DESIGN

Mechanical components are based on previous designs of teams in the league, and developed its own designs to meet the needs of the robots and the requirement of the game.



Fig. 1 Real robot

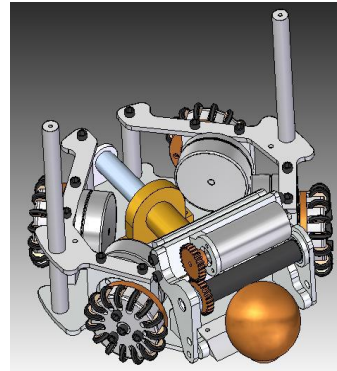


Fig. 2 3D Mechanical model of the robot

**Chassis:** The chassis was built based on the design of Skuba 2009. All the pieces were made with CNC machinery using aluminum 7075. The material and the fabrication process provide the robot a good balance between strength and weight, also a high similarity of parts.

**Traction:** The robot's traction is omni-directional, with four custom-built wheels. Each wheel has a diameter of 50mm with 15 rollers, these wheels are connected with the motors through a gearbox of 61:17 based on the design of Skuba 2009. The robot has four brushless motors "Maxon EC45- Flat 30W", these motors provide a maximum speed of 3.2 m/s to the robot. The Robot's chassis with wheels and motors is shown in Fig. 3.



Fig. 3 Robot's chassis with wheels and motors

**Dribbler:** The dribbling system of the ball is essentially composed of an EC-22 brushless motor mated to a cylindrical rod covered in rubber with 10mm of diameters. This set provides a maximum rotation speed of 12000 rpms, also the design features a cushioning system to make more effective the dribbling ball. The Fig. 4 shows the dribbling system and the Fig.5 shows the model of dribbling system.



Fig. 4 Dribbling System

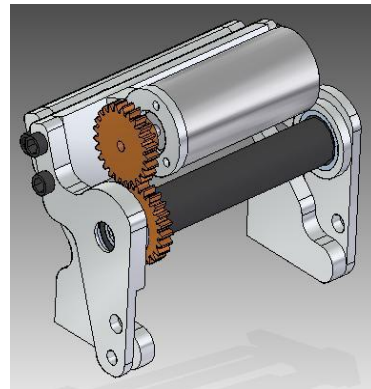


Fig. 5 Model of the dribbling system

**Flat Kicker:** The main kicker device is a custom solenoid. The core is made of Bakelite, wrapped with 6 layers (400 turns approx) of 24AWG enameled wire. The plunger is composed by two parts, a highly magnetic one and other non-magnetic. This configuration provides to the robot a maximum kick speed of 10m/s.

**Chip Kicker:** the parabolic kick system provides a 4m of ball kick's distance. It uses a different solenoid that the main kicker.

## 2.2 ELECTRONIC DESIGN

The robot's electronic system consists of two components: the logical system implemented on a Spartan 3 FPGA and the power system that performs coupling of control logic signals to the motors and sensors. The Fig. 6 shows electronics boards.

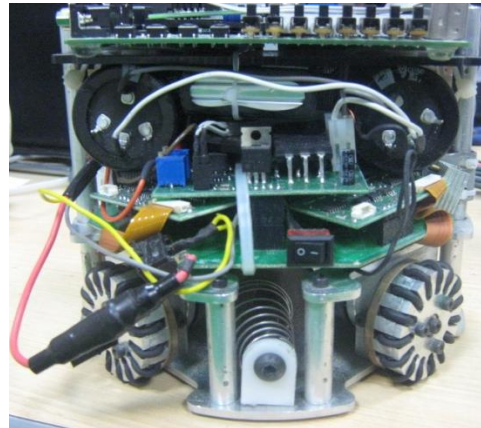


Fig. 6. Electronics Boards.

**Traction motors control:** It consists in a speed PI controller manually tuned. The speed sensor is implemented by a quadrature encoder 300 PPR. The brushless motor driver consists of a simple combinational circuit that switches the three-phases according to the state of the Hall Effect sensors of motor. In order to regulate the motor's speed we use a PWM signal, which is operated by a logical AND with each one of the brushless motor driver outputs.

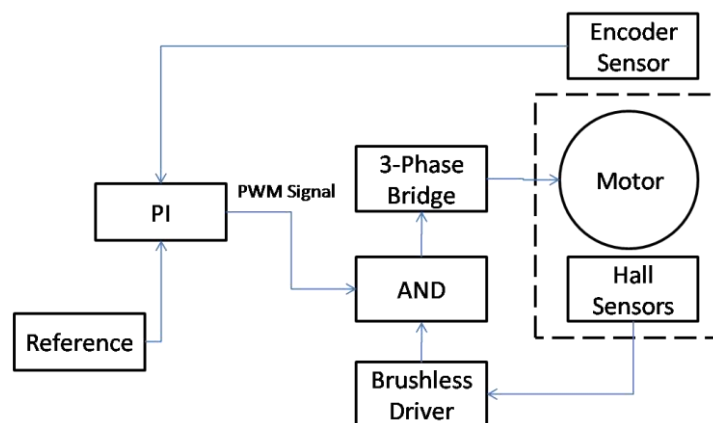


Fig. 7 Control system of traction motors

**Dribbler Motor Control:** This system is similar to shown in Figure 6 (above). The fundamental difference is that it doesn't use an encoder to measure the speed but uses motor's Hall Effect sensor signals for this purpose. This modification was done because the dribbler control doesn't require a high performance driver. Additionally, it was implemented an over-current

protection circuit avoiding the damage of the three-phases Bridge when the motor it's been blocked.

