KIKS 2011 Team Description

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Abstract. This paper is used to qualify as participation to the RoboCup 2011 small-size league (SSL) about team "KIKS". Our robots and system are designed under the RoboCup 2011 rules in order to participate in the RoboCup competition held in Istanbul. The major improvements in this year are the enhancement of the performance of dribble device, changing the structure of the AI system and renewal of the circuit. The overview of there is described.

Keywords: RoboCup, small-size league, brushless DC motor, IR-sensor.

1   Introduction

Main purpose of our participation to the RoboCup world competition is confirmation and evaluation of the results of the PBL (Project Based Learning) experiments. The creative minds of students are educated using the robot contest held in department of electrical and electronic engineering. For the RoboCup world competition, our team has continuously participated for seven years since 2004. We came in the top 4 in Singapore 2010. Thus, since the aim will be higher, further improvements are also needed in this year.

Our robot's performance improved by replacing to brushless DC (BLDC) motor at last year. But, we found the problems for durability through the competition. The dribble device is also in the similar poor condition. So, we reviewed whole mechanical design and tried to replace to BLDC motor for the dribbling device.

The main topics of developed system in 2011 are following terms,
 ・Improvement of the structure of strategy system.
 ・Development of the circuit for BLDC motors.
 ・Development of the circuit for Digi's XBee wireless communication.

2   Hardware of the robot

In driving motor we use the brushless motors (maxon EC45 flat) with a custom back-extended shaft for useful to attach encoder, based on the reference [1]. They are used pinion gear with 20 teeth and internal gear with 72 teeth. That is, the reduction ratio is 1:3.6. Each robot is equipped with three solenoids. One is for straight kick and the rest two's are for the chip kick. These solenoids are driven by a 200[V] chargeable capacitor. Therefore, the robot will be able to shoot the ball at a speed of 10[m/s]. Moreover, the robot can also kick the ball to the position of 3[m] away from the robot by using the chip-kick device.

The specification of the robot is shown in Table 1. The detail is described in following sections.

Table 1. Specification of the 2011 robot

	2011
Weight	2.3kg
Material	Aluminum alloy
Driving motor	Maxon EC45 flat(30Watt)
Gear ratio	3.6:1
Wheel diameter	56mm
Number. of solenoids	Straight kick:1 Chip kick:2
Straight kick power	Ball speed of 10m/s
Chip kick power	3.0m away from robot

At present, we are doing the minor change of the robot of 2010 model focusing attention on the following points.

1. Changing the motor used in Dribbling device and mechanisms.
2. Redesign of wheel unit.
3. Improvement of mounting arrangement of IR-sensor.
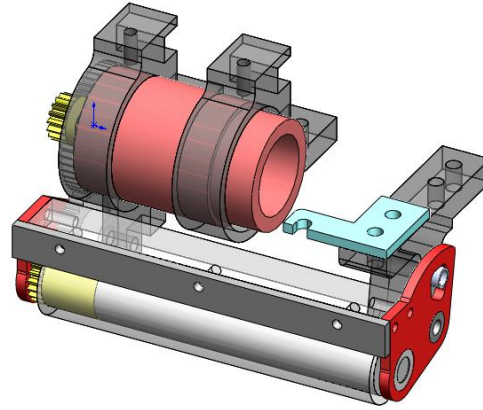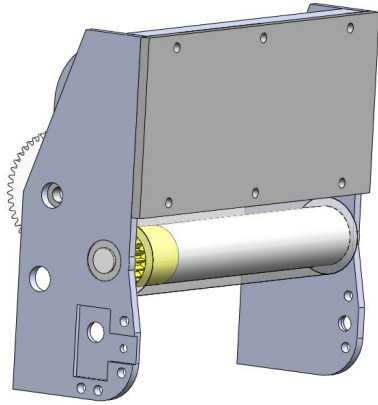
2.1   Improvement of dribbling device

Fig. 1 New dribbling device (CAD image)   Fig. 2 Dribbling device of 2010 model (CAD image)

Figure 1 and 2 shows the dribbling device of 2011 and 2010 model, respectively. The dribble device of 2010 model had stronger retentive force compared with old machine. That mechanism, however, was not structured to effectively receive and absorb with the strong shock of the ball. Therefore, the gears and the structure were damaged by the impacts. In addition, the power of the dribbling motor (Maxon RE-max24) was not enough to give rise to the strong backspin of the ball for the back pass. Thus, we changed the motor to new one (Maxon EC-max22). As the results in 2011 model, the rotational velocity of the dribble rollers was achieved approximately three times compared with old model. And the gear would not be broken by using the improvement of the shock-absorbing mechanism. The difference of the dribble device's performance is summarized in Table 2.

