KUDOS Team Description Paper for Humanoid Kidsize League of RoboCup 2016

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Abstract. We performed match at RoboCup2015 with our own robot, KUbot and KUboteen. Through the competition we found our robots strength and weakness. After we remedied for our robots shortcoming, we made new robots, KUboteen2 and KUbot3. Also, we applied new techniques such as Shadows-Reflexibility recognition and PD-control System. After then, our robots could have been work much better. This paper briey describe our preparation and research for RoboCup2016.

Keywords: KUDOS, KUboteen, KUboteen2, KUbot3, Humanoid Robot, Shadows-Reflexibility Recognition, PD-control System.

1 Introduction

We are KUDOS, which is an acronym of Kookmin University Dream of Soccer. We named our team so for two reasons. First, the ultimate objective of RoboCup is to field a team of robots that can win against the human soccer World Cup champions by 2050. Realizing this objective is the dream of robotics and soccer players. In this light, we chose dream of soccer as part of our team name. Second, kudos is a synonym of prestige. Because we aim to achieve prestige at the Humanoid KidSize League of RoboCup, the meaning of kudos well matches our team objective.
To explain about each teams area, First, the control area, KUDOS has participated in the RoboCup since 2012. The stadium turned into a grass field at 2015. So we used the PD control to make a stable walking. And we are ready for the RoboCup 2016 to make a soccer algorithm which use a geomagnetic sensor and we adapt it to Kuboteen2.
Second, the vision area, according to the tilt angle of the robots head, we make robots image processing to mask rapidly only the field. And we make an algorithm to sense the things which is the close to a circular shape. We also add the algorithm using reflectivity to sense the ball accurately.

Third, the design area, we developed our own robot, KUbot, KUboteen. With many years experience of competition, we felt that we need new robots for competition.
Since the rule changes every year and the artificial grass has a very powerful affection, we developed new algorithms and designs for KUboteen, KUboteen2, and KUbot3.

2 Hardware

2.1 KUboteen

KUboteen is developed to deal with RoboCup2016's large field, bigger ball and trend of bigger robot. KUboteen is based on our prior robot, KUbot. And it has same electric devices such as computing unit and sensors. However, we selected a new actuator that can output a higher torque than former one to gain the force which enable to move heavier robot. Also calf and thigh frame are designed to minimize the engagement force applied to the actuator during a competition and to supplement the stability of the robot hardware.

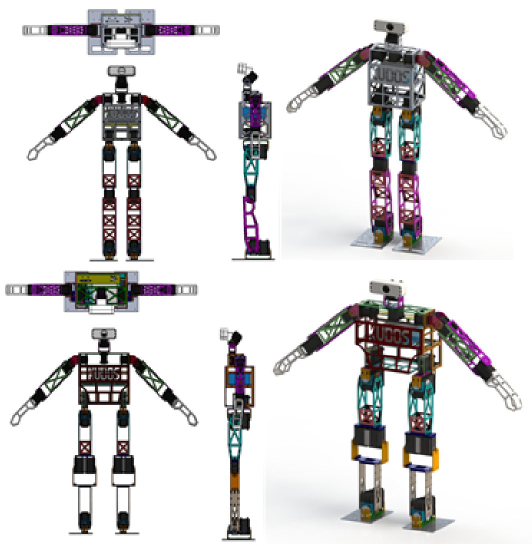

Fig. 1. KUboteen and KUboteen2

2.2 KUboteen2

KUboteen2 is developed to withstand the weight power of larger actuator compare with KUboteen. KUboteen2 is based on KUboteen, except knees and pelvis.

KUboteen2 is designed identical with same-height humans ratio. Then we expand width of pelvis. As field get larger, robots should move faster than former speed. Then, we put two actuators in robots knees to make higher torque to move fast. Also, we put some parts to fasten bolts in the actuator to support the stability of robot hardware in hip-yaw.

2.3 KUbot3

After RoboCup 2015, we got new rules for field. Field was changed to artificial grass. Then we need to develop some parts to operate the robots in the field. Original robot, KUbot, was hard to walk in stable motion because of height. Knee of KUbot3 was originally MX-28. We changed that actuator to MX-64, and robot could walk stable around the field. This is the KUbot3 based on our prior robot, KUbot.

