CIT Brains & Team KIS

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Abstract. This paper describe the overall system and design for the RoboCup AdultSize humanoid league for CIT Brains and Team KIS collaboration team. Team KIS developed the robust mechanism against external impact force using a novel geared motor system, which contains a shock absorbing mechanism, and light-weight eccentric oscillating speed reducer made by plastic. CIT Brains developed the overall software system such as image processing, soccer strategy and walk control.

Keywords: eccentric oscillating speed reducer, shock absorbing mechanism, image processing, soccer strategy, walk control

1 Introduction

Team CIT Brains and Team KIS is a collaboration team joined together from CIT Brains AdultSize League of Chiba Institute of Technology and Team KIS of Chiba Institute of Technology and Nabtesco Coporation. Both team has previous experience with RoboCup AdultSize Humanoid League. CIT Brains has previously participated in RoboCup Humanoid KidSize, TeenSize and AdultSize, receiving 1st place in the KidSize 4-on-4 in 2014 and 2015. Team KIS previously participated in RoboCup 2017 and received 2nd place in technical challenge.

This paper will describe the overall system and design CIT Brains and Team KIS' AdultSize humanoid robot Ixion, a robust humanoid robot developed by Team KIS capable of withstanding various impact and force, equipped with software system developed by CIT Brains. The first two sections will discuss the overview of the hardware and the novel geared servo motor system with a shock absorbing mechanism developed by Team KIS. The last three sections will discuss the software system with improved ball detection, strategy and walk control developed by CIT Brains.

2 System Overview

Ixion (Fig. 1), developed by Team KIS, consists of a USB camera, a computer board, an inertial measurement unit, a battery and several motors as specified in Table 1. The overview control system is shown in Fig. 2. The camera captures images which are processed on the main CPU board to detect ball positions and landmarks. From these data, the robot strategizes and determines its next course of action such as following the ball or evaluating whether to dribble or to shoot the ball. After deciding its action, the CPU sends action command to the servos. The architecture to play soccer autonomously was the based on CIT Brains' robot[1].

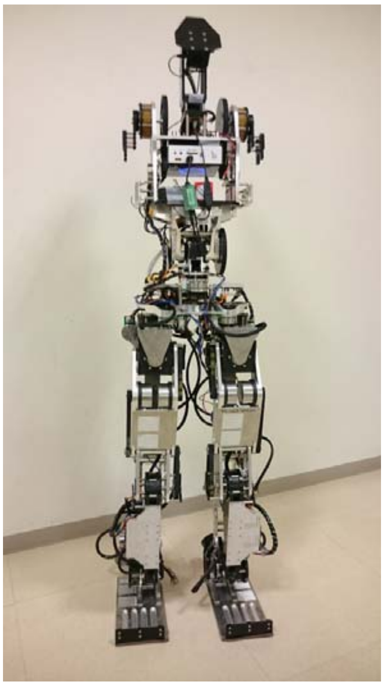


Fig.1 Ixion

Table 1 Specification of the robot

Weight	23.0 kg (Including Batteries)
Height	1400 mm
Velocity (Forward)	0.4 m/s (Maximum)
Walking Directions	All direction and rotation (Select the angle, stride, period and so on)
CPU Board	ZOTAC ZBOX nano ID69 (Intel Core i7-4500U)
OS	Linux (Ubuntu1404)
Motors	Maxon EC 60 flat, EC 45 flat
Battery	Li-Po 22.2V x 1

