RoboCupJunior Soccer
Team Description Paper (TDP)
RoboCup Asia Pacific 2018 – Kish Island

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Preface

A junior soccer lightweight robot consists of 3 main parts: Mechanics, Electronics and Programming. At first we learned the things which were needed for building a robot. Being done with the learning course we started designing the 2D schematics using "SolidWorks" software and our PCBs using "Altium Designer" software. After soldering electronic modules, connecting body parts and motors, in short assembling the whole robot, it was ready for the programming section. So we started programming codes on the robot, executing and testing many different algorithms such as out-line detection algorithms and so on for having a superior, powerful and dominant robot in the field.

Keywords: Robocup Asia-Pacific, Junior Soccer League, TDP Sample, Technical Description Paper, Programming, Mechanics, Electronics

Introduction

Junior lightweight soccer is a branch of robotics competitions which shall nurture students for the future of electronics and robotics. In the process of building a robot, students learn many things like designing PCBs, 2D sketches; They do 3D simulations and learn C/C++ or Python programming languages, work with communicative protocols and launch different electronic modules and parts such as microcontrollers, SBCs, drivers, transistors and etc.

In this process, students meet many problems and difficulties they shall deal with, like: programming bugs, electrical problems, broken mechanical parts and etc. Solving these difficulties empower their problem-solving spirit and make them fine young engineers.

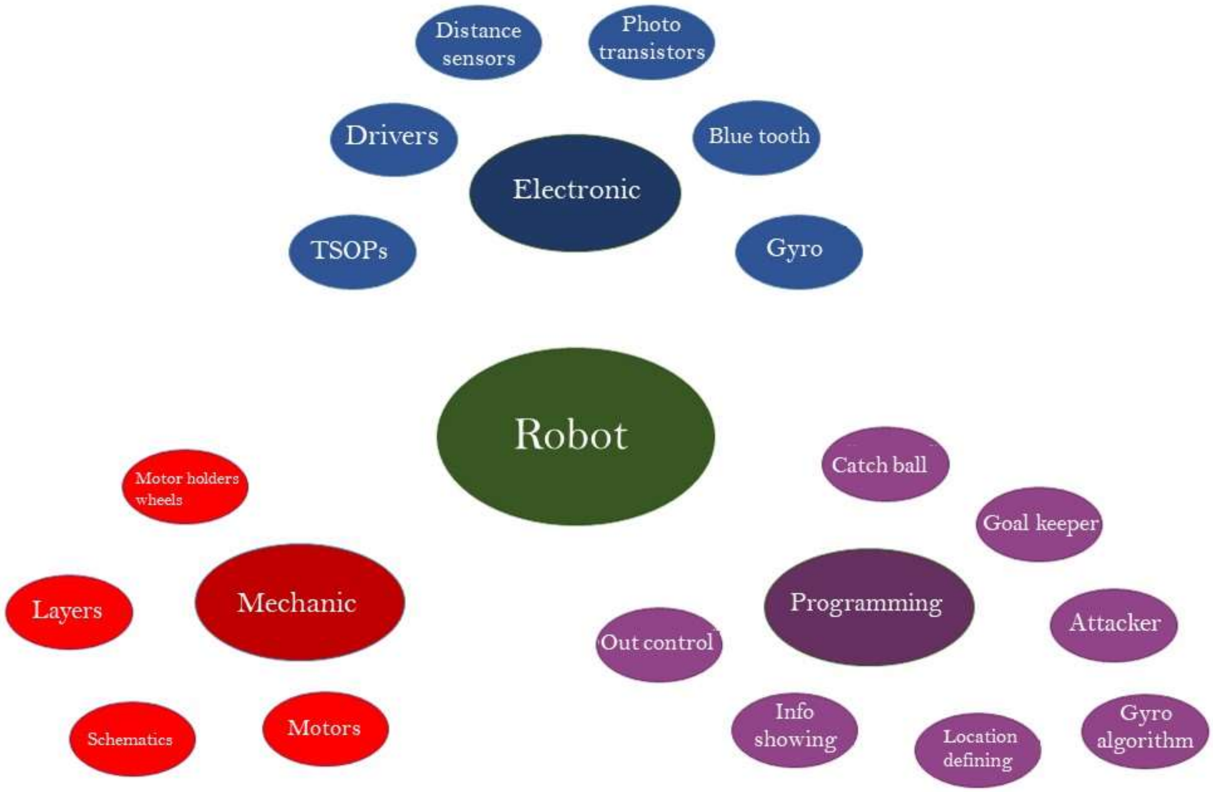


Chart 1: Producing and designing the robot

1. Locomotion System:

1.1. Mechanics of locomotion system:

1.1.1. Body

Due to weight limitation in this league, the material to use for the layers is important. Fiberglass is lightweight and also flexible so it is a perfect choice of material for body parts.