**Kicker's Circuit:** This circuit consists of two elementary parts: A DC boost converter circuit which charges two capacitors of 2700 $\mu$ F from 0 to 200V in 10 seconds. The second part of this design is a two IGBTs which conduce energy from capacitors to corresponding solenoid. The control signal of each IGBT is a PWM signal that allows modulating the shot intensity.

**Ball's Sensor:** This sensor is an IR emitter-receptor pair, which it detects the ball presence inside the robot's Dribbler. The sensor's signal is amplified and digitized to be analyzed by the AI system.

**Communication:** For this purpose we use X-Bee modules, which provide full-duplex communication between the robots and the central system. The X-Bee modules operate in broadcast mode at 2.4GHz frequency and can be set up in 8 different channels. Our team usually used the channel 4, but it can be set up quickly in to another channel.

**Power Supply:** This is a single Li-Po battery; it has 11.1 volts and nominal capacity of 2000mAh which provides to the robot with 30 minutes game play autonomy.

### 3. ARTIFICIAL INTELLIGENCE SYSTEM

In this section we describe all about Team's intelligence. The decisions are taken depending on the different game situations and the orders given by the RefereeBox. Besides we can develop processes to optimize the mobility of robots on the field so they can avoid collisions and the robots will be able to move through less congested places.

#### ***Vision processing***

The vision information that comes from SSLVision is organized according to the color mark's of team. Several filters are applied by a set of logical rules, in order to avoid wrong information that can be introduced at the moment that the vision system loses the track of the robots or the ball. Also a ball's motion-speed prediction operation it's been done so the system can anticipate the movements.

### ***Roles and skills Architecture***

The general architecture has a hierarchy form. The vision and RefereeBox information are evaluated in a module enabled for the team's strategy, which gives the roles (game attitudes) to each one of the robotic agents according to the game's situation. The block diagram it's shown in the Fig.8.

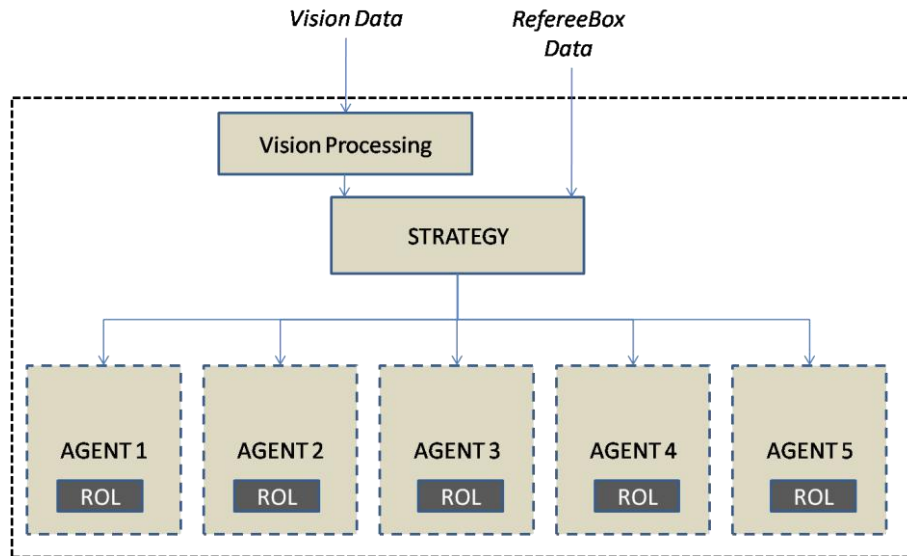


Fig. 8 Artificial intelligence system

### ***Simulator***

This tool was designed to develop different strategies to avoid mechanical damage of the robots. The simulator works in two dimensions and its basic features are translational and rotational movement of the robots, simulation of collisions and three-dimensional movement of the ball, also including the possibility of human intervention through controls XBOX.

## **4. CONCLUSIONS AND RESULTS**

This Project began in 2009 and so far we have a team who participated on the Latin American Robocup Open 2010 taking the second place.

The design and development of these robots has allowed the students to involve in this matter. The students can learn how to program the systems that can be found on each robot, and also the general artificial intelligence, the electronical and mechanical design required for the development of each one of the platforms.

Since 2009 we have faced different problems and challenges of build these robots, but with the help and useful information found in the ETDPs, We could solve many problems and create a platform according to the requirements for the RoboCup F180 League. We hope to take a part this year at the RoboCup 2011 and can share all our experience with teams around the world.



Fig 9. STOX's team



Fig 10. Latin American Robocup Open 2010.

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