KIKS 2015 Team Description Paper

Tetsuya Sano, Soya Okuda, Kosuke Matsuoka, Yu Yamauchi,
Hayato Yokota, Tatsuro Sakaguchi,
Masato Watanabe and Toko Sugiura

National Institute of Technology, Toyota College
Department of Electrical and Electronic engineering,
2-1 Eisei-cho, Toyota Aichi, 471-8525, Japan

sugi@toyota-ct.ac.jp
URL: http://www.ee.toyota-ct.ac.jp/~sugi/RoboCup.html

Abstract. This paper is used to qualify as participation to the RoboCup 2015 small size league. Our team's robots and systems are designed under the RoboCup 2015 rules. The major points of improvement in this year are improvements about the performance of driving wheels, electrical circuit and AI system. The overviews of them are described.

Keywords: RoboCup, small size, autonomous robot, global vision, engineering education

1. Introduction

The robots have been made to obtain better performance since 2002. There are still problems for running stability, electronic circuits and intelligent tactics etc. We checked them in last year, and redesigned for some term mentioned above. The main topics of development for robot in 2015 model are following terms,

1) Improvement of the driving wheels
2) Improvement of the electrical circuit
3) Improvement of the AI system

2. Hardware of the robot

The main configuration for hardware is basically same with the 2013 model[1]. The wheel was tried to improve for a stable travelling performance. In 2015 model, we also use the brushless motors (maxon EC45 flat) for the driving motor as in many other teams. For the dribbling device, we use the brushless motor (maxon EC-max22) again. Each robot has two solenoids. One is for straight kick and the other is for chip kick. The robot is able to shoot the ball at a speed of over 10[m/s], however, it is down to 8[m/s] to keep to the regulations. The height and maximum projection on the ground for the robot is 148[mm] and 178[mm], respectively. And the maximum percentage of ball coverage is 18%. The robot's specification is summarized in Table 1. The reduction of robot's weight was achieved in comparison with 2014 model. We lowered the center of gravity and height for robot by reduction of the diameter of

adfa, p. 1, 2015.

wheel and also by using of flat type solenoid. The other mechanical elements are remained basically with no changed from last year.

Table 1. Specification of the robot (comparison with 2014 model)

	2015 version	2014 version
Weight	1.9kg	2.3kg
Material	Aluminum alloy	Aluminum alloy
Driving motor	maxon EC45 flat (30watt)	maxon EC45flat (30watt)
Driving gear ratio	4.0:1.0	3.6 : 1
Wheel diameter	50mm	56mm
Number of solenoids	Straight kick: 1 Chip kick: 1	Straight kick: 1 Chip kick: 2
Straight kick power	Ball speed of 8m/s	Ball speed of 8[m/s]
Chip kick power	3.0m away from robot	Max 3.0m away from robot under the condition of initial angle 40°
Dribbling motor	maxon EC-max22	maxon EC-max22
Roller diameter	15mm	15mm
Dribbling gear ratio	1.2:1.0	1.2:1.0

Travelling performance for the wheel

The wheel used in 2014 was superior in durability performance in themselves, but the vertical vibration of the robot was caused because of the large extension between the small ring-tires. And it is also induced the noise to the acceleration sensor. Eventually, it negatively affected to the durability of the robot.

Fig. 1 Wheel of 2014 model (left) and 2015 model (right)

Therefore, as shown in Fig. 1, it was increased the number of small ring-tire on wheel to make the wheel's shape close to pure circle and reduce vertical vibration.

Moreover, the grip power of wheel was raised by using of X ring as small tire of ring wheel.

3. Electrical design

The electronic circuit is mostly same with last year. The circuit block of base board and FPGA are shown in Fig. 2, respectively.