Frames are designed circular because circle plane's area is bigger than the rest of the geometrical planes in a certain radius and it also doesn't have any edges (in shapes which have edges, forces are focused at sharp points and high probability of damages, but forces in circular shapes are spread).

Because of the ease of designing that "Altium Designer" doesn't provide, layers at first are all designed with "SolidWorks". They are imported to Altium Designer environment for the circuit design. The PCBs in the end are given to CNC companies to get them printed.

The body of the robot consists of three layers (Bottom layer, Disc layer, Top layer). The radius of bottom layer and top layer is 10/76 cm and the radius of disc layer is 5/8 cm. (All layers are circular).

1.1.2. Motors and wheels

Motors are one of the most important parts in a soccer robot, which are the basic parts of the mobility system of the robot. Mobility system is based on 4 motors and omnidirectional wheels which provide us motion in all directions.

One of the problems of the 4-motor mobility system is its weight which doesn't let us use shooting system or dribbling system. Although advantages are more.

Now we have some options for clipping motors. For example:

1. Motors with 130degree angle (Recommendation of the World Committee)
2. Motors with 90degree angle

We chose 90 degrees for moving at the same speed in each direction. Here are two examples:

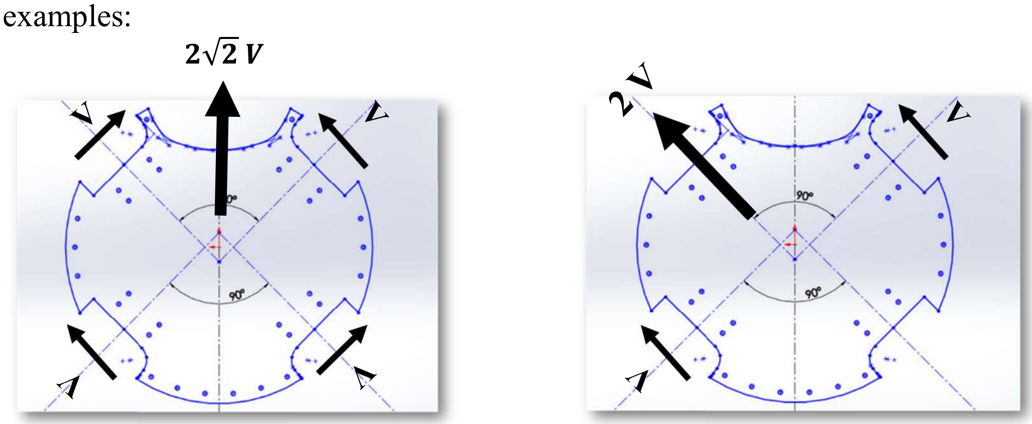


Fig 1, 2: velocity calculations for moving forward and northwest

1. Light and compact
2. 1000 rpm of no-load speed
3. Precise speed control due to its high sensitivity to voltage.
4. Nominal voltage: 9 V
5. No – Load Current: 0.007 A

Fig 3: Faulhaber 2224V009SR motors

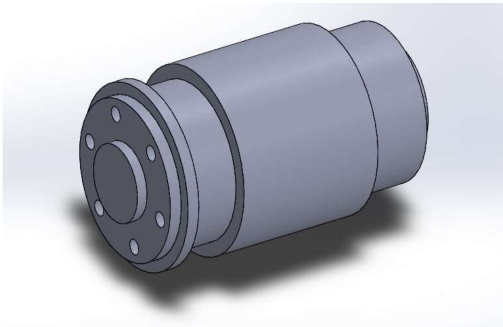


Fig 4: Faulhaber 2224V009SR motor - Solidworks design

These motors are attached to the bottom layer with 3Dprinted motor holders, which is built of ABS material making it lighter while staying unbreakable compared to other materials.

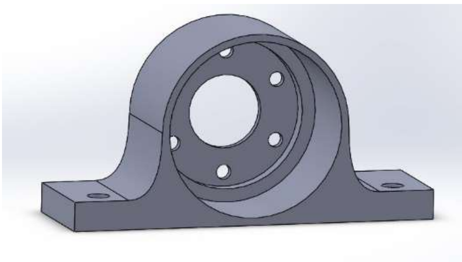


Fig 5: Motor holder

We used Omni directional wheels with 2.25 cm radius. The wheel has some tiny wheels around named (O-RING). O-RINGs do vertical movements while the whole wheel does horizontal movements which make it able to move in different directions.