Table 2 Comparison between new and previous dribble devices' characterization

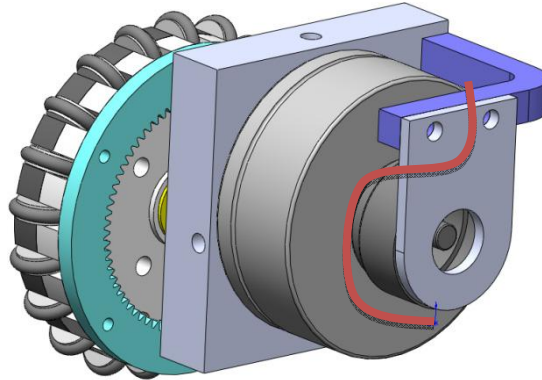|	New(2011)	Previous(2010)
Dribbling motor	Maxon EC-max22	Maxon RE-max24
Power	25Watt	11Watt
Nominal speed	9820rpm	5870rpm
Nominal torque	22.9mNm	12.4mNm
Gear ratio	1:1.3	0.77:1

2.2   Changes in tire unit

Fig. 3 Previous tire unit (CAD image)

A tire unit in 2010 is shown in Fig. 3. To assemble the robot in the structure of Fig. 3, it is necessary to bend the encoder cable. The encoder is only fixed by adhesive tape. So, when the encoder cable was pulled by someone or somewhat accidents, the encoder was often come off. Thus, we changed the structure of the unit to solve this problem as shown in Fig. 4. In this structure, since the cable may not be pulled, the probability of coming off of the encoder will be lower. Moreover, we changed the encoder which is able to fix with the screws in order to treat easily for overhaul. In addition, this unit is constructed with the popular spacer on sale. Thus, it is very good to using for maintenance.
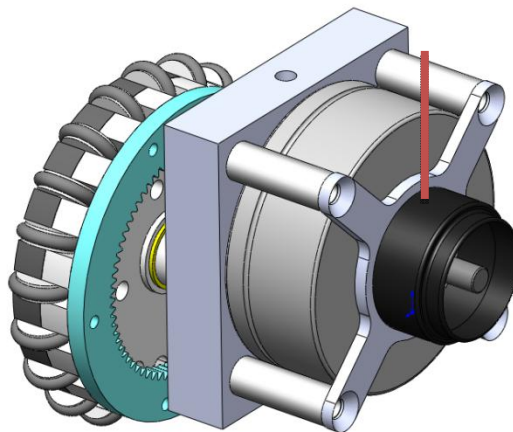

Fig. 4 New tire unit (CAD image)

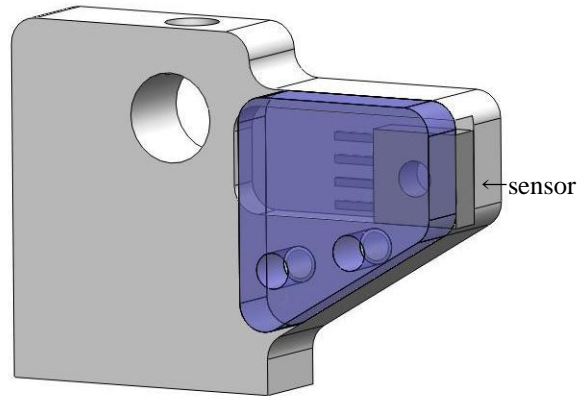## 2.3   Improvement of sensor to find a ball