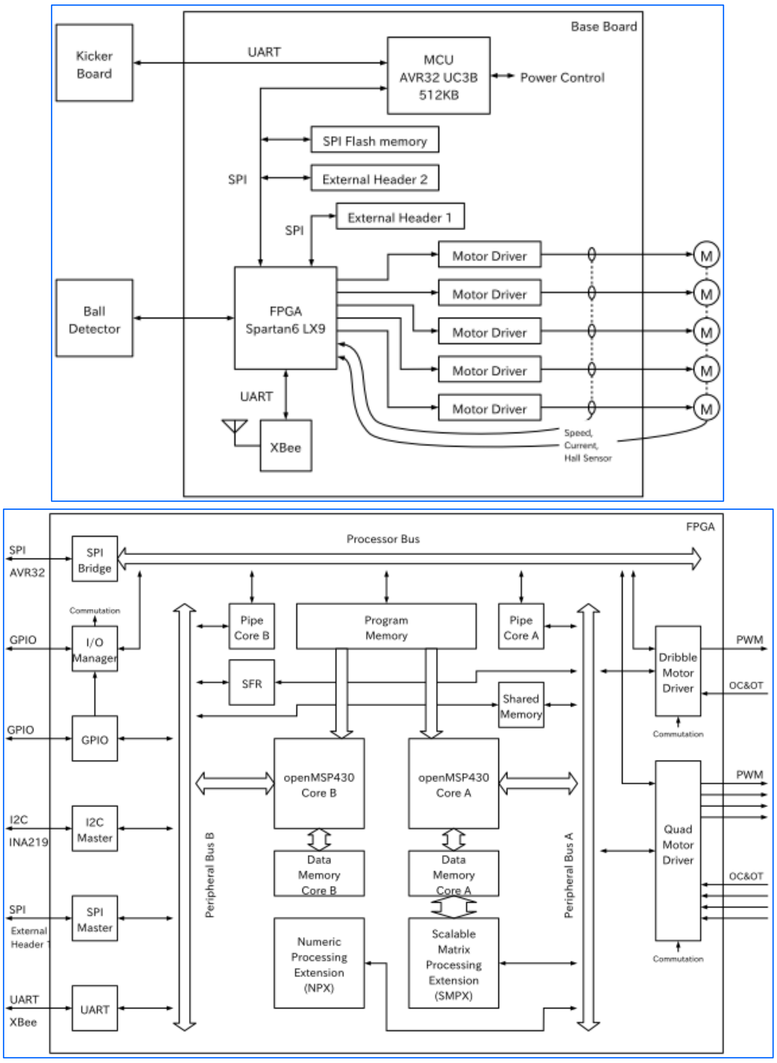


Fig. 2 Circuit block of base board (upper) and FPGA (lower)

adfa, p. 3, 2015.

3.1. Introduction of new kicker board

New charging circuit is introduced in this year as shown in Fig. 3. In previous, there were some little big elements like coils etc., however, they are replaced by surface mounted components. As the results, the thickness of substrate is decreased and the number of damaged components is smaller.

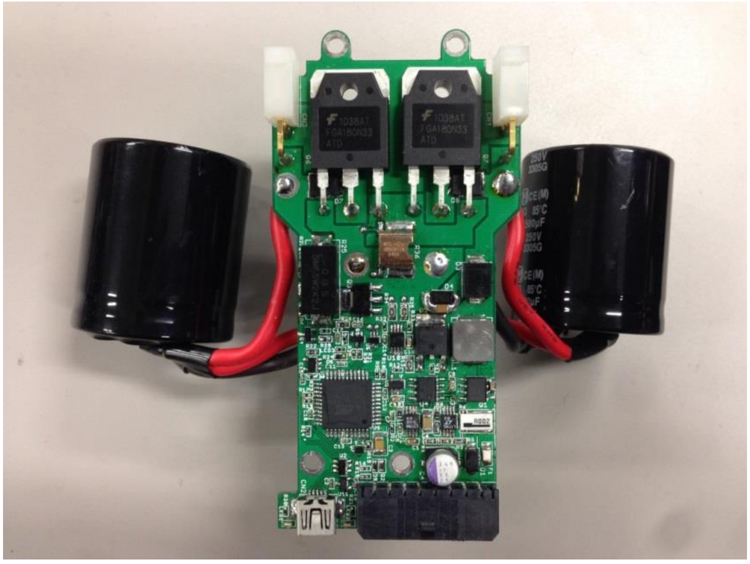


Fig. 3 New Kicker Board

AVR is used as MCU on FPGA. It is able to write program directly from PC through USB terminal.