Fig 6: Omni directional wheel

1.1.3. Circuits

In order to drive each motor an IC called driver is used because microcontrollers can't provide enough voltage and current for driving them. Drivers are electrical pieces which provide enough voltage and current for motors and they can also change the rotation direction. L6203 is a full-bridge driver which is a better one compared to other drivers like L298 and L293 because it can provide up to 5 amperes current.

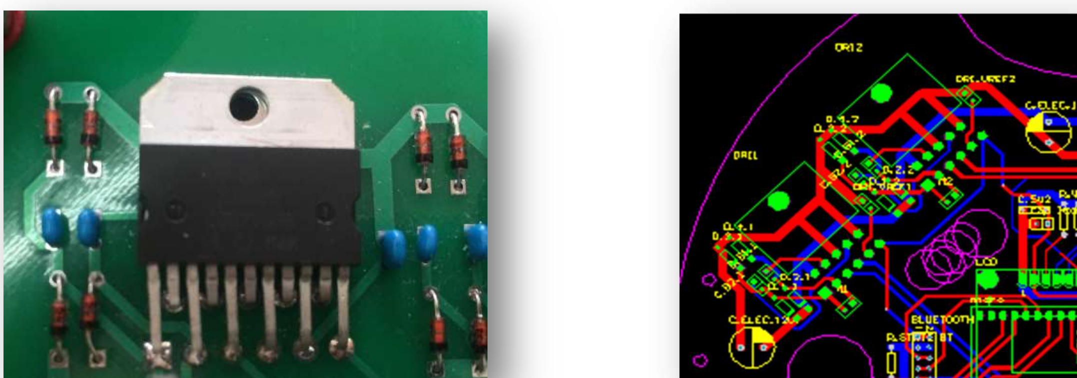
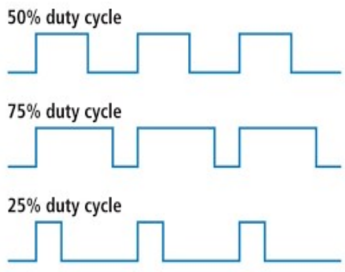


Fig 7,8: Drivers

Motor movement algorithms:

Motors are one of the most important parts in a soccer robot. Controlling spin direction and velocity of each motor is done at the programming section.

For controlling the velocity of motors "PWM" method is used. So we wrote two functions; Motor() for controlling motors velocity and Move() for controlling



movement direction. In Motor() function we have defined which pin gets high or low for controlling the spin direction. In Move() function, the amount of "PWM" needed for each motor is given as an input allowing the robot move in 16 directions.

Gyro data is also important in defining the movement direction and calibration.

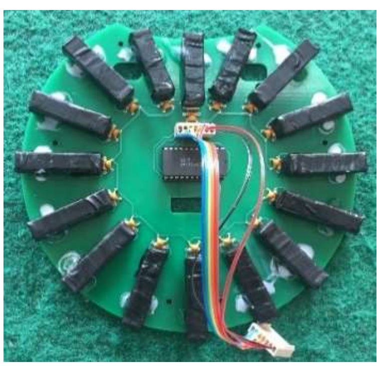
Fig 10: PWM

2. Ball Detection

2.1.Sensors

Mapping the location of the ball in the field is really important and it is done by 16 sensors called TSOPs. These sensors are IR receivers which are just sensitive to 38KHz infrared pulses. IR8601 is used in the robot because the output data changes proportional to the distance changes of the ball.

The output of this sensor is PWM wave, so an RC filter is needed for interpreting this wave to a digital number; ADC section in the microcontroller is in charge of this process.



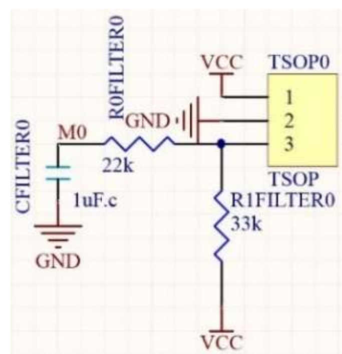


Fig 11,12: TSOPs

2.2.Algorithms

ADC or analog to digital converter is a voltameter, a unit in the microcontroller, which measures the voltage of each ADC pin and reads sensor data.

