

# CIT Brains and Hajime Robot

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In this paper, we describe on our system for the RoboCup soccer kids size humanoid league. The system we designed has some features. Especially, its high mobility and well-designed control system are remarkable. The robot can walk speedily and robustly. The normal speed is approximately 0.2m/s. It also has a feedback system with gyro and acceleration sensors to prevent falls. It can walk on some irregular grounds. The second feature is well-designed control system. The robot has two control circuit boards. One is used for walk, and another is used for image recognition, strategy and so on. Both circuit are designed for humanoid, and they are light weight and powerful. Especially, the latter has NetBSD operating system, so we can use UNIX powerful tools. And, it also has FPGA for real-time processing. Then, it can capture and process images at 30 frames per second.

## 1. Introduction

In this paper, we describe on our system for the RoboCup soccer kids size humanoid league. Our robot is well-designed and controlled robustly, because the members of our team are collected from Toin Phoenix (4th prize of RoboCup2006, 2on2), Toin Albatross (The winner of RoboCup2004 JapanOpen Small Size League, One of Best 8 of RoboCup2006) and Hajime Robot. His Robot's mobility on irregular grounds achieves distinction at RoboCup2006. It can walk speedily and robustly. The normal speed is approximately 0.2m/s. It can also walk any direction smoothly. It has acceleration and gyro sensors. They are used for stable walking. They are also used to detect falls. If it detects falls, it stands up automatically. Another remarkable point is control system. The robot has two CPUs. One is used for walking, and another is used for image recognition, strategy and so on. Both CPUs are designed for humanoid. They are light weight and high computational capability. Especially, the latter computer has NetBSD operating system. We can use UNIX powerful tools.

Generally, UNIX system is unsuitable for real-time operation. However, our system also has a FPGA. It helps real-time computing.

## **2. Overview of the System**

The photograph of our robot is shown in Fig.1. The specification of the robot is indicated in Table 1. The overview of our system is shown in Fig. 2. Our robot system consists of a camera, computers, sensors, servo motors, batteries and some user interfaces such as switch and LED. The camera sends image signal to the main CPU board. The signal is captured and sent to frame buffer memory. The CPU calculates the image data to detect the positions of ball and robots. After that, according a rule of behavior, robot selects a next action. The action command is send to another sub CPU via RS232C network. The sub CPU decodes and executes the command. It sometimes returns the status data to the main CPU. If the command is a kind of moving the body, the CPU sends a command to servo motor via RS485 network. The servo motor has own CPU. Because they are daisy-chained, the command is sent to all motor. The command includes motor ID, so a specific motor receives the command. The CPU in the motor decodes and executes the command. The motor is controlled independently from the sub CPU. The sub CPU should not send commands at short intervals. Totally, this system is constructed as a well-designed hierarchic system. So, we can modify the system easily.

## **3. The Mobility of The Robot**

One of the significant features of our robot is the mobility. The mechanism, circuit and software for walking are developed by Hajime Research Institute, Ltd. It can walk speedily and robustly even if the ground is irregular. According to the command via RS232C, the robot activates many functions such as walking, kicking, returning the status data and so on. The list of main functions is indicated in Table 2. When the controller gets a command, it decodes and executes. If the command is related to servo motors such as walk, motion and read status, the controller sends a command to servo motors via RS485. Because all servo motors are daisy-chained, the command is sent to all motor. The command includes ID number, so the servo motor can identify the command to which is sent. The servo motor decodes and executes the command. If the command is request to send status, the servo motor return the status via RS485. It can return many kinds of status data. Now, the controller just requests the position and temperature data. We can extend if we want to get other information like feedback gain. The controller also gets information from gyro and acceleration sensors via A/D converter. According the data, the robot controls the posture to prevent falls. The robot does not fall practically, however, in game it sometime fall by pushing other robot. When the robot stays such situation, it detects the fall and stand up smoothly.

