Humanoid Soccer Robot Design by TKU Team for Humanoid League of RoboCup 2010

Ching-Chang Wong, Kai-Hsiang Huang, Yueh-Yang Hu, Hsiang-Min Chan, Hao-Che Chen, Chih-Hui Hung, Ching-Ching Jiang, and Wei-Ning Hsu

Department of Electrical Engineering, Tamkang University
Tamsui, Taipei County, Taiwan
E-mail: wong@ee.tku.edu.tw

Abstract. A humanoid soccer robot named TWNHR-VI (TaiWaN Humanoid Robot-VI) and designed by the TKU team to attend the humanoid league of RoboCup 2010 is described. First, a mechanical structure with 23 DOF (degrees of freedom) for this humanoid robot is described. Then, system architecture and electronic components are presented, where a webcam, a gyro, an accelerometer, and a wireless network are used to obtain the information of the environment and communicate with the other robots. A human-machine interface is implemented to study the locomotion control design of the biped robot. From the practical experiments, the implemented TWNHR-VI can be a soccer robot to decide some actions to get up from a fall, find a ball, walk to an appropriate position, and kick a ball autonomously.

Keywords: Robot soccer game, Soccer robot, Humanoid robot, Autonomous robot.

1. Introduction

The robot soccer games are used to encourage the researches on the robotics and artificial intelligence. Two international robot soccer associations, RoboCup and FIRA, advance this research and hold some international competitions and symposiums. The goal of RoboCup is “By the year 2050, develop a team of fully autonomous humanoid robots to win against the human world cup champion team.” In the humanoid league, many technology issues and scientific areas must be integrated to implement the biped robot, such as mechanics, electronics, control, computer science, and semiconductor. Besides, the research technologies of biped walking control, autonomous motion, direction judgment, kicking and shooting ball will be applied [1-5]. A humanoid soccer robot named TWNHR-VI and designed by the TKU team to attend the humanoid league of RoboCup 2010 is presented. In order to let TWNHR-VI can play a soccer game autonomously, three basic skills are designed and implemented on it: environment perception, move ability, and artificial intelligence. In order to let TWNHR-VI have a high ability of environmental detection, a webcam, a gyro and an accelerometer are equipped on the body of TWNHR-VI to obtain the information of the environment so that TWNHR-VI can decide an appropriate action. In order to communicate with the other robot, the robot has wireless network device. Many functions are implemented on a control board named RoBoard. It can process the data obtained from the other sensors. It can also process the high level artificial intelligence, such as the navigation. TWNHR-VI is designed as a soccer player so that it can get up from a fall, walk, turn, and shoot the ball autonomously.

2. Structure of Humanoid Robot TWNHR-VI

A structure of the humanoid robot TWNHR-VI is described in this section. TWNHR-VI is developed for realizing and analyzing the human movement and behaviors. One of the most important difference between the human body and the robotic body is the human body is flexible while the robotic body is rigid. The human body can absorb the disturbance, such as the reaction force from ground. Robot soccer game is a good test platform to verify the ability of TWNHR-VI. The robot must play a soccer game autonomously. In order to play the soccer game, three basic skills are designed and implemented on it: environment perception, move ability, and artificial intelligence. Fig. 1 shows the whole view of TWNHR-VI. Table 1 shows the specification of TWNHR-VI. The details of hardware and software designed will be presented in following sections.

Fig. 1. Whole view of TWNHR-VI

3. Mechanism Architecture

The robot searches a ball and two goals, and moves to its desired location with avoiding many obstacles in robot soccer game. High DOF make it possible to achieve these motions in parallel. The mechanical design and joints configuration of this robot are described in Fig. 2, where 23 DOF are implemented in the robot

Table 1. Specifications of the TWNHR-VI

<table>
<tr><td colspan="5">Specifications</td></tr>
<tr><td colspan="2">Height</td><td colspan="3">56 cm</td></tr>
<tr><td colspan="2">Weight</td><td colspan="3">3.7kg</td></tr>
<tr><td colspan="2">Walking Speed</td><td colspan="3">8 cm/sec</td></tr>
<tr><td colspan="5">Mechanism System</td></tr>
<tr><td></td><td></td><td>Number of DOF</td><td>Actuator Torque (kg/cm)</td><td>Actuator Speed (sec/60°)</td></tr>
<tr><td>Head</td><td>Neck</td><td>2</td><td>12.5~17.1</td><td>0.269~0.196</td></tr>
<tr><td>Trunk</td><td>Waist</td><td>1</td><td rowspan="3">28.3~37.7</td><td rowspan="3">0.167~0.126</td></tr>
<tr><td rowspan="3">Legs</td><td>Hip</td><td>3 (×2)</td></tr>
<tr><td>Ankle</td><td>2 (×2)</td></tr>
<tr><td>Knee</td><td>1(×2)</td><td>64.4~77.2</td><td>0.167~0.126</td></tr>
<tr><td rowspan="3">Arms</td><td>Shoulder</td><td>2 (×2)</td><td rowspan="3">12.5~17.1</td><td rowspan="3">0.269~0.196</td></tr>
<tr><td>Elbow</td><td>1 (×2)</td></tr>
<tr><td>Wrist</td><td>1 (×2)</td></tr>
<tr><td colspan="2">Total</td><td colspan="3">23</td></tr>
<tr><td colspan="5">Electronic System</td></tr>
<tr><td colspan="2" rowspan="3">Sensors</td><td>Webcam</td><td colspan="2">320x240 resolution</td></tr>
<tr><td>Accelerometer</td><td colspan="2">3-axis</td></tr>
<tr><td>Gyro</td><td colspan="2">300 degree/sec</td></tr>
<tr><td colspan="2">Processors</td><td>RoBoard</td><td colspan="2">1GHz</td></tr>
<tr><td colspan="2">Power</td><td>Lithium Battery</td><td colspan="2">16V, 1600mA, 11.1V, 1600mA</td></tr>
</table>

