

## K-Bots

### Team description paper for RoboCup 2015

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**Abstract:** The Small Size League is one of the most important events in RoboCup. This league has encouraged the mechanical design, artificial intelligence, coordination and cooperation of mobile robots. This paper describes the design of our robots for RoboCup 2015 SSL (Small sized league) competition. A pair of robots have been designed and manufactured by PAF Karachi Institute of Economics and Technology (PAF KIET) which will participate in RoboCup 2015. In this paper, we have presented the ideas related to hardware and software designs while emphasis is on the mechanical structure of the robots.

### 1. Introduction

This is the first time that the Team K-bots is participating in the international RoboCup event with the aim of showing our best effort in an international level competition. Our team consists of members of **KIET ROBOTICS CLUB (KRC)**.

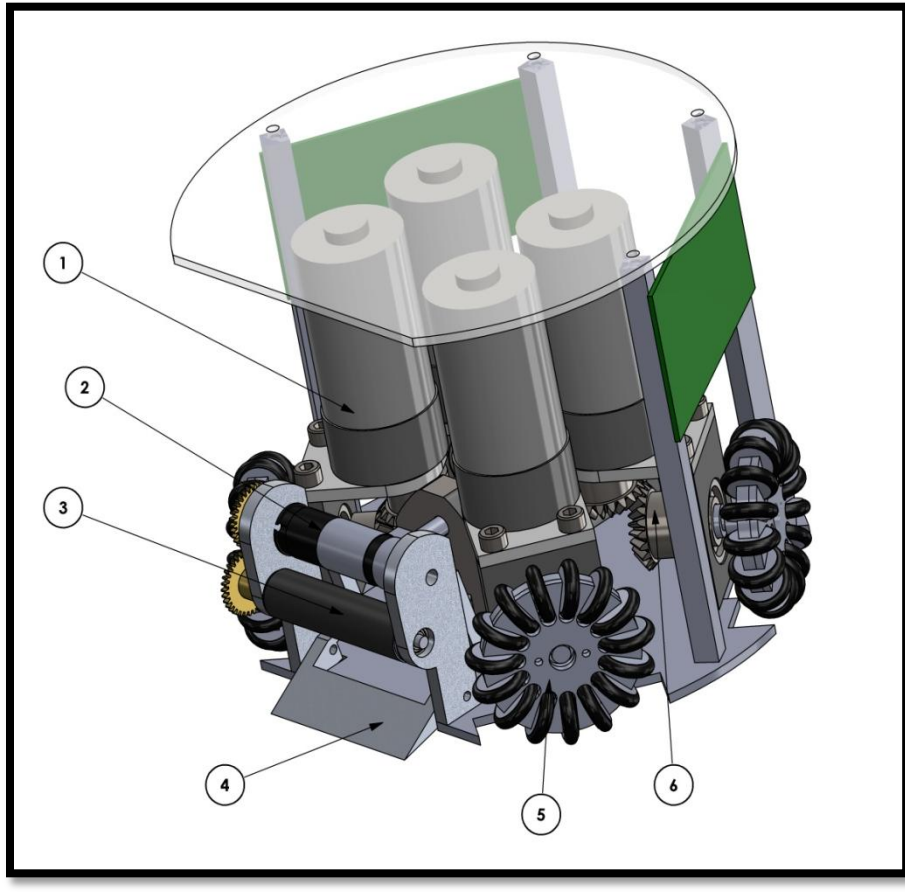
Our team is supported by **PAF-Karachi Institute of Economic and Technology**. PAF-KIET is one of the top universities in **Karachi, Pakistan**. We have recently participated in **Robosprint 2014** at CASE University, Islamabad. We qualified till the quarter finals. The team consists of undergraduate students from different semesters. PAF KIET participated in the Special category of Robosprint. In Special category, the robots are manually controlled i.e. without artificial intelligence. We are proud to announce that we are the host of the next **Robosprint 2015**.