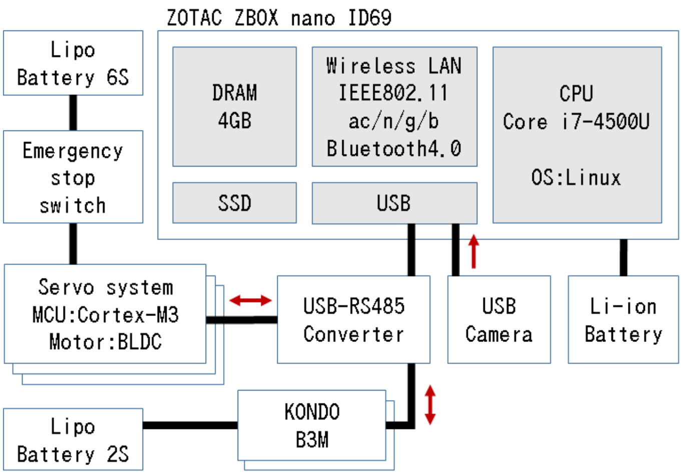


Fig.2 Overview of the control system

3 Shock Absorbing Servo Motor

One of the most challenging problem to build a human-size robot was how to keep the robustness against external impact force. The larger the robot, the larger impact force it receives which damages the mechanism especially in gears attached to the motors. Team KIS developed a novel geared servo motor system with a shock absorbing mechanism using elastic material to the servo motor system to decrease peak impact force. Team KIS called this mechanism Shock Absorbing Servo Motor (SASM).

Figure 3 shows the shock absorbing servo motor (SASM). Fig. 4 show the proposed mechanism. The mechanism is separated between the inner case and the outer case. The case are connected with the elastic urethane rubber rod. When the impact force is applied to the outer case, the urethane rod is deformed, decreasing the peak of impact force applied to the inner case. The SASM has easy-changeable urethane rubber rods; adjusting the number of rods or the rod material can change the elastic characteristic.

The strongness of the gear was confirmed in RoboCup 2017 technical challenge high jump challenge. The robot jumped for a period and landed without breaking the gear.

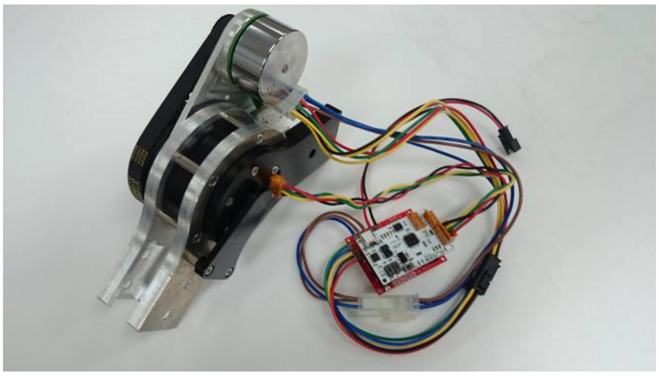
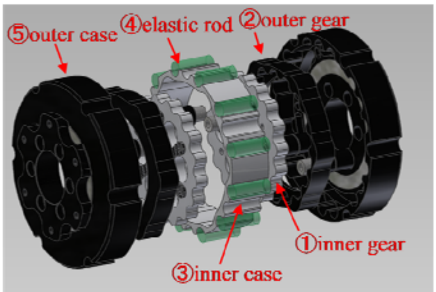
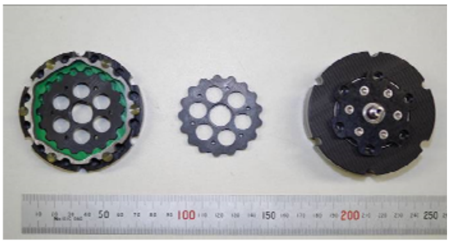


Fig.3 Shock Absorbing servo motor including an original control circuit (Max. 100A)





(a) structure of the mechanism (b) developed mechanism

Fig.4 Proposed mechanism with the elastic urethane rubber rod

4 Ball Detection Using Deep Learning

In RoboCup2015, the game ball was replaced with a FIFA soccer ball. The color of the new game ball was nearly identical to the goal post and the white lines thus it was extremely difficult to distinguish between objects using color-based object recognition. CIT Brains implemented an object detection method using convolutional network to distinguish object as shown in Fig. 5. The robot can detect the ball with high accuracy using deep learning.