3.2. Voltage booster circuit

The DC-DC converter is used to boost up the voltage for the solenoid. The input voltage of 16V is converted to 220V output. This chopper circuit is controlled by PIC in each robot. In kicking device, the output voltage is charged in 3mF capacitor. The time to charge up to 200V from 16V is about 3 seconds. The power control to solenoid is achieved through the current On/OFF control by IGBT.

In this year, the following point was improved in chopper booster circuit.

(1) Higher frequency for chopping

(2) Current limitation for charging to capacitor and kicking power to solenoid

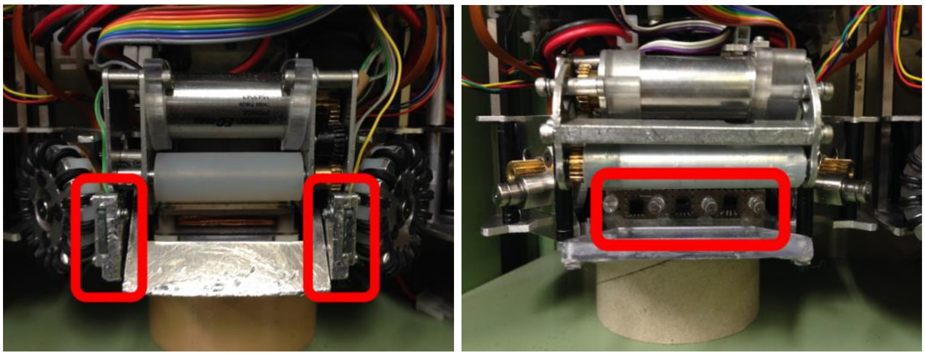
(3) Introduction of forced discharge-circuit

adfa, p. 4, 2015.

3.3. Change of communication format within wireless module

It was increased doubly volume of information that include moving and rotating direction and velocity for the driving wheel and dribbling roller compared with previous format. As the results, it enables us to control such like reversing the dribbling motor.

3.4. Prototype ball sensor module



(a) Conventional (b) Prototype

Fig. 4 Ball sensor in front of robot

In current ball sensor, it is arranged on the both side of the catching part in front of the robot as shown in Fig. 4 (a). When the ball came from diagonal direction, there was the case that a sensor does not response enough and it may fail in catching a ball as a result. Thus, we tried to arrange the ball sensors inside a robot as shown in Fig. 4 (b). The robot emits infrared rays to the front of the body and receives the light reflected from ball. It shows the good performance in test for detection of the ball in wider area. But, this prototype sensor has larger size than previous one, so it is necessary to remove chip-kick mechanism to mount this sensor into robot. Furthermore, it is difficult to make an adjustment of the detecting area. Now in final, we have a plan to change more small size module used infrared LED.

3.5. PC Software for FPGA Board

Monitoring program of new circuit was developed in last year. All data, e.g. battery voltage, capacitor voltage, angular velocity for each motor, can be observed in monitoring program. These data can be outputted to the file of CSV or VCD format, and also evaluated with gnuplot. This monitoring program can also write into microcomputer in FPGA with HEX format program by means of two methods. One is a mode of completely stored in ROM, and another is that of temporarily stored. The temporary store means that it will be back previous program when the power supply is shut down. By applying this method, it will be convenient for debugging.

adfa, p. 5, 2015.

3.6. Inertial Measurement Unit for Circuit

We built a scalable system for circuit. One of them is a terminal connector for add-in boards in a circuit. It is necessary for advanced control of robot to mount IMU (Inertial Measurement Unit). The pictures of new designed IMU and the FPGA board are shown in Fig. 5 and Fig. 6, respectively. Thus, now we can use gyroscope sensor and accelerometer by using the value from IMU.

Fig. 5 IMU circuit

Fig. 6 IMU circuit mounted on FPGA

adfa, p. 6, 2015.

4. Software design

Our AI server is called SIS (Strategy Information System). The SIS consists of four threads as shown in Fig. 7. There are "Game Thread", "Sender Thread", "SSL-Vision Receiver" and "Referee Box Receiver". The analysis of strategy and action for all robots are executed in "Game Thread".