Now we have started our research on **Small Sized League (SSL) Vision System**. We have implemented several changes to our previous design and put our endeavor efforts, so that it could compete efficiently in **RoboCup Small Sized League**.

The remaining paper is organized in various sections as follows: **Section 2** describes the basic mechanical design of our robot. **Section 3** introduces the electronic control we have implemented in our project. **Section 4** describes the details of software system we have utilized.

## **2. Hardware Design**

In this section we introduce our robot's new mechanical design which we have been working on since RoboSprint 2014. As this is the first time that PAF KIET is participating in ROBOCUP, we started from scratch in terms of both hardware and electronics design. We emphasized on hardware making sure to include in the CAD design every detail of the robot. After thinking and trying to make the design as much as cost effective as we could, we followed the approach to use 4 Omni wheels driven with simple DC motors; vertically mounted bevel gears are used to turn the wheels. **Figure 2.1** shows the robot along with all the major hardware parts



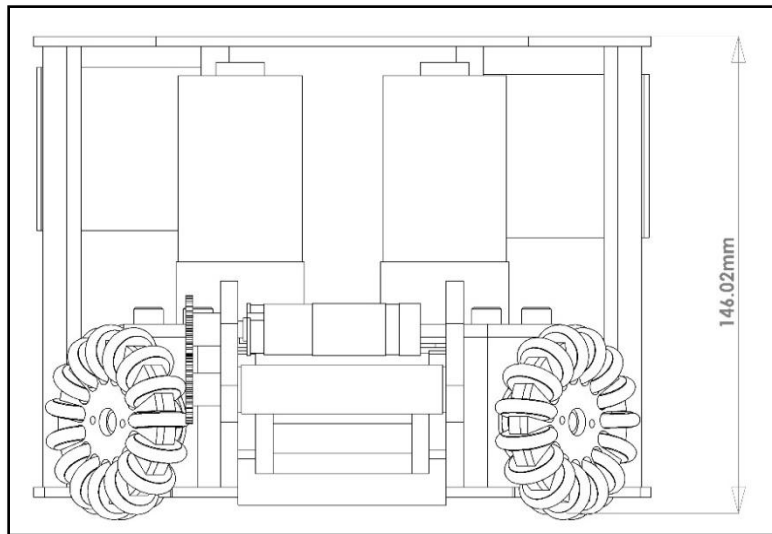
*Figure 2.1: Mechanical Parts of Robot*

### **Main Hardware Parts:**

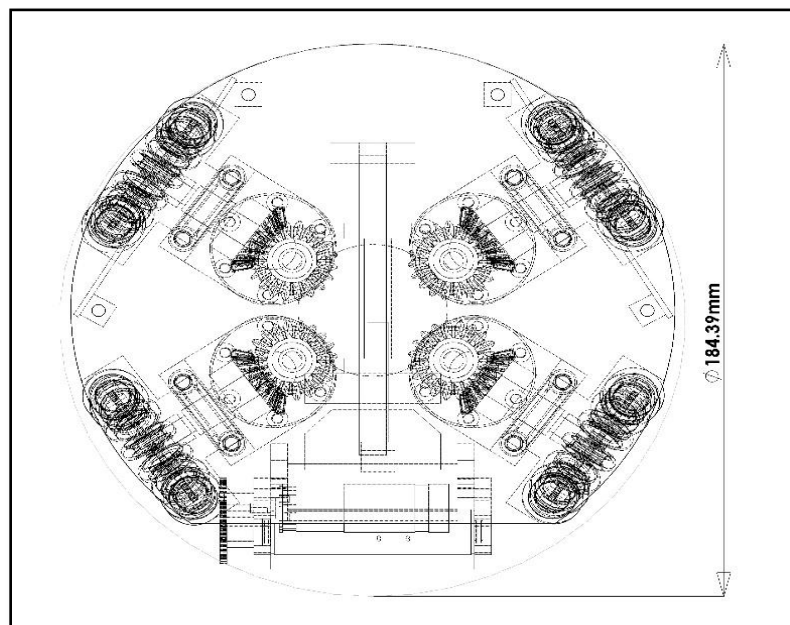
1. DC gear motor to drive the dribbler
2. Rubberized dribbler
3. Chip kick
4. Custom-made Omni wheels
5. Bevel gears
6. Solenoid coil to kick the ball
7. Solenoid coil to pull the chip kick
8. Ball Kicking Shaft
9. Chip Kick Mechanism

