KIKS 2013 Team Description Paper

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Abstract. This paper is used to qualify as participation to the RoboCup 2013 small size league about team "KIKS". Our robots and systems are designed under the RoboCup 2013 rules in order to participate in the RoboCup competition. The major improvements in this year are the enhancement of the performance and robustness of wheels, electrical circuit and automatic control system. The overviews of them are described

Keywords: RoboCup, small-size league, engineering education, global vision

1. Introduction

In RoboCup world competition, our team has continuously participated since 2004. We came in top 4 in Singapore and Istanbul, and in top 3 in Mexico last year. Since we are aiming for higher place compared with last year, further improvements has been done in this year.

One of the educations for creative minds of students is using the robot contest. We have executed the robot contest in our college just like RoboCup junior every year. So, main purpose of our participation to the RoboCup world competition is confirmation and evaluation of effect for creativity.

In last year, there was a problem that the travelling performance of robots was poor. So, we redesigned a new wheel and improved the stability of the robots under travelling on the field. We also redesigned speed controller on the AI server. As the results, response performance was better than that of last year.

The main topics of robot’s hardware developed for 2013 model are following terms,

・ Improvement of the wheels

・ Improvement of the electric circuit

・ Improvement of the speed controller on the AI system

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2. Hardware of the robot

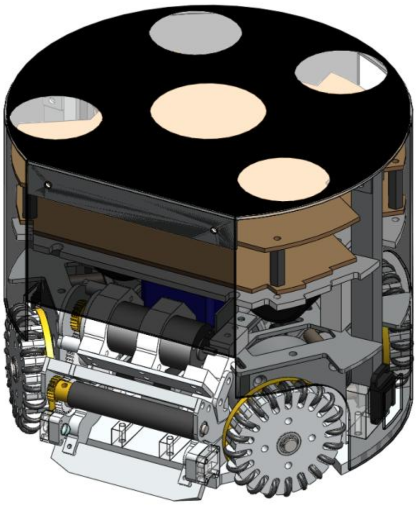

Fig. 1 Overview of 2013 model

Table 1. Specification of robot for 2013 model

	2013 version
Weight	2.3kg
Main material	Aluminum alloy
Driving motor	maxon EC45flat (30watt)
Gear ratio	3.6 : 1
Wheel diameter	56mm
Number of solenoids	Straight kick: 1 Chip kick: 2
Straight kick power	Ball speed of 8[m/s]
Chip kick power	Max 3.0m away from robot under the condition of initial angle 40°

The overview of 2013 model is shown in Fig.1. The main configuration is basically same with the 2012 one. The wheel was only improved to achieve a stable travelling performance. We redesigned the omnidirectional wheels again. In 2013 model, we also use the brushless motors (maxon EC45 flat) as the driving motor, like many teams. For the dribbling device, we use the brushless motor (maxon EC-max22) again. Each robot has three solenoids. One is for straight kick and the other two are 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

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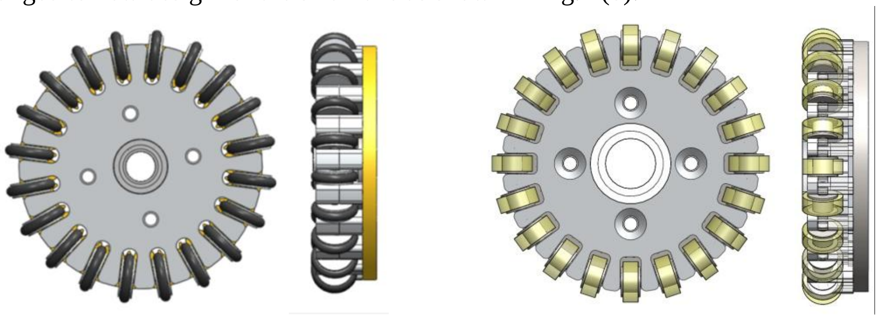
the ground for the robot is 148[mm] and 178[mm], respectively. And the maximum percentage of ball coverage is 18%. The specification of the robot is summarized in Table 1.

2.1 Travelling performance of the wheel

Since 2011 competition, we have used the same brushless motors as many teams do. But, there was a problem in previous wheel for performance of straight-running stability of the robot. That is, our robots were not able to run straight stably under the condition of max speed of $2ms^{-1}$ and acceleration of $3ms^{-2}$. Figure 2(a) shows the previous wheel. There were two reasons why straight-running stability was bad. One was that the small tires on wheel do not rotate smoothly. There were frictions between small tire and the tire's house. Another one was that the characteristic of friction to the playing field for rubber small tire is not so good. It is made to occur the slipping of robot in play, because of use of O-rings with cross-section of circle with smaller ground contact area. Thus, we redesigned new wheel to solve these problems. It was changed to new design for the small tire as shown in Fig. 2(b).