Robot's kicker is always set in front of the opponent's goal so there is an Algorithm which for catching the ball, the robot has to always get behind the ball.

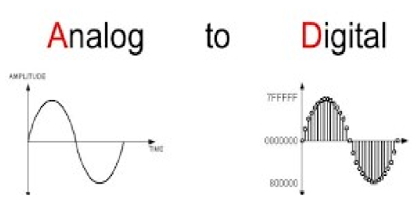


Fig 13: How ADC works

16 sensors are in 16 different directions soldered on the disc layer for finding the ball is the best way. And for gaining accuracy and lower amount of noise each sensor is put in a box.

3. Goal and Direction Detection

3.1.Sensors

The robot has no way to directly detect the location of the opponent's goal but with range-finder module, it can measure distances between itself and walls.

Robot's kicker is essential to be in front of the opponent's goal for scoring fast and not to score own goals. GY-25 is a gyroscope module which has a built-in microcontroller that calculates degree deviation from a selected point by integrating the data it receives from velocity (Kalman filter). This module is light and isolated from any magnetic noises due the way it works.

Fig 14: GY-25

For communicating with this module UART protocol (universal asynchronous receiver-transmitter) is needed. This protocol is serial and the baud rate is one important factor for both the receiver and the transmitter. In "USART" protocol there is a clock line but in "UART" protocol the "baud rate" set in the program is used instead of the clock line. TX and RX are two pins of the microcontroller which are used in this protocol transmitting and receiving data.

Another module which does the same thing is the CMP03 compass. The problem is that magnetic noises make this module give us wrong outputs and this troubles robot performance.

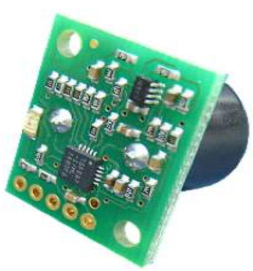


Fig 15: SRF02

For detecting the location of the robot in the field, SRF02 ultrasonic sensors are used. Sharp sensors are another choice for range-finding but because of their non-accurate outputs they weren't used.

3.2.Algorithms

Gyro module helped the robot to look straight at the opponent's goal. We divide the field in three parts (the middle part which the goals are located at the two ends of this area, the left part and the right part).

When the robot is placed in the middle part it can easily score goals by moving forward but if the robot is in the left or the right part of the field, the robot changes the kicker's direction for scoring goals easier from the sides.

4. Out Line Detection

4.1. Sensors

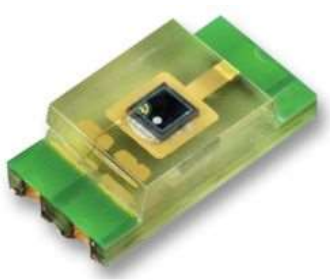
The out-detection system consists of a simple circuit: An LED emitting light and a phototransistor receiving the reflexion of the emitted light.

A phototransistor is an electronic device that is able to sense light levels and alter the current flowing between emitter and collector according to the level of light it receives. Temt6000 is the sensor, which we decided to use in our robot.

LEDs light are chosen to be white because red and blue light are banned from using due to the law and is not as good as white.

SRF02s can help detecting out-lines too. These sensors outputs range in centimeters and by the distance from the walls we have a better view of the out-lines. But they can't measure distance in short range (under 20cm). There are three SRF02s in our robot (back, left and right).

I2C is the communicative protocol we use to talk to these sensors with. I2C is a serial protocol for two-wire interface. It is popular because there can be more than 2 devices (as masters or slaves) connected together with only two wires. By the way two pull-up resistors are needed to be placed due to the way this protocol works. The two wire that I2C uses are: SCL (serial clock) and SDA (serial data). In addition, each slave has its unique address to talk to.



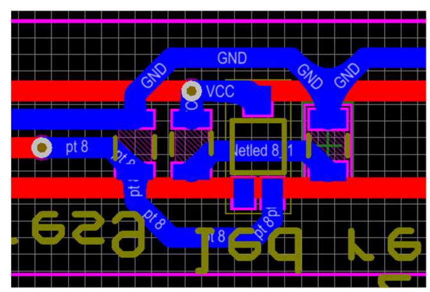


Fig 16,17: Bottom layer sensors

4.2. Arrangement and Design

16 sensors are placed in 4 main directions (front, back, left and right sides). Since the kicker is always facing forward, the robot touches the out-lines just from these 4 main directions.

