Humanoid Soccer Robot Design by TKU Team for Humanoid League of RoboCup 2008

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Abstract. A humanoid soccer robot named TWNHR-IV and designed by the TKU team to attend the humanoid league of RoboCup 2008 is described. A platform for the study of biped walking control is designed and implemented. First, a mechanical structure with 26 degrees of freedom for this humanoid robot is described. Then, a system architecture and electronic components are presented, where a CMOS sensor, a digital compass, an accelerometer, and eight pressure sensors are used to obtain the information of the environment. In order to design the robot locomotion control, a human-machine interface is implemented to study the locomotion control design of biped robot. From the practical experiments, TWNHR-IV 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.

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 the international competitions and the international 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 [1-10]. A humanoid soccer robot named TWNHR-IV and designed by the TKU team to attend the humanoid league of RoboCup 2008 is presented. In order to let TWNHR-IV 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-IV have a high ability of environmental detection, a CMOS sensor, an electronic compass, an accelerometer, and eight pressure sensors are equipped on the body of TWNHR-IV to obtain the information of the environment so that TWNHR-IV can decide an appropriate action. A control board with a FPGA chip and a 64 Mb flash memory are mainly utilized to control the robot. Many functions are implemented on this FPGA chip. It can receive the vision signal obtained by the CMOS sensor via a serial port and process the data obtained from the other sensors. It can also process the high level artificial intelligence, such as the navigation. TWNHR-IV 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 the Humanoid Robot TWNHR-IV

A new humanoid robot TWNHR-IV is described. TWNHR-IV is developed for realizing and analyzing the human movement and behaviors. One of the most important difference between the human body and robot is the human body is flexible while the robot is rigid. The human body can absorb the disturbance, such as the ground reaction force, very well. Playing soccer game is the test platform to verify the ability of TWNHR-IV. The robot needs to 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 and overview of TWNHR-IV. Table 1 shows the specification of TWNHR-IV. The details hardware and control software design will be presented in following sections.

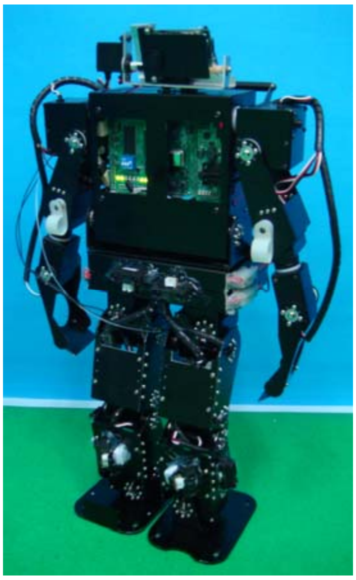


Fig. 1. Whole view of TWNHR-IV.

Table 1. Specifications of the TWNHR-IV

Specifications				
Height		43 cm		
Weight		3.4 kg		
Walking Speed		12 cm/sec		
Mechanism System				
		Number of DOF	Actuator Torque (kg/cm)	Actuator Speed (sec/60°)
Head	Neck	2	1.7	0.10
Trunk	Waist	2	40.8	0.19
Legs	Hip	3 (x2)	37.5	0.13
	Knee	2 (x2)		
	Ankle	2 (x2)		
Arms	Shoulder	2 (x2)	20.0	0.14
	Elbow	1 (x2)		
	Wrist	1 (x2)		
Total		26		
Electronic System				
Sensors	CMOS Sensor		160x120 resolution	
	Accelerometer		3-axis	
	Digital Compass		5° heading accuracy, 0.5° resolution.	
	Pressure Sensor		8bit, no parity, no flow control, TTL level	
Processors	Sunplus-DSP		32.768MHz	
	Altera-NIOS		80MHz	
Power	Lithium Battery		12V, 2100mA.	

3. Mechanism Architecture

In soccer game, for example, the robot searches a ball and two goals, and moves to its desired location with avoiding many obstacles. High DOFs make it possible to achieve these motions in parallel. The mechanical design and joints configuration of this robot are described in Fig. 2, where 24 degrees of freedom are implemented in the robot.

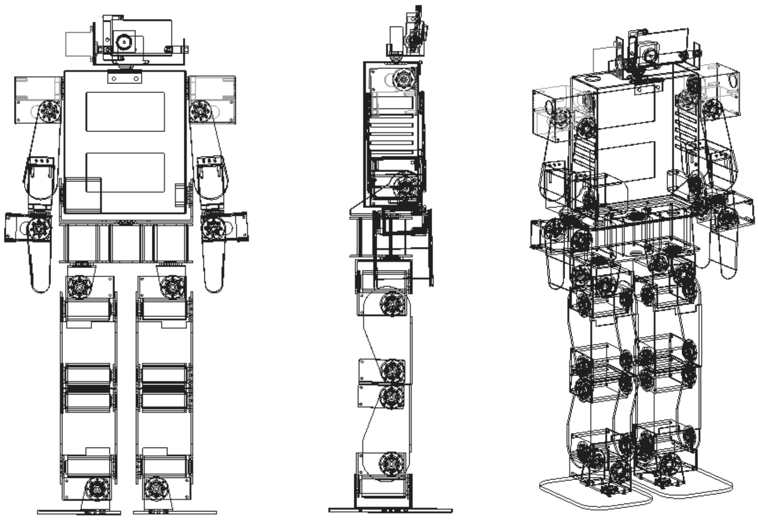


Fig. 2. Mechanical design of TWNHR-IV.

4. Electronic System

In the electronic design of the robot, the system block diagram is described in Fig. 3, where 26 servomotors with high torque are used as the actuators of the robot. In order to build a fully autonomous vision-based humanoid robot, a 16-bit DSP processor with a CMOS sensor is chosen to process the vision image of environment. Many functions are implemented on a FPGA chip to process the data and control the robot so that the weight of the robot is reduced.

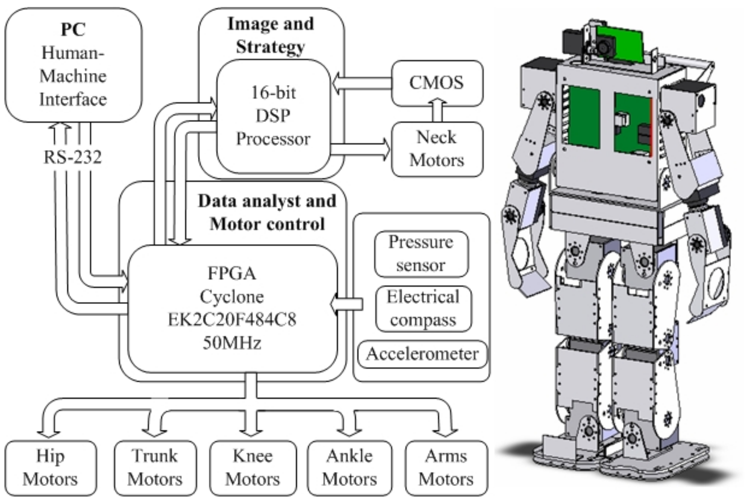


Fig. 3. Diagram of TWNHR-IV's electrical system.

5. Human-Machine Interface

A human-machine window interface is designed and implemented by BCB to control and monitor the locomotion of the biped robot. This human-machine interface is designed to be a convenient develop platform to shorten the develop 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.