(a) Previous wheel (b) Present wheel

Fig. 2 Previous wheel and new wheel

The new small tire is constructed with wider urethane material, metal pin and washers as shown in Fig. 3(b). A previous wire shaft connected with all small one is changed into each metal pin in new wheel. By using of two washers in small wheel's house the friction of small tire is decreased drastically. The urethane tire with cross-section of rectangular is effective to enhance the friction between wheel and playing field.

As the results of wider width of small tire and more precise approximate circumference in new wheel, the robot can run smoothly and turn quickly. In addition, the resin material as outside shell for wheel is easy for cutting work, and is effective for realization of high-speed rotation due to its light weight.

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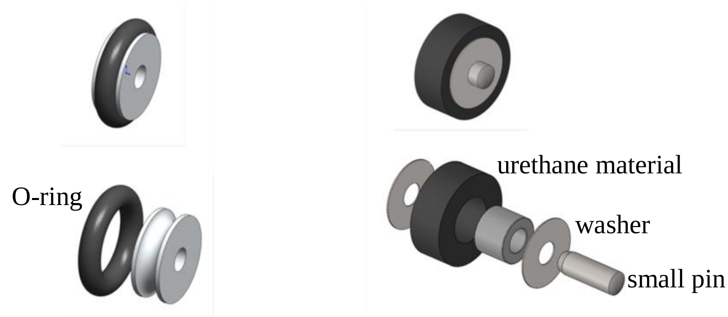

(a)Previous small tire (b) Present small tire

Fig. 3 Component of small tire on wheel

Whole image of wheel is shown in Fig. 4. Because of an axle is only put on the back-board in new wheel, it was decreased the position gap of axle hole between the front- and back-board. In addition, it is easy for assembling and maintenance by attaching the axle of every small tire on wheel independently.

(a)Previous wheel (b) Present wheel

Fig. 4 Whole image of wheel

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3. Electrical design

The electronic circuit of KIKS is mostly same as last year. The new electronic circuits consist of two main boards shown in Fig. 5. They are main control unit and peripheral control unit. 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 motor driver and voltage booster. The major changes are motor driver and voltage booster circuit.