4.1. Structure of strategy system

The structure of "Strategy System" in "Game Tread", and the "Speed Controller" in "Sender Thread" was modified in 2014. For example, it was introduced "Class Agent" in the strategy system as shown in Fig. 8 to develop program more efficiently.

The "Class Agent" indicates a class that selects appropriate "Support Action" depending on given role for each robot in game. In the structure of Fig. 8, the "Class Formation" decides only each robot's role. The knowledge and intelligence to play a given role is kept in the "Class Agent". As the results, we could develop more efficiently programs which have flexible intelligence by introducing of this structure.

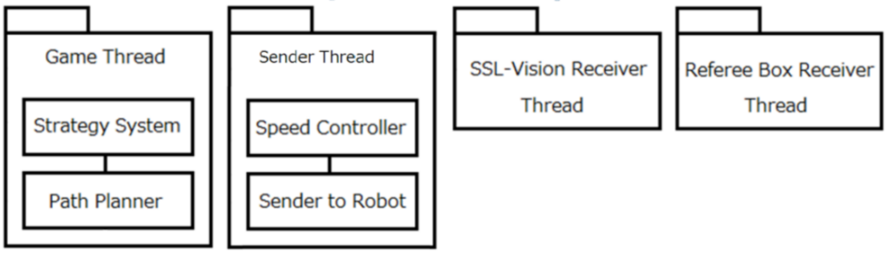


Fig. 7 Structure of SIS

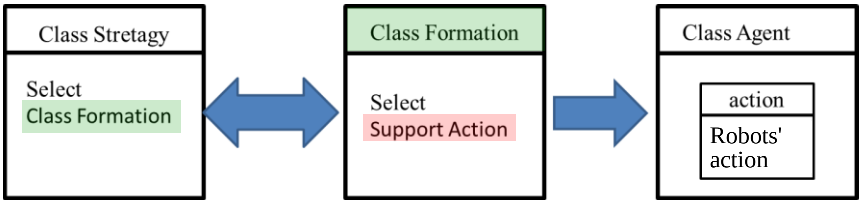


Fig. 8 Classes in the strategy system

4.2. Improvement of receiving program for pass

In recent years, the intelligent tactics is required in the game for enlargement of the field. It means that the attack is not only shoot, but pass is more important. The success rate of pass in play is low in our team, however, because of the bad precision of the pass course caused by structural insufficiency of the chip-kick bar and mechanical precision. In addition, there is also problem on the AI system that it does not make correct positioning data of receiving robot for the ball.

As mentioned above, our robot cannot kick now correctly a ball toward the friendly robot. Therefore, it might not be able to pass the ball to target position. Thus in previous, we predict a trace of ball by using Karman-filter and make a keeping the receiving robot in target place. But, due to the instability of the information from overhead view camera, the precision of trajectory prediction of ball was not enough. As the results, there was much failure of the ball-passing. Typical result of trajectory prediction for the ball is shown in Fig. 9. The black lines in Fig. 9 show the trajectory prediction of ball on each flame in the case of kicking from right lower position toward the center of goal line.