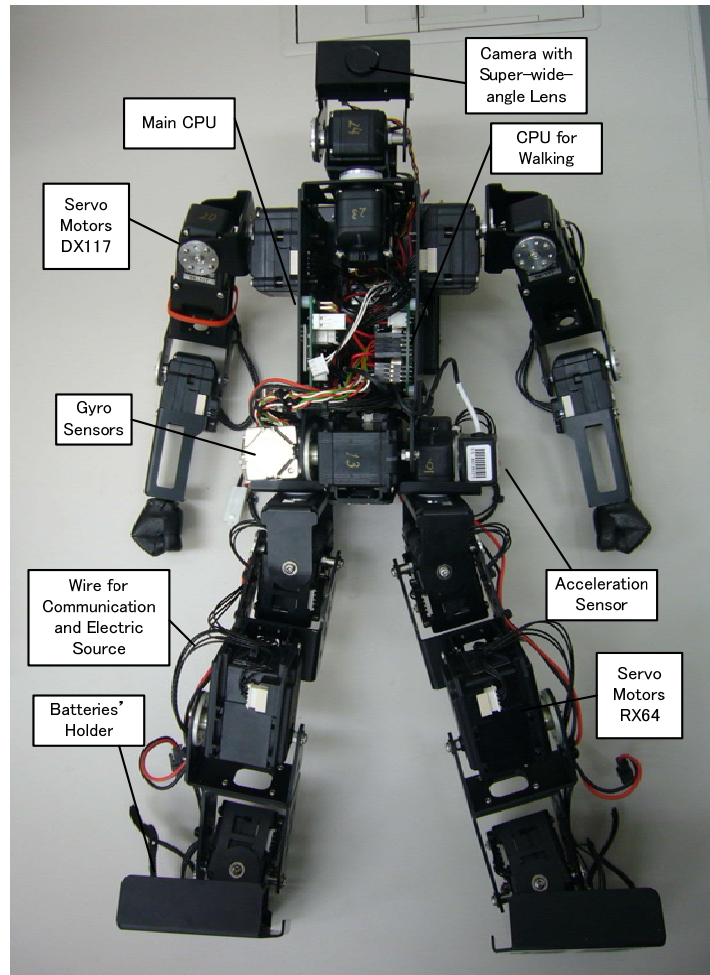


Fig.1 Structure of the Robot

Table 1 Specification of the Robot

Weight	3.0 kg (Including Batteries)
Height	495 mm
Velocity (Forward)	approximately 0.2 m/s
Walking Directions	Forward, Backward, Side Step, Turn (Select the angle, stride, period and so on)
CPU Board	Main: Brains Corp. mmEye-PPC (Freescale MPC5200) Sub: Hajime Robot HC3 (Renesas SH-2/7145F)
OS	NetBSD (mmEye-PPC)
Interface	Ether(100Base-TX) x 1, USB x 1, CF x 1, RS232C x 2, Sound In/Out, Digital I/O, etc
Servo Motor	Robotis DX117 x 18, RX64 x 3 (Including a CPU for communication and control)
Battery	Thunder Power TP1320-2S (7.4V, 1350mAh) 13C x 2

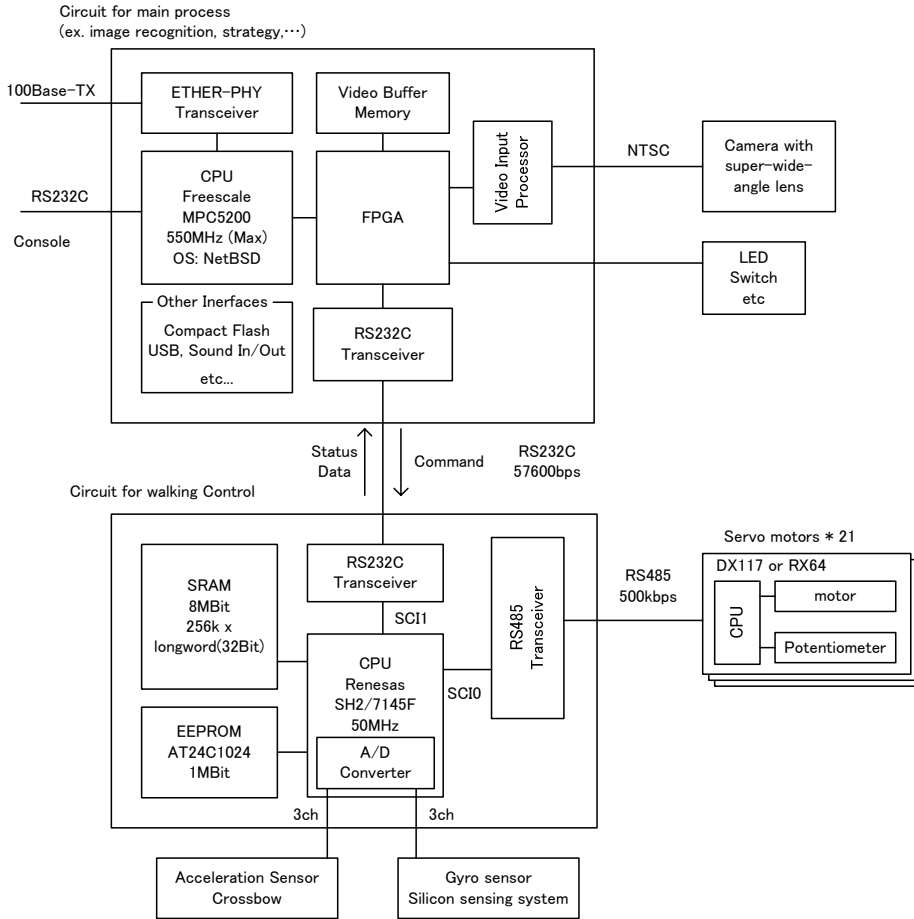


Fig.2 Overview of the System

Table 2 Main Command List for Sub CPU

Command	Parameter			
	Step	Angle	Stride	Period
Forward	Step	Angle	Stride	Period
Backward	Step	Angle	Stride	Period
Turn	Step	Angle		Period
Side Step	Step	Angle	Stride	Period
Stand Up				
Motion	Number			Repeat
Read				
Servo	ON/OFF			
Gyro	ON/OFF			