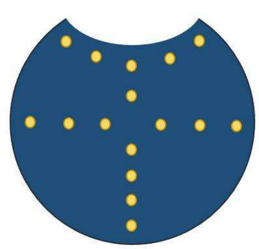


Fig 18: Bottom layer – out-detector sensors

4.3. Algorithms

Phototransistors are there to understand when the robot touches the out-lines. In our code, we've defined four layers in each direction. If the first layer detects the line, our robot stops its motors; But almost always this kind of brake doesn't stop the robot completely due to the robot inertia so after the first layer, in second layer the motors are set to spin opposite direction at half speed and at the 3rd, they are set to spin opposite direction at full-speed.

5. Forward Robot

5.1. Algorithms

When the attacker or forward algorithm is executed, the robot tries to get itself behind the ball and move it forward to score goals. The attacker has to control the ball in different parts of the field and score goals.

6. Goalkeeper

6.1. Positioning Sensors and Circuits

For executing the goalkeeper algorithm, we have to know our location in the field. SRF02 sensors are enough for providing us such data.

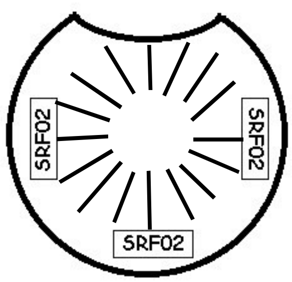


Fig 19: SRF placement

6.2. Algorithms

6.2.1. Positioning Algorithms

In our alghorithm the field is divided to 3 different areas (middle area and side areas). If the goalkeeper robot is placed in the middle area it will return to its goal straightly and if it is placed in the sides it will move with a curved move and will positson in the middle of the goal.

6.2.2. Goalkeeping Algorithms

For receiving the ball the goal keeper does not go more than the middle line of the field and stays back for defending the goal better. The goalkeeper has a special catching algorithm.

7. Communication

7.1. Modules and Circuits

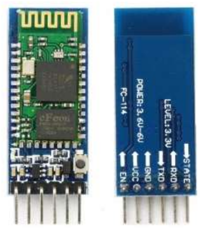


Fig 20: HC-05

For communication between robots HC_05 Bluetooth module is used. This module is fast and easy to use in short to middle range usages. This module works with the serial protocol (UART mode).

There are three kinds of communications:

1. simplex
2. half-duplex
3. full-duplex

This module can do a full-duplex communication.

7.2. Algorithms

One robot sends its locations and the ball location from it to the other one. With this done, the master robot has the location of the other robot and its location so it decides which robot is nearer to the ball, then it will move as forward and catch the ball while the other robot (the further one) is set in charge of the keeper and goes back to the goal.

8. Innovations

8.1. Mechanical Designs

The lack of appropriate measurement tools in “Altium Designer” for designing the robot led us use “SolidWorks” software. After the sketching is done, we export the sketches as “DWG” format and import it in “Altium designer” to place our components and tracks on. This made circuitry design easier.

In the next robot we are going to place motors with 110 degrees angle and use wheels with bigger O-RINGs.

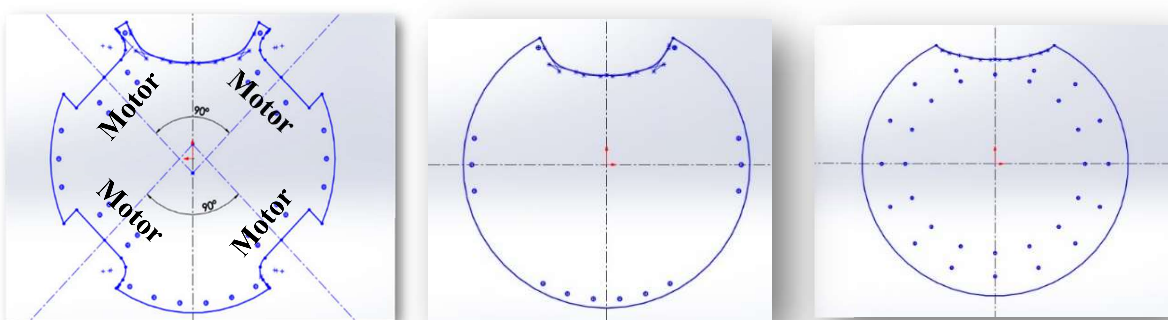


Fig 21,22,23: Solidworks schematics

8.2.Circuits Design and Sensors

Designing three PCBs allows us to use less wires, place sensors in different PCBs without limitation of place.

