

# STOx's 2013 TEAM DESCRIPTION PAPER

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**ABSTRACT.** This paper shows the status of Small Size League team of Santo Tomas University. The team is active in RoboCup since 2011 and intends to participate in Eindhoven 2013. The software and hardware designs are described emphasizing on the improvements made of this year.

## 1 INTRODUCTION

STOx's SSL Team was built by The Robotics Research and Development Group (GED). The group is attached to Electronics Engineering Faculty of Santo Tomas University, in order to join the global initiative RoboCup. In 2010 we participated for the first time in Latin American Open RoboCup which we got placed second. Subsequently, we participated by first time in 2011 at RoboCup Worldchampionship, in which the team got ranked in top 12 and then we participated in RoboCupWorld-Championship 2012 where team were left in Round Robin.

Over 2012 competition, we detected some problems with communications system that limits and reduces the performance of robots and therefore this year the team has decided to implement a new communications system that will be explained in greater detail forward.

Hardware Robot design includes mechanical devices and electronics control systems. These systems have had a very good performance so far, so we decide to keep almost the same structure with a little modification.

Software design is composed by modules as Filtering, Prediction, High Level Control and Artificial Intelligence (AI) system that determine team strategy. All of these modules have been restructured to improve the team performance, also the robots performance.

As a result, for this year our team main advances are: an implemented new communication system, an incorporated more robust intelligence architecture. This architecture is supported by the creation and implementation of a new software platform.

## 2 HARDWARE DESING

Initially, our equipment consists of eight identical robots built in 2011. The mechanical design of these robots won't be significantly changed. 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 is showed at Fig. 1.

### 2.1 MECHANICS

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 game requirements.



**Fig. 1.** Real robot

**Chassis:** The chassis was built based on the design of Skuba 2009. All pieces were made with CNC machinery using aluminum 7075. The material and the fabrication process provide to 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. We implemented double seal o’rings to the rollers to provide more grip to wheels. The Robot’s chassis with wheels and motors is shown in Fig. 2.



**Fig. 2.** 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. 3 shows the dribbling system and the Fig.4 shows the model of dribbling system.



**Fig. 3.** Dribbling System



**Fig. 4.** 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. The speed is limited by software to 8m/s to comply current rules.

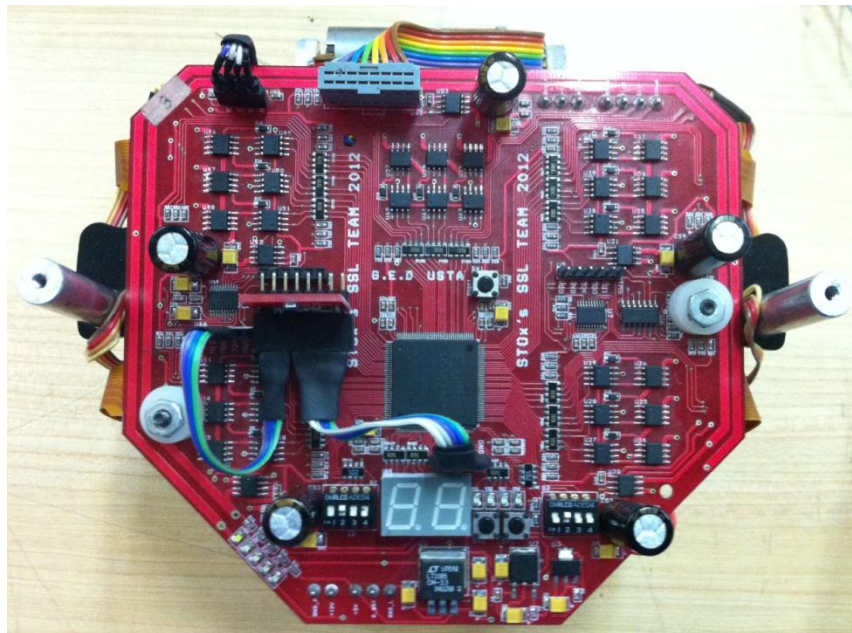


**Fig. 5.** Flat Kicker

*Chip Kicker:* the parabolic kick system was based on Skuba's design and provides a 4m of ball kick's distance. It uses a different solenoid than main kicker.

## 2.2 ELECTRONICS

By 2012 we designed a custom board. This board allows us to get over electronics system problems, so this board is used in our robots so far and its performance is very good. Figure 6 shows the Main Board.