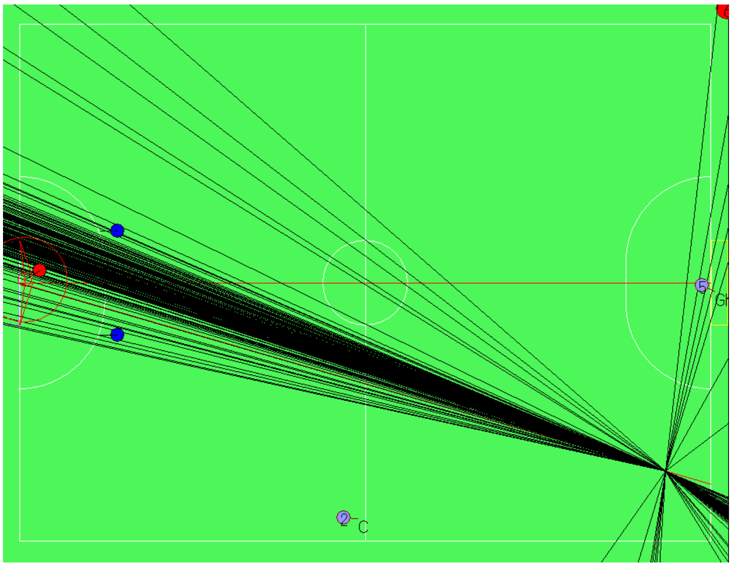


Fig. 9 Trajectory prediction of ball by using Karman-filter

Many lines shown in Fig. 9 result the estimation error. That is, it will cause the failure of shooting to the goal and/or passing toward the friendly robot. It is serious problem. So, the statistical processing for the ball's position is introduced and tried to stabilize the estimated results. The *x*, *y* coordinate data of ball on each frame are given as *x*1,*y*1, *x*2,*y*2, *x*3,*y*3,…, respectively. First, the average for *x* and *y* is calculated as E_x and E_y. Next, the variance and covariance is calculated. As the results, the equation of regression line is given as followings[2],

$$Y - E_y = \frac{Cov[xy]}{Var[x]}(X - E_x) \qquad (1)$$

where, *x* and *y* coordinate of ball are appeared in *X* and *Y* , respectively.

The results of trajectory prediction for ball calculated in real-time by using eq.(1) is shown in Fig. 10. As similar to the Fig. 9, the prediction of ball on each flame is performed in case of kicking from right lower position toward the center of goal line.

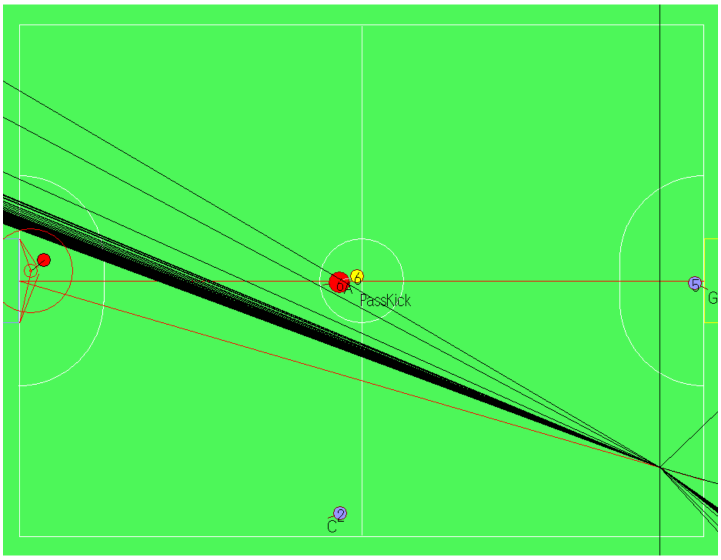


Fig. 10 Trajectory prediction of ball by using statistical process

A difference of distance between target position and reached point is due to the kicking performance caused by the mechanical problem. Moreover, a few lines out of the goal shown in Fig. 10 is attributed to the ball bounce, immediately after the kicking is done. It induced the straight-running instability. Nevertheless, the trajectory prediction for ball will be better than that of Fig. 9. As the results, it was increased for the success rate of passing. But, it is not enough for the accuracy of passing and moving. For the future, it will be need to introduce some new better method.

For the path generation, we plan using method based on the RRT[3]. But, there is a problem to take much moving-time to the destination because of the insufficient control of the robot at present.

5. Conclusions

Our robots have been continuously improved in every year. As the results, the motion and the performance of the robots are getting better.

We hope that our robots will perform better in this coming competition.

References

[1] Ryu Goto et al.: KIKS 2013 Extended Team Description, 2013
[2]K. Fukunaga: Introduction to Statistical Pattern Recognition, Academic Press, 1972.
[3] James Bruce and Manuela Veloso: Real-Time Randomized Path Planning for Robot Navigation, Intelligent Robots and Systems, 2002. IEEE/RSJ Int. Conf. Intelligent Robots and Systems, pp.2383-2388, 2002.

adfa, p. 9, 2015.