## **2.1. Robot dimensions**

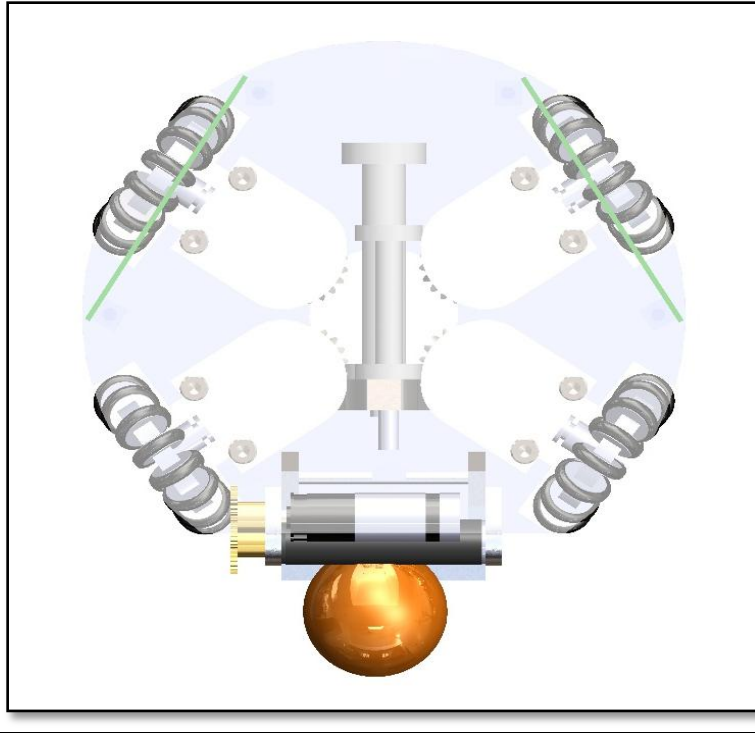
The robot is dimensioned according to the prescribed size limits of the RoboCup. The ball coverage is less than 15%. Below given figures 2.2, 2.3, and 2.4 shows different views and illustrations of robot.



**Figure 2.2: Front View of the Robot-Line Drawing**



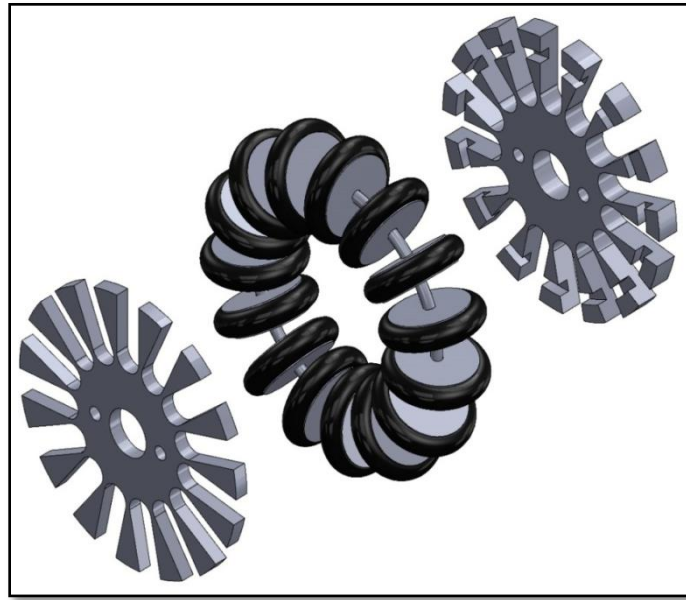
**Figure 2.3: Top View of Robot-Line Drawing**



*Figure 2.4: 3D Rendering of the Top View of Robot*

## **2.2. Wheels**

Our robot is equipped with four Omni wheels which are driven by geared DC motor. The wheels are designed completely in house by the team members in CAD tool. Wheel diameter is 60 mm, made from aluminum and its base is a light weight material. These omnidirectional wheels mounted on the robot give it three degrees of freedom, rotational, x- and y- direction.