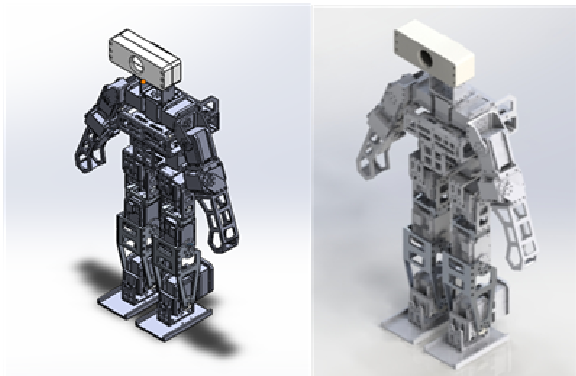

Fig. 2. KUbot3

Table 1. KUbots Specification

Series		KUbot3	KUboteen	KUboteen2
Height		479mm	850mm	850mm
Weight		3kg	6.7kg	7.6kg
Number of DOFs		20 in total (6 DOF Legs x2 =12, 3 DOF Arms x 2 = 6, 2 DOF Head x 1 =2)		22 in total (7 DOF Legs x2 =14, 3 DOF Arms x 2 = 6, 2 DOF Head x 1 =2)
Actuator	Actuator	DYNAMIXEL MX-28, MX-64	DYNAMIXEL MX-64, MX-106	
Control Unit	Main	SBC-fitPC2i	Intel D34010WYK	
	Sub	CM-730		
Camera		logitech C920		
Intertiameasurement unit		Gyro : 3-Axis LYPR540AHAcceleration : 3-Axis ADXL335		
Other specs		Sound: speaker Display: body LED magnetometer: 3-axis akm8975		

3 Algorithm for Robot Soccer

We developed an algorithm for robot soccer, shown in Figure 1.
It follows 4 steps, (1) Find the ball (2) Approach the ball (3) Find a goalpost and take a position to shoot. (4) Shoot or dribble the ball.
In first step, the robot finds the ball by moving its head only. It moves its head up, down, right and left. If it cant find the ball, it rotates and moves head again to find the ball. If it cant find the ball this time, it moves toward our goalpost and finds the ball. It repeats these small steps to find the ball. When the robot approaches too close to a goalpost, it turns toward the opponents goalpost and repeats the steps.
If the robot finds the ball, it approaches the ball and finds a goalpost. The robot revolves around the ball until the robot lines up with a goalpost and the ball. That is step 2 and 3.
Then the robot shoots or dribbles the ball.

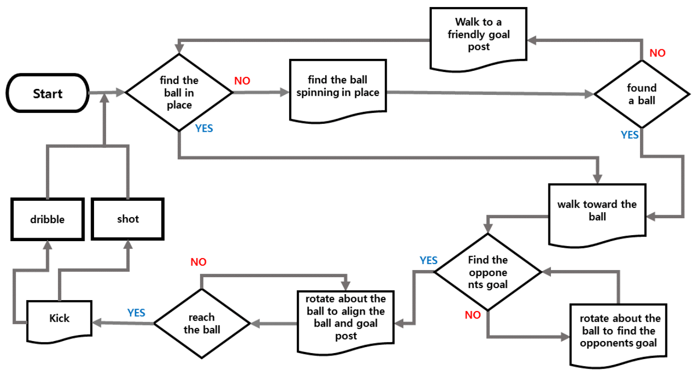

Fig. 3. Algorithm for field player

4 Vision

4.1 Vision Processing

The processing time becomes much longer if the picture has high resolution or contains many algorithms. To make the processing faster, we cut out the unnecessary part of the picture with the tilt. As a result, the robot separates the field for processing and the time shortens.

4.2 Detecting the Ball

Recognizing shadows and reflexibility. The ball has multiple colors and complicated shape. For new ball last year we used SURF (Speeded Up Robust Features) algorithm that chased the pattern to detect the ball. [4]However, it was pretty slow and influenced easily by light and environmental changing. So this year, we use the algorithms that recognize the reflexibility and shadow. It is much faster and more accurate for detecting the ball. Figure 1 shows the result.[5]

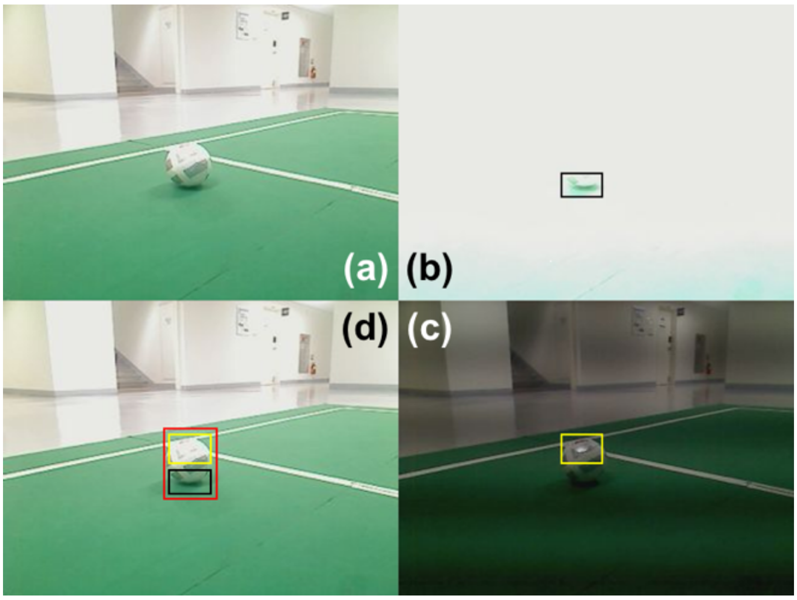

Fig. 4. (a) Original Picture, (b) Shadow Area, (c) Reflected Area, (d) Final Ball Detecting Area

4.3 Shape Detection

From 2015, the color restriction on surroundings was removed. That means it is hard to distinguish the ball, goalpost and line only with color detection. So we developed new additional algorithms with shape detection. Because of this, the robot detects the ball by circle detection. As a result, we use the ball detecting system with both algorithms: shadows-reflexibility recognition algorithm and shape detection algorithm.