The robot can walk at many mode, forward, backward, side step, turn and so on. We can select not only the mode, but also angle, stride, period and so on. For example, when the robot finds the ball diagonally forward, the robot can walk to ball by selecting angle to the ball. By adjusting these parameter as situation, the robot can move and action appropriately.

#### 4. Image Processing and Strategy

Another significant feature is high computational capability. Especially, the main CPU board developed for this humanoid is powerful and light weight. The CPU is MPC5200. It has NetBSD operating system. It can process the image recognition and strategy at 30 frames per second. After calculation, it sends a command to sub CPU board for walking control. Moreover, in the CPU, many processes are running. We can use UNIX powerful tools. For example, we can check the image from camera by web browser of a remote PC via LAN. Images of the interface are indicated in Fig.3. The usability is like a standard UNIX computer. It has significant merit compared to standard UNIX computer, it can shutdown any time. The CPU board has many interfaces such as USB, Compact Flash, Digital I/O, RS232C, Sound In/Out, IrDA and so on. We sometimes extend functions using these interfaces. Now we are trying wireless network and talking interface. It also has a FPGA, it helps real-time computing. However, this CPU should not control robot's motion, and now it is not so required real-time computing at short intervals.



Fig.3 Interface of adjusting parameters for image recognition

## 5. Strategy Development Environment

Now we are developing a user friendly strategy development environment. We developed such kind of environment for small size league. It includes simulator, so the programmer can check an algorithm of strategy immediately in the environment. And, it also records the game. The programmer can check problems by replaying and analyzing the game. To develop the environment for humanoid league is more difficult. However, we are trying to develop it and want to feedback it to this league.

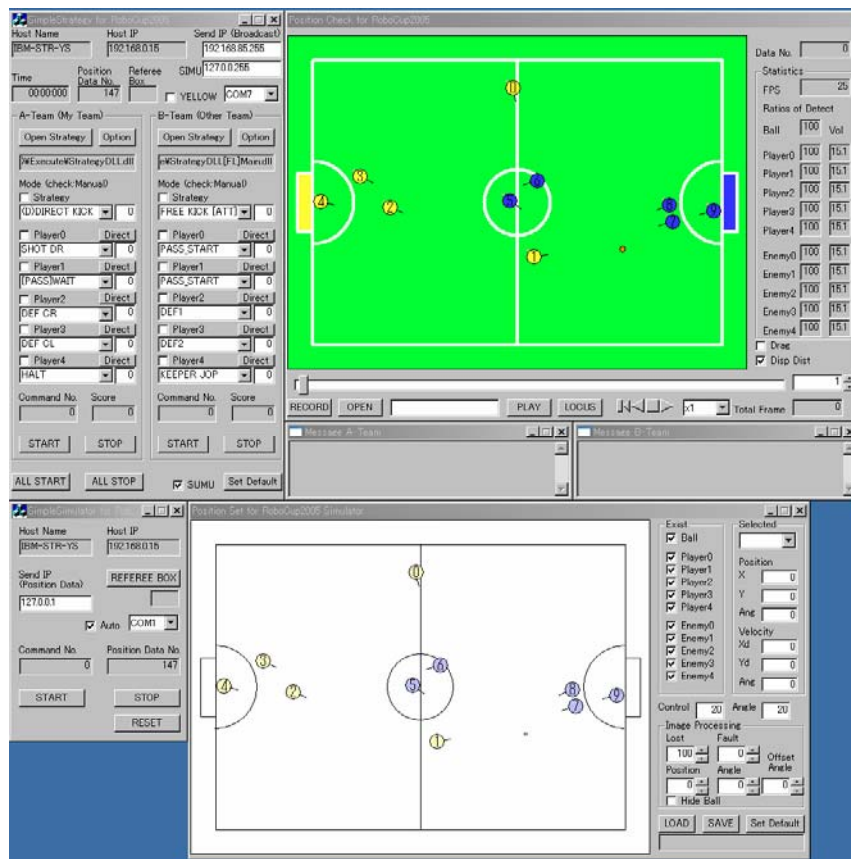


Fig.4 Strategy Development Environment (for Small Size League)

## 6. Conclusion

In this paper we described on our system. Our system has some features. Especially, the high mobility and well-designed control system are remarkable.