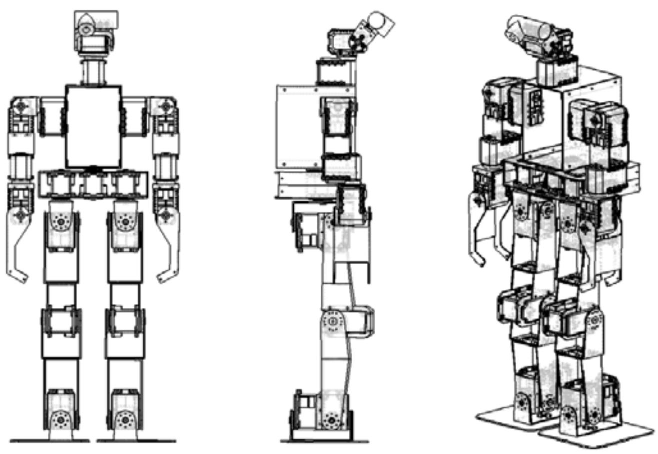

Fig. 2. Mechanical design of TWNHR-VI.

4. Electronic System

In the electronic system design of the robot, the block diagram of electrical system for TWNHR-VI is described in Fig. 3, where 23 servomotors with high torque are used as the actuators of the robot. In order to build a fully autonomous vision-based humanoid robot, a robotics control board named RoBoard which contains traditional microcontroller and full function computer is used to build the system of the humanoid robot. RoBoard has a 32bit x86 CPU running at 1000 MHz and 256 MB DRAM. Many functions are implemented on RoBoard chip to process the image, data and control the robot.

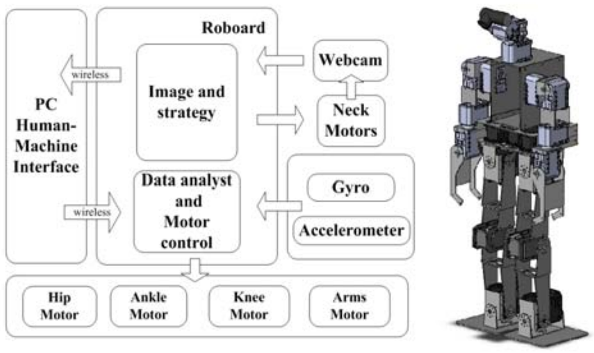

Fig. 3. Block diagram of TWNHR-VI's electrical system

5. Human-Machine Interface

A human-machine window interface as shown in Fig. 4 is designed and implemented by Visual Studio 2008 to control and monitor the locomotion of the biped robot. This human-machine interface is designed to be a convenient development platform to shorten the development time of the locomotion control design. Besides, the interface also provides a real-time motion design module. User can see behavior of robot right away.

6. Experiment results

The preliminary experiment results of kicking a ball are presented to verify the TWNHR-VI's ability. Four pictures are shown in Fig. 5. There are four situations for the robot: (a) Find the ball. (b) Walk toward the ball. (c) Kick the ball to the goal. (d) Goal.

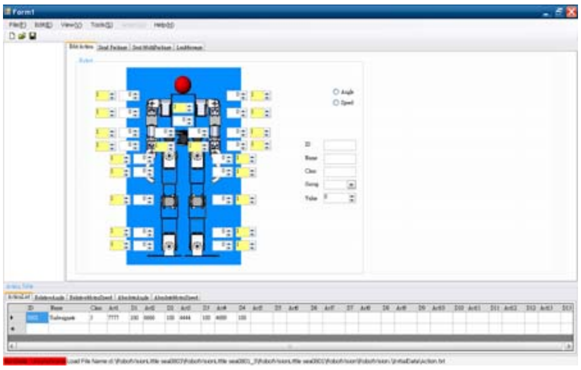

Fig. 4. Display of the human-machine interface**.**

(a) (b)

(c) (d)

Fig. 5. Photographs of TWNHR-VI searches a ball and kicks the ball**.**

7. Conclusion

A design and implemented method of a humanoid soccer robot named TWNHR-VI is presented. A mechanical structure with 23 DOF is designed and implemented so that

TWNHR-VI can get up from fall, walk forward and backward, turn right and left, and kick the ball. A webcam, a gyro, an accelerometer, and a wireless network are equipped on the body of TWNHR-VI to obtain the information of the environment and communicate with the other robots so that it can decide an appropriate action behavior. A platform with a human-machine interface is implemented. We can view the motion of TWNHR-VI at any direction from the window interface. Based on the platform, we can simulate the motion of TWNHR-VI so that the locomotion control design of the biped robot is fast and efficiency

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