Fig.5 Distinguishing ball and goalpost

5 Ball Exploration Using Frontier Based Method

The introduction of deep learning improved accuracy of detecting the ball. However, the behavioral pattern in the strategy when the ball is not found was an important issue. CIT Brains developed a field search algorithm based on Frontier-Based Exploration[2] to speed up the discovery of the ball as shown in Fig. 6. The improved strategy allows the robot to take more aggressive actions.

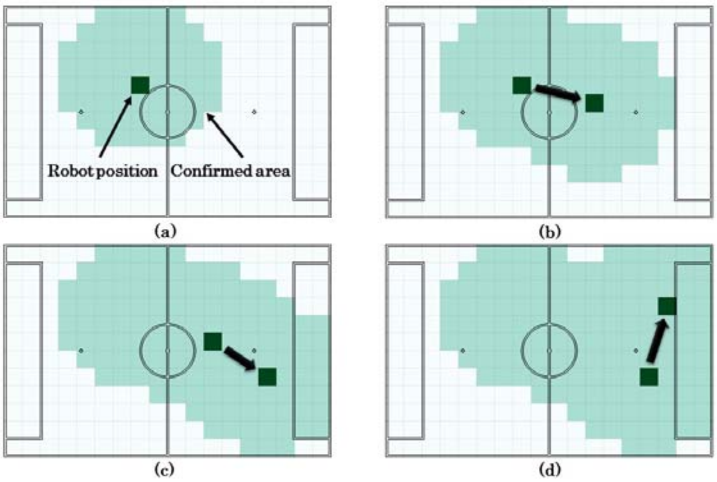


Fig.6 Ball exploration on the field

6 Walking Control

CIT Brains developed an improve motion control by applying the preview control method to the COM trajectory generation method as proposed by Kajita et al. [3]. In this method, it was possible to generate a stable COM trajectory in real time by using target values a few steps ahead. Even if the target position is dynamically changed, it was still possible to recalculate the COM trajectory depending on the current state of the robot as shown in Fig. 7.

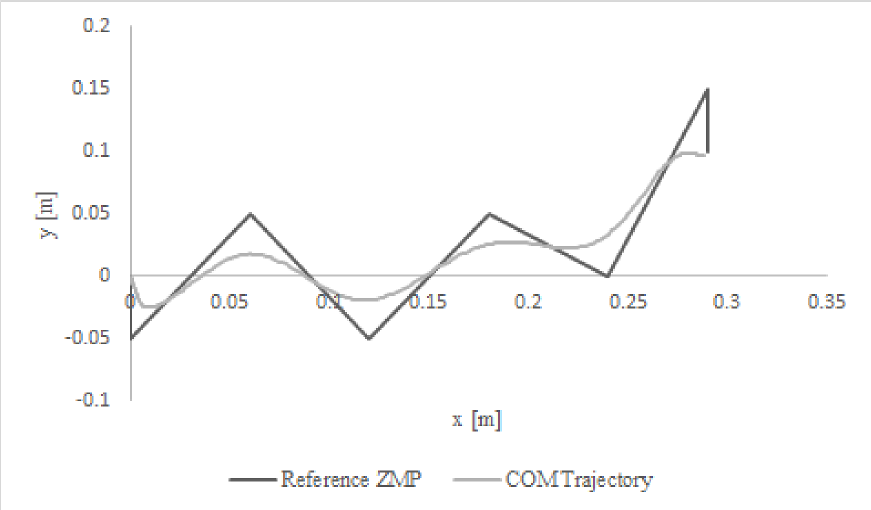


Fig.7 COM trajectory when target position is dynamically changed

8 Conclusion

In conclusion, this paper describe the overall system and design CIT Brains and Team KIS' AdultSize humanoid robot Ixion, a robust humanoid robot developed by Team KIS, with software system developed by CIT Brains.

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