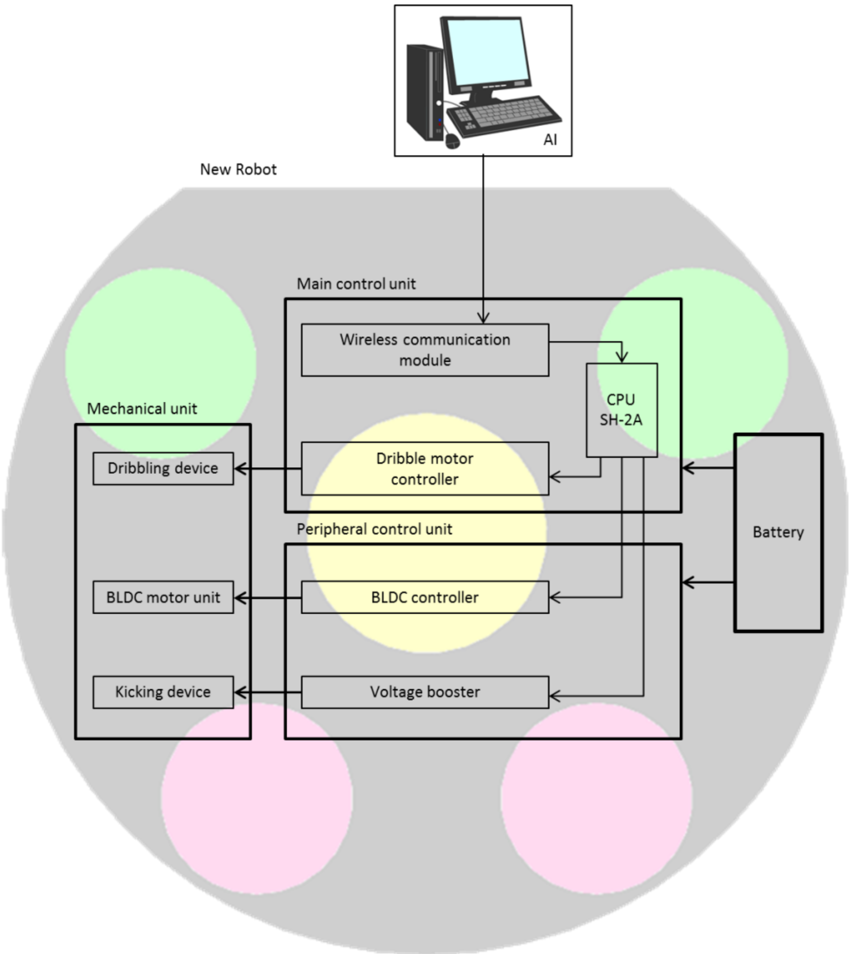

Fig. 5 Construction of electrical circuit in the robot

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3.1 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 for 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's 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.

3.3 BLDC motor driver

An each robot has four BLDC motor driver circuits for omnidirectional moving. The MCU of motor driver is dsPIC30F4011. This circuit is added electrical current sensing system. So, it is possible to control torque of each motor. 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 is used to boost up the voltage 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 4100μF capacitor. The time to charge up to 200V from 16V is 2.46 seconds.

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4. Software design

Our AI system is called the Strategy Information System(SIS). SIS design is mostly same with last year. The overall software architecture is shown in Fig. 6. The software consists of four threads, i.e., the Game Thread, Sender Thread, SSL-Vision Receiver Thread and Referee Box Receiver Thread. Moreover, the Game Thread includes some modules.

Especially in 2013 version, we tried to improve speed controller on SIS. As the results, we achieved the max speed of 2.5ms^{-1} and max acceleration of 3.75ms^{-2}. The detail is described below.

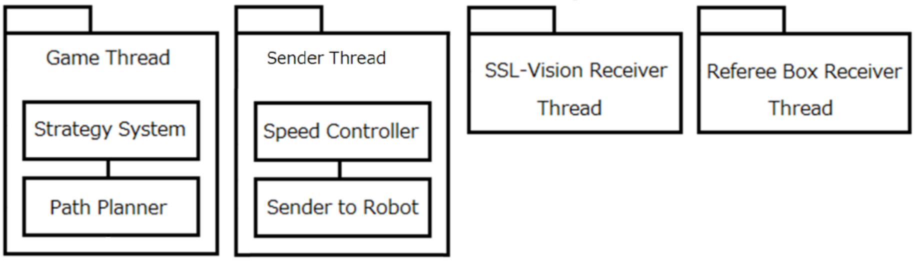

Fig. 6 Software architecture

4.1. Improvement of speed controller

Up to now, it was examined by simple bang-bang control for speed control of robot. However, the method caused our control system to become unstable easily, and it was not robust for disturbance. Thus, we developed new speed controller for robots on SIS. It has made it possible for running faster and more stable.

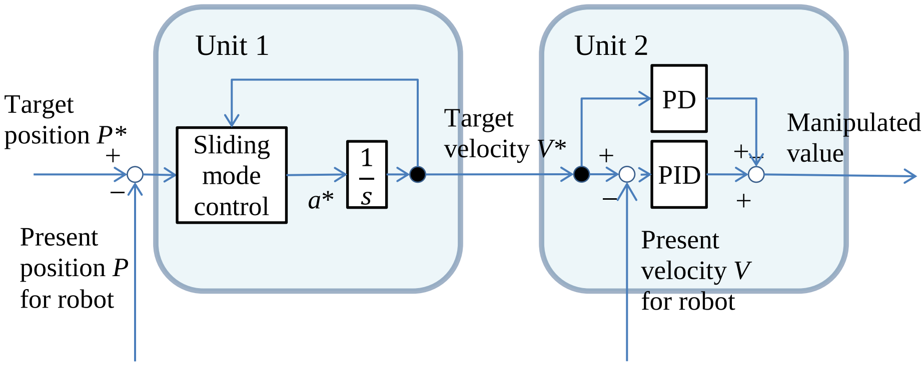

Fig. 7 New speed controller with two units

New controller has 2 units as shown in Fig. 7. The Unit 1 outputs the ideal motion speed based on the robot's position with considering of max acceleration and convergence velocity $V*$ to the target position $P*$. We applied tentatively sliding mode control theory for speed of robot. As the result, it can easily control them. The equation of sliding mode parameter σ and ideal acceleration a^* are shown as follows,

$$\sigma = (P^* - P) + HV^* \qquad (1a) \quad ,$$

$$a^* = \begin{cases} a_{max} \ (\sigma > 0) \\ -a_{max} \ (\sigma < 0) \end{cases} \qquad (1b) \quad ,$$

, where H is positive efficiency and used to decide convergence velocity.