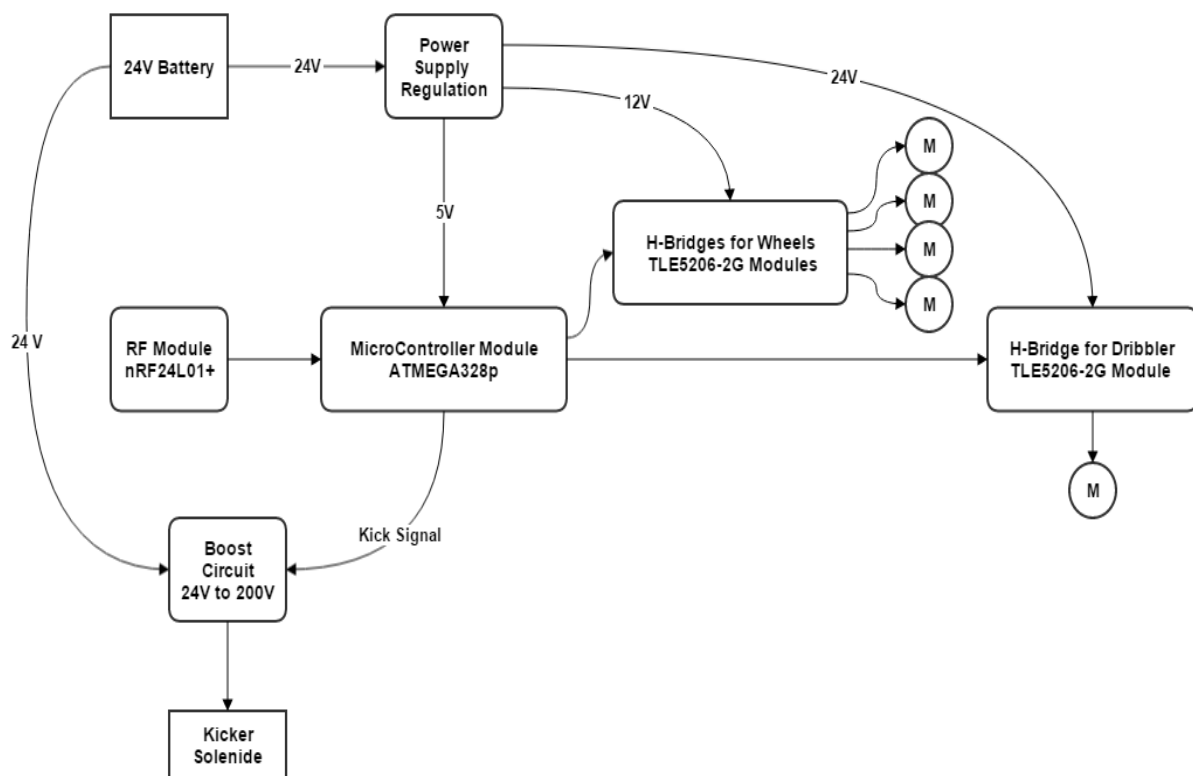
*Figure 2.5: Omni Wheels-Exploded View*

### 3. Electronics

As our research team is divided primarily into mechanical and electronics tracks, we are able to continue with the electronics work in parallel with the mechanical aspect. As this is our first participation in RoboCup, we are emphasizing on selecting the right tools and components for the electronics design.