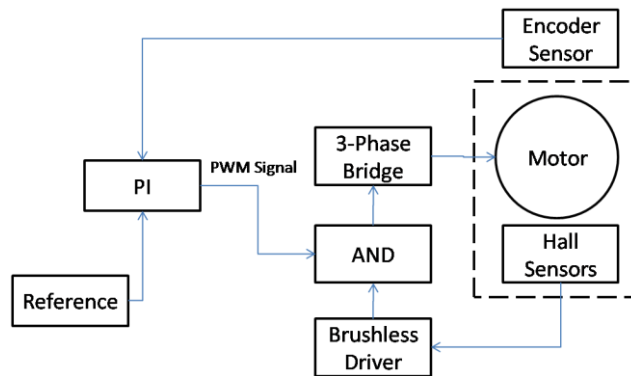


**Fig. 6.** Main Board

The robot's electronic system consists of two components: the logical system implemented on a Spartan3 XC3S400-PQ144 FPGA and the power system that performs coupling of control logic signals to the motors and sensors.

**Traction motors control:** It consists in a torque 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.

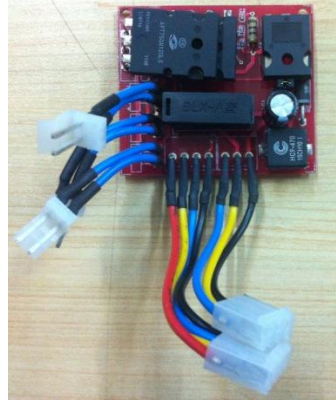
PI controller was implemented over a Microblaze Embedded Processor within Xilinx Embedded Processor Development Kit.



**Fig. 7.** Control system of traction motors

**Dribbler Motor Control:** This system is similar to shown in Figure 7 (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 has 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 composed by two IGBTs which conduct energy from capacitors to a corresponding solenoid. The control signal of each IGBT is a PWM signal that allows modulating the shot intensity. The kicker board is shown at Fig. 8.



**Fig. 8.** Kicker board

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

**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 of game autonomy.

### 2.3 COMMUNICATION

Until last year 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. However, during RoboCup 2012 we detect that communications are the most relevant problem affecting team performance. This problem was evident during communication between central system and robots because of the latency. It was found that the process of sending and receiving data takes more than 16ms, which means there is an accumulation of information and latency is generated. For that reason, this year we decide to change the communications system and also we developed a new module based on nRF24L01 module. This module works in the range between 2.4GHz and 2.5GHz, it depends on the channel selected. The channel and the addresses of receiving and sending data can be assigned by software also the transmission power and the air data rate. In our case, the air data rate is 250 Kbps and the transmission power is 0 dBm.

Communication system has a RF server who makes a connection between main control module and robots. This allows to system to send convenient information every time. The server has two main modules; the first one is dedicated to data transmission and the second one to reception.

At this system each robot information status is not updated permanently but it happens when the robot has the ball, as a result every robot has only a single module to transmit and receive information. The communication system is shown in Figure 9.

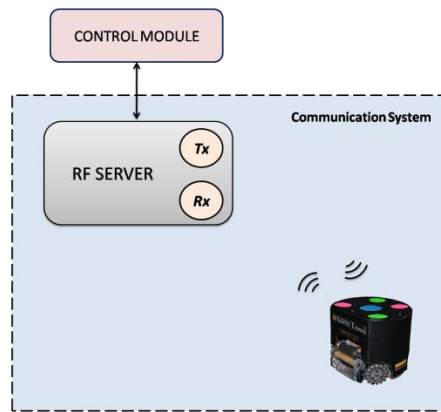


Fig. 9. Communications system

### 3 SOFTWARE

By this year STOxs team software was developed on Microsoft Visual Studio 2010. The software is compounded by such modules as filtering, prediction and control. It developed an intelligent multi-agent architecture. By this year we added new game strategies based on our past competitions experiences. The software architecture is shown in Fig. 10