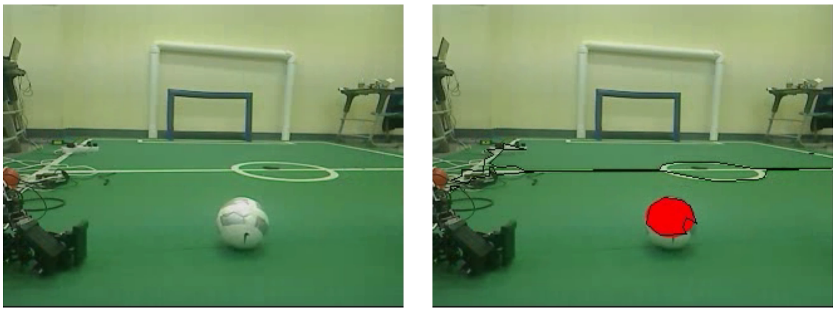

Fig. 5. Detecting the Ball with the Circle Detection

5 Locomotion

RoboCup 2015 that was held in Hefei, China, had a lot of rules that changed. One of the most challenging changes was that the field was changed from a flat surface to grass. Stable walking is the most basic step for robot soccer, so navigating on grass added a new level of difficulty.

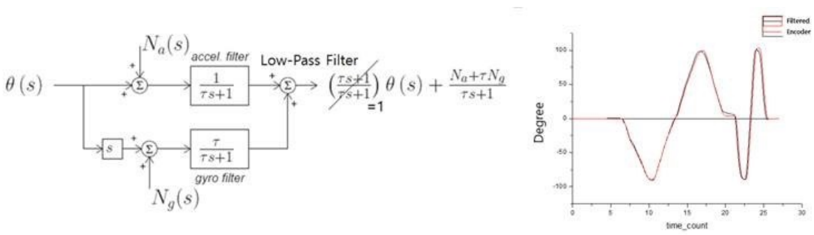

Fig. 6. Complementary Filter Block diagram and Graph

We see the necessity of stabilizing the robot walking on the grass. If we could measure the robots degree accurately and use the proper control algorithm, the robot would walk stably on the grass. We could measure the robots degree from a gyroscope and accelerometer that is in the IMU sensor. However, the gyroscope contains error that comes from drift. The accelerometer contains errors and noise too. So we need to apply the complementary filter to get a meaningful value for degree. [Fig 6] [2] [3]

The model the robot will use is an inverted pendulum system so that we can simplify and analyze the robot structure. In the last competition, we only used D control for walking. But it was hard to walk stably on the grass with only D control. So we added the P control to stabilize the walking. [1]

In playing, there is also a situation where robots walk into each other. When this kind of disturbance occurs, the robot also needs to be stable. So to control

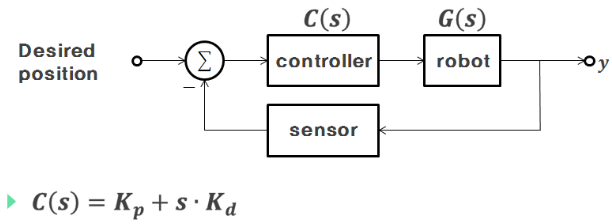

Fig. 7. Inverted Pendulum

for this problemfor the robot, we impacted the robot constantly and tested the controller.

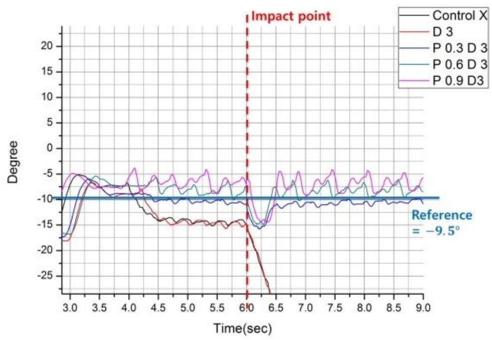

Fig. 8. Impact when the Robot is Walking

We recognize the problem that the robot is unstable when impact occurs. So we added the P control while keeping the D control that we used before. As you can see from Figure 8, it works well. It can withstand the impact and it arrives to the desired value. With this progress, we are assured that we can demonstrate a better performance in RoboCup 2016.

6 Conclusion

We have participated RoboCup every year with passion. For RoboCup2016, we newly developed our robots and continuously studied various methods such as shadows-reflexibility and PD-control System. We will participate in RoboCup regularly and grow further as a team. We aim to show much better performance in RoboCup2016.

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