The electronics can primarily be distributed into the following portions

1. Power Supply
2. Controller Board
3. H-Bridge Circuitry
4. Boost Circuit for Kicker
5. Wireless Communication
6. Handheld Controllers



*Figure 3.1: Block Diagram of the Electronics*

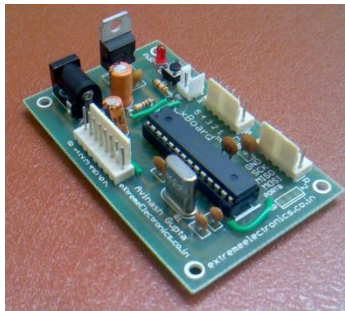
**Figure 3.1** shows a basic block diagram of all the electronics components and their connections, we are using modular approach and keeping all the circuits in separate modules/PCBs so that replacements may be easy and modifications would not require replacement of everything.

### **3.1. Power Supply**

The power supply consists of 3 batteries of 12V, each having 3 Li-ion cells - the batteries are charge-able and are connected in such a way that two batteries are connected in series and to obtain 24V volts, one battery is kept separate providing the output voltages 24V, 12V and 5V DC. 12V and 5V are regulated output voltages. The 24V is fed to the dribbler motor via the H-bridge and also to the boost circuit for energizing the Kicker solenoid. The kicker and dribbler power source is kept separate and isolated from the microcontroller power source; hence we are using the 3 batteries.

### **3.2. Controller Board**

The controller board serves as the main core of the bot. The initial prototypes were done with ATMEGA8 controller but later replaced with ATMEGA328p to be able to use the Arduino libraries like (nrf24L01) along with our code. The Control module simply consists of connectors to connect to various other modules in order to control them.



*Figure 3.2: Atmega328p Board*

### **3.3. H-bridge Circuitry**

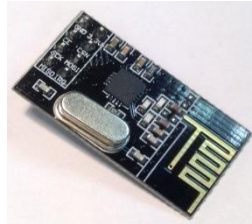
In our robot we will be using TLE5206-2G Module. The TLE 5206-2G is an integrated power H-bridge with DMOS output stages for driving DC-Motors. It delivers up to 5A continuous current and 6A peak current and operates up to 40V. The integrated circuits present in the IC protects the outputs against short-circuit to ground and to the supply voltage. Each TLE5206-2G has two H-bridges and has the required power rating to run the motors. We are running our motors for Omni wheels at 12V and the dribbler motor is driven at 24V for the additional speed.

### **3.4. Boost Circuitry for Kicker**

Our Kicker solenoid is rated to work at 150V and above till 250V DC, hence it required a Boosted DC voltage. For this purpose we are implementing DC-DC Boost converter that uses an ATtiny microcontroller as a feedback mechanism to keep the boost voltage within desired limits. Due to the use of ATtiny to sense the boost voltage and limit the output if needed, programmable and hence the kicking power can be controllable. The Kicker circuit is also isolated from the main supply by means of optical isolators.

### **3.5. Wireless Communication**

For wireless communication we first tested Zigbee Modules, RF Transceivers simple 4 channel ones and also the 2.4GHz modules, settling with the 2.4GHz nRF24L01+ modules as the optimal choice due to their low cost (approx 5 times less than a Zigbee). Now our bots receives commands from control module using this 2.4GHz module. The nRF24L01+ modules are SPI controllable and the library provides collision avoidance and unicast and broadcast capabilities.



*Figure 3.3: nRF24L01+Module*

### **3.6. Ball 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.

### **3.7. Controllers**

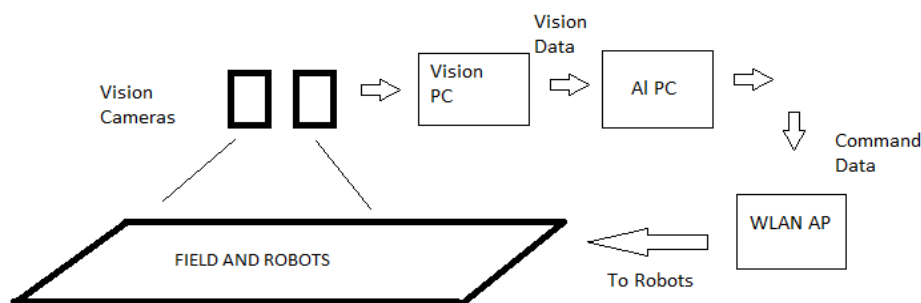
Our robots are controlled by two ways:

- Hand-held controllers(Modified USB Joysticks)
- C# app.