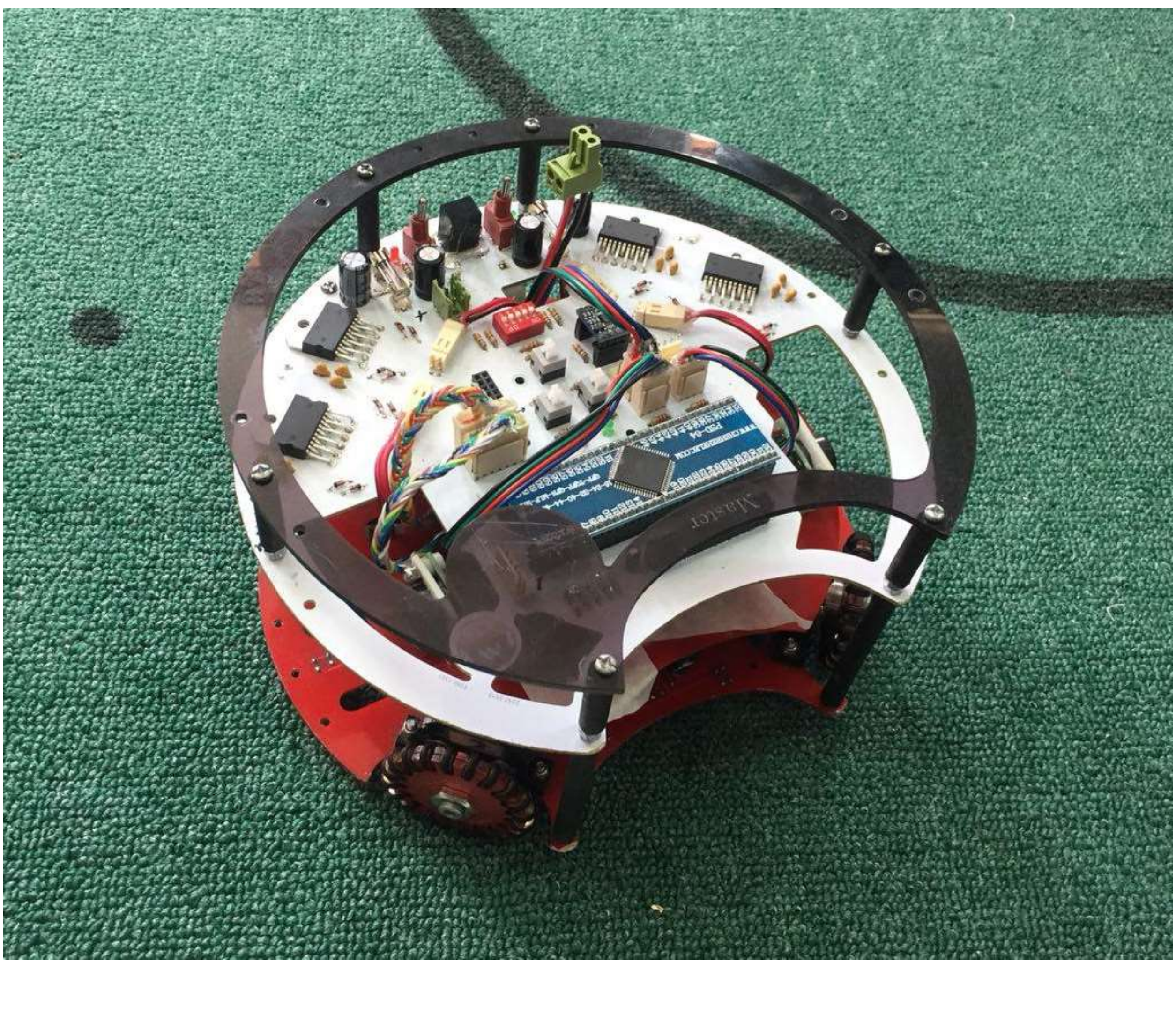
GY-25 is used instead of CMP03 for avoiding environmental magnetic noises.

In the next robot we are going to use STM32F103 instead of ATMEGA32A.

8.3.Programming and Algorithms

Every field are not exactly the same as each other. Each has its special white line and the green color may differ. This made us come up with out-line calibration. For calibrating our out-detector sensors, we've placed a special key on the board. When it is pushed, the robot goes in to calibrating mode; that's when it reads all outputs of out-detector sensor and then the robot defines a manual white color output range and green one with calculating a mean of every data of every output.

9. Final Robot



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