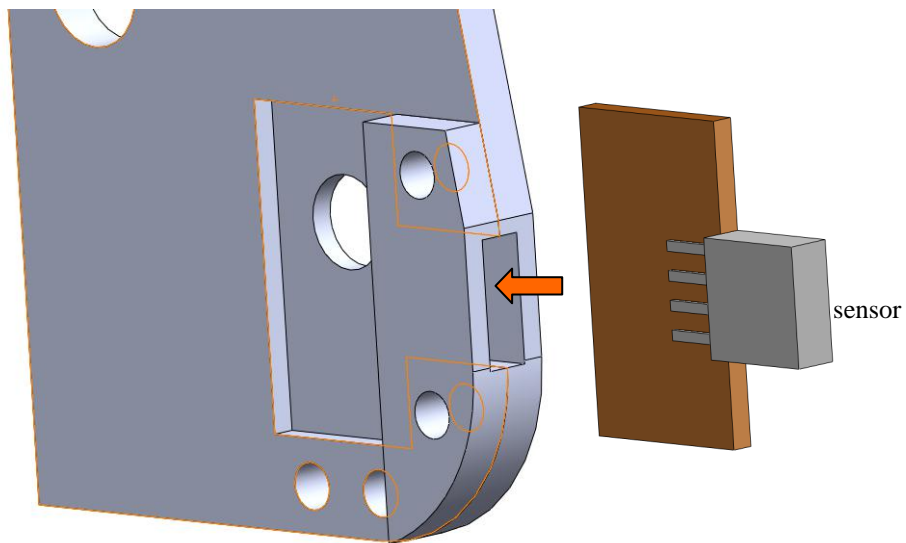Fig. 5 Previous sensor units (CAD image)

Fig. 6 New sensor unit (CAD image)

The sensor of 2010 model was fixed as sandwiching by two plates as shown in Fig.5. This structure, however, would slip off the sensor when the sensor was given by a strong impact. So, the new sensor was mounted on the circuit board in order to fix rigidly as shown in Fig. 6. Furthermore, the sensor is covered with the duralumin for protection.

3   Electrical design of new circuit

The new electronic circuits in 2011 model consist of two main boards. They are main control unit and peripheral control unit shown in Fig. 7, respectively. The main control unit includes the main CPU, power supply circuit, wireless communication module, ball detecting circuit and dribbling motor controller. The peripheral control unit includes BLDC controller and voltage booster.
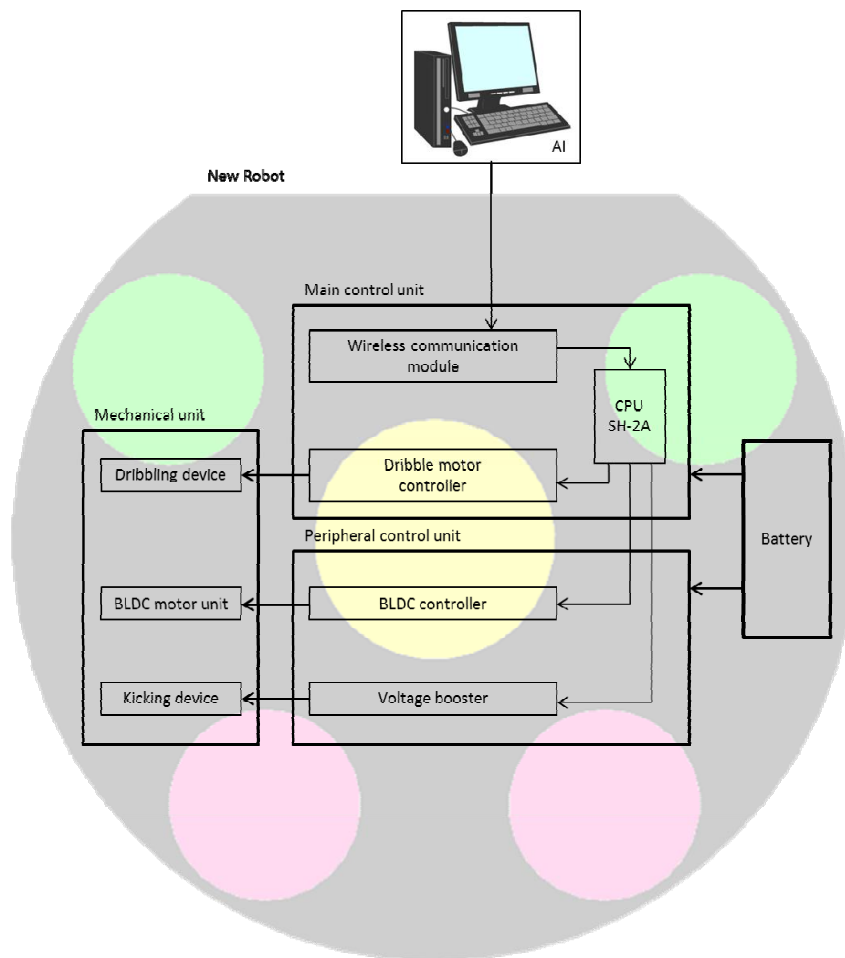

Fig. 7 Construction of circuit in the new robot

3.1 Main Control unit

We have developed new main control unit. This unit includes the circuit for detecting a ball, power supply circuit and wireless communication module. The SH7262 (SH-2A series of Renesas) is used for a main CPU that communicate each PIC to the peripheral controllers, such as BLDC controller, voltage booster circuit etc. The CPU runs 144MHz (345MIPS) and has 1MB RAM. Its performance is enough to achieve the precise control of the robot.