These controllers help us to determine the working of the robots and to test their functioning by manual operation.

## **4. Software**

For the purpose of real time image processing and object recognition, we are using two Play station Eye cameras, simple USB ones and modified SSL vision software which uses opencv for camera interface. We have successfully installed cameras and interfaced with the SSL vision software. Moreover we have done calibrations according to our field. The basic block diagram of working of software is shown in figure 4.1.



*Fig 4.1 Block diagram of software system*

## **4.1. Software Structure**

The main parts that integrate our software structure are as follows. The Block diagram of our software is shown in **figure 4.2**.

### **1. CAMERA:**

We are using Play station Eye which is capable of capturing standard video with frame rates of 30 hertz at a 640×480 pixel resolution, and 120 hertz at 320×240 pixels. We are using two of these cameras for the imaging of the field. Each camera covers one half of the field. These cameras give data to the SSL vision server.



*Figure 4.3: Playstation3 Eye Camera*

### **2. VISION MODULE:**

Vision module is the SSL software. In this system data is sent to every robot to make their move in relation to the ball, which is followed by algorithms.

### **3. STRATEGY MODULE:**

This module uses the outputs/data from the vision module to decide which the best action in a particular situation is. The Strategy is determined by a simple application running on a client PC which determined where to move the robots for attack and defense positions and send the relevant coordinates to the robots to move. The system is currently centrally controlled and the robot only performs the tasks sent by central system.

### **4. GUI:**

It shows relevant data from the system. It monitors the whole process and also detects error of the system.