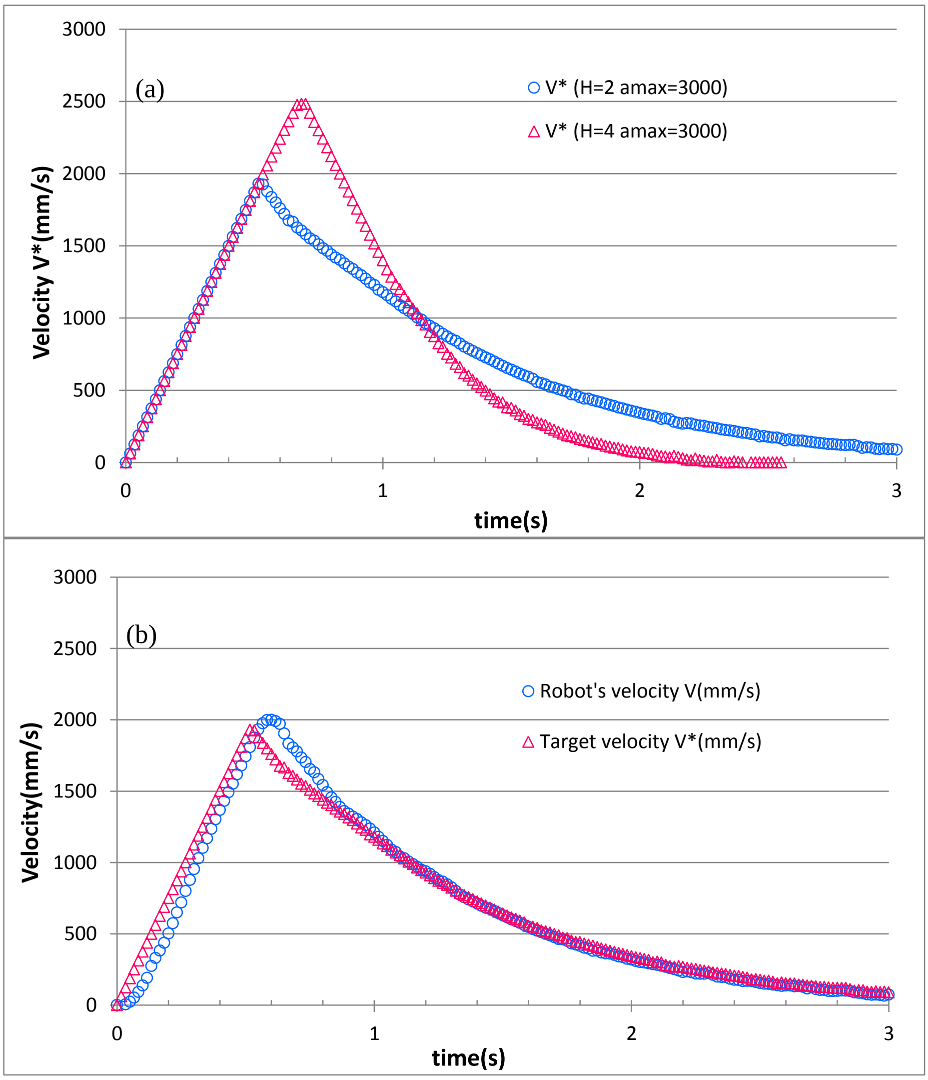

Fig. 8 Time dependence of velocity for robot

The Unit 2 outputs the manipulated value to follow the robot's velocity V to target velocity $V*$ getting from Unit 1. Since it has two-degree- of freedom control as shown in Fig. 7, it is robust against the disturbance. Figure 8 show the time dependence of the velocity until arriving to the target position. In Fig. 8(a), it is shown that the target velocity V^* is varied depending on the coefficient H of eq.(1a). Thus, it will be got optimum performance under the condition of stable control loop by applying appropriate parameter. In Fig. 8(b), it is shown that the agreement between robot's velocity and target velocity is fairly good. That is, the velocity of robot will be able to respond within 100msec.

5. Conclusions

Our robots have been continuously improved in every year. As the results, the travelling performance is getting better and robots are able to move more quickly than last year.

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

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