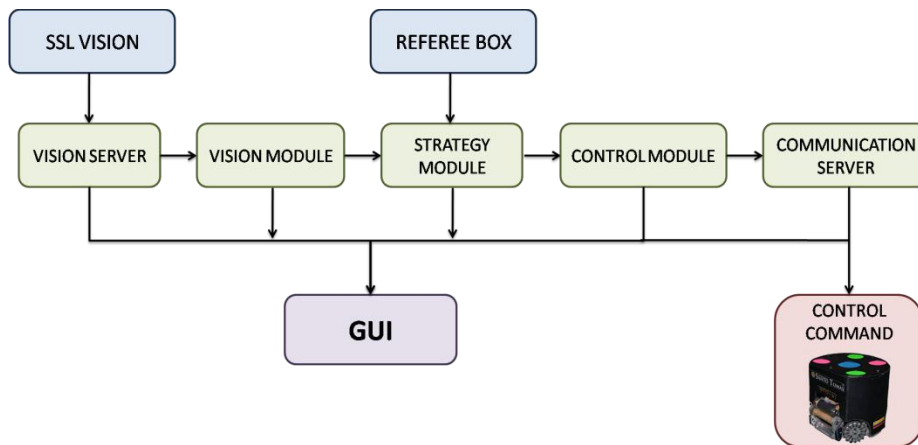
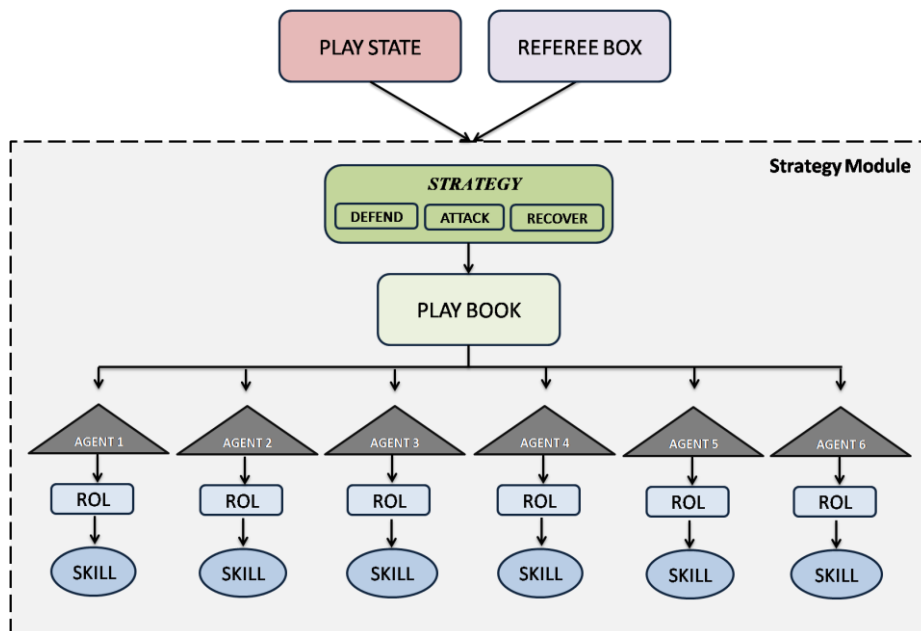


Fig. 10. Software architecture

**Vision Server:** This module receives data from SSL- Vision by an UDP socket. It integrates information of both cameras and organizes data depending on each team color.

**Vision Module:** With the aim to compensate system latency this module predicts every robot position and ball's position using Kalman filters. Also ball's tracking is performed to assure the veracity of ball position inside game field..

**Strategy Module:** 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. The general architecture has a hierarchy form. The vision and RefereeBox information are evaluated in a module enabled for the team's strategy; at this module play book evaluates roles (game attitudes) and related skills for each robot according to the game's situation. The block diagram it's shown in the Fig.11.



**Fig. 11.** Strategy module

**Control Module:** Consists of two parts: A first part is a path planning algorithm that calculates the movement robot to reach an objective position avoiding obstacles. Second part is a BangBang algorithm that controls and manages the efficient of robot speed changes inside the game field.

**Communication Server:** Its main task is to send the commands from control module to each one of robots who has the ball.



**GUI:** It is a Dialog Box that shows more relevant system data. It allows detecting errors and monitoring some process. Also it provides an On-line setup adjustment.

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

## 4 CONCLUSIONS AND RESULTS

Since 2011 when we participate for a first time in a RoboCup World Championship, the team has improvements in the behavior, performance and efficiency of robots. Following the competitions path, we found difficulties and problems that had been solved thanks to every challenging experience and collaboration of other teams' members. We appreciate that other teams have shared with us some of their knowledge and useful ideas achieved so far.

This year we are eager to show our advances and improvements, beating some problems detected in 2012. We expect to continue improvement and evolution of our robots Intelligence System. We want to provide our experience and knowledge to growth of Small Size League.



**Fig. 12.** STOX's team



**Fig. 13.** RoboCup Mexico City 2011.

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