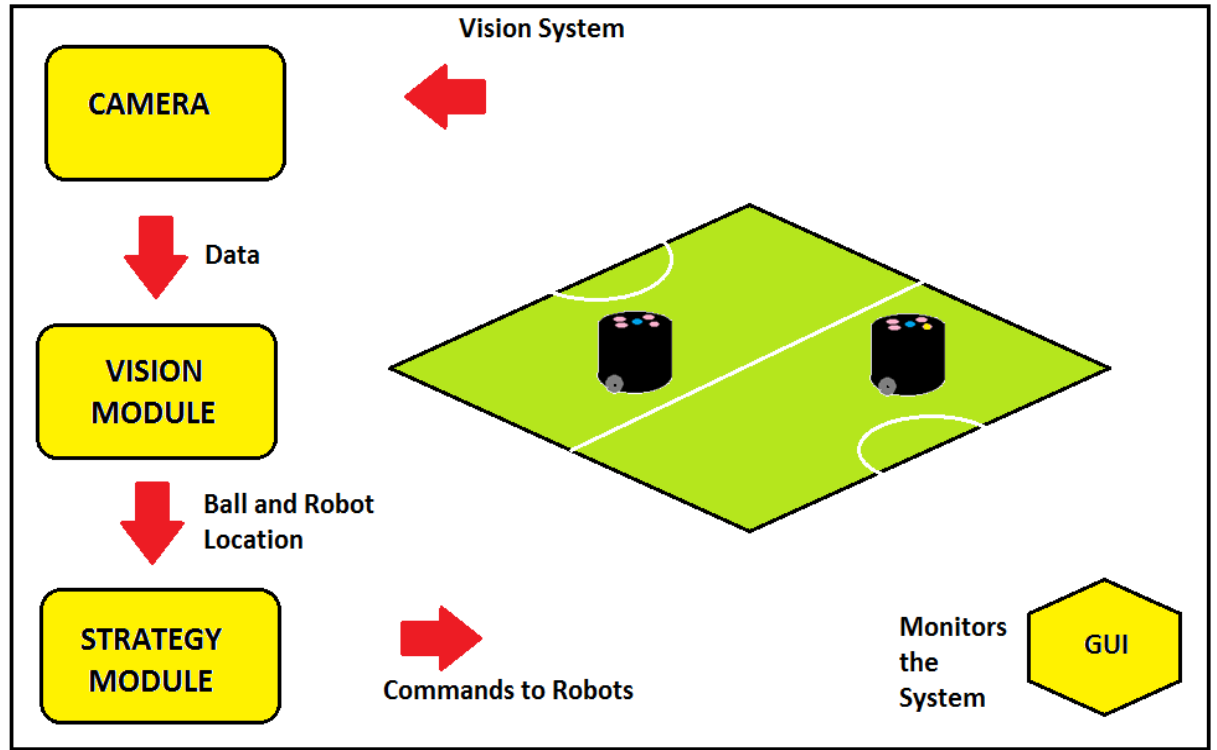


Figure 4.2: Block Diagram of our software structure

## 4.2. WORK ON STRATEGY ALGORITHMS:

Our team is doing work on strategy algorithms which are a major part of Small Sized League.

The strategy algorithms are divided into two parts.

- **OPERATIONAL FUNCTIONS:**

**Low Level Functions:** It includes the basic behavior of the robot like exactly addressed movements, stop, spin back On/Off, kick, and chip.

**Medium Level Functions:** These functions are more general than low level functions. One function is POTENTIAL FIELD MOVE. When a robot wants to go to a specific point it should move accordingly to potential field rules to avoid making contact to other robots or losing ball.

**High Level Functions:** This function specify the current task of robot e.g., defensive position, goal kicks, corner kicks, passing the ball and soon.

- **DECISION MAKING FUNCTIONS:**

Functions that determine game current status and proper high level functions. The input of this system besides the data coming from each robot via wireless communication is the data coming from vision software and the referee.

## **5. Future Plan**

Our team's future plans for the participation in ROBOCUP 15 are:

- Implementing the newest design of our robot.
- Improvements in the navigation techniques and path planning algorithms.
- Trajectory control issues

## **6. Results and Concluding Remarks**

In **Robosprint 2014** we had a fully functioning team that was able to play in all the games. Our performance was very good and we finished fourth in the competition. This success was highly appreciated by our university and it motivated us to compete in **RoboCup**. So this year we have decided to take ourselves to the next level i.e., by making autonomous robots. We have addressed several issues and we still have a research agenda in order to reach a good performance in **RoboCup 2015**.

In this paper, we described a number of new approaches that we have been working on since **Robosprint 2014**. So far we have received positive results and hope that if we qualify for the **RoboCup 2015**, our robots will be able to put up a good show in the competition.

## **7. References**

1. RoboCup Small Size League: SSL Web Site.  
[www.robocupssl.cpe.ku.ac.th](http://www.robocupssl.cpe.ku.ac.th)
2. SSL-Vision Developer Team: RoboCup Small Size League Shared Vision System:  
[www.code.google.com/p/ssl-vision/](http://www.code.google.com/p/ssl-vision/)
3. TLE5206-2G ,datasheet, available online: [www.alldatasheet.com](http://www.alldatasheet.com)
4. nRF24L01+, datasheet, available online:[www.nordicsemi.com](http://www.nordicsemi.com)
5. ATmega328p, datasheet, available online: [www.alldatasheet.com](http://www.alldatasheet.com)
6. Play station 3 eye camera features:  
[www.us.playstation.com/ps3/accessories/playstation-eye-camera-ps3.html](http://www.us.playstation.com/ps3/accessories/playstation-eye-camera-ps3.html)
7. Team description paper: CM Dragons 2009  
[www.cs.cmu.edu/~mmv/papers/09robocup-cmdragons.pdf](http://www.cs.cmu.edu/~mmv/papers/09robocup-cmdragons.pdf)