3.2 Wireless communication system

We have used the Digi's XBee module for communication system between host PC and each robot. The wireless communication frequency is 2.4GHz band. The XBee module is able to communicate faster than conventional wireless module. It is possible to communicate up to 115200bps. Up to now, the communication speed was 19200bps. So since we will be able to send more information to the robot, it is possible to develop more advanced controller.

3.3 BLDC controller circuit

An each robot has four BLDC control circuits for omnidirectional mobile. The MCU of BLDC controller is dsPIC30F4012. Three phase PWM module and Quadrature Encoder Interface for motor control in MCU are very useful for development of BLDC controller. The motor speed of the robot is controlled by PI speed control in MCU. This circuit is also used for dribbling motor controller.

3.4 Voltage booster circuit

The DC-DC converter to boost up the voltage is used for the solenoid. The input voltage of 16V is converted to 200V output. This chopper circuit is controlled by PIC in each robot. In the kicking device, the output voltage of 200V is charged in 4100uF capacitor. The time to charge up to 200V from 16V is 5 seconds.

4 Improvement of strategy system

Strategy system was also improved. The architecture of new strategy system is illustrated in Fig. 8. The strategy system consists of four modules called "Situation Analysis", "Strategy", "Formation" and "Action".
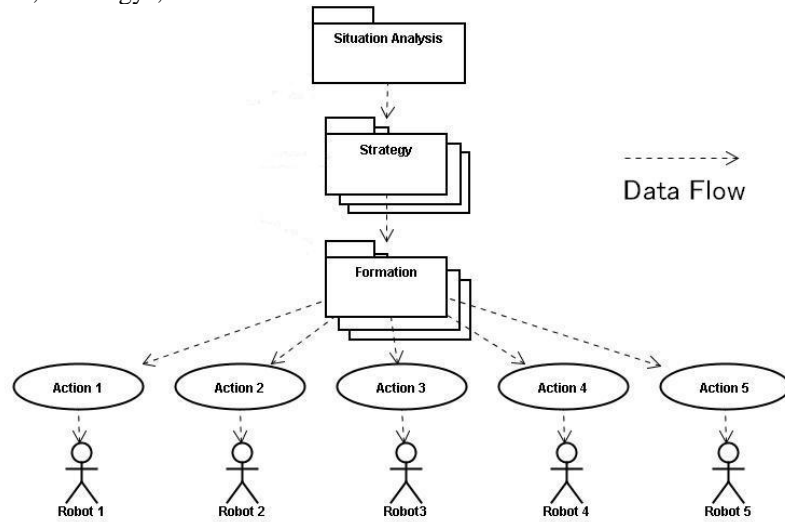

Fig. 8 Construction of strategy system

4.1 Situation Analysis module

This module is located at top level in strategy system. This module plays the role of analysis about the game situation from both position of the ball and robots on the field, and generation of the trial instruction command.

4.2 Strategy module

This module is located at below level of Situation Analysis module. The role of this module is to select the optimal next Formation module from result of analyzing. For example, when the result of analysis is "Indirect Free Kick of Own team", the Strategy module will select the "Indirect Kick Formation module". On the other hand, when the result of analysis is "Need to Defense", the Strategy module will select the "Defense Formation module". Since the Strategy module has many strategy patterns, it will be able to select the optimal Strategy module corresponding to the game situation.

4.3　　Formation module

This module is located at below level of Strategy module. This module plays the role of the decision of the next Action module which should be performed by each robot.

4.4　　Action module

This module is located at the bottom level in strategy system. The role of this module is to command the specific operations to each robot. The "Direct Shoot Action" for instance, is command to kick a ball for the robot. Alternatively, the "Wall Defense Action" means moving the robot to the position to defend the goal.

5　　Conclusions

We have improved the robots of SSL as well as last year. As the results, some problems found in last year were solved and the performance of the robot was achieved best among the recent years.

We hope that our robot will be doing the best in coming world competition.

References

[1] Piyamate et al. Skuba 2010 Extended Team Description. In: Proceedings of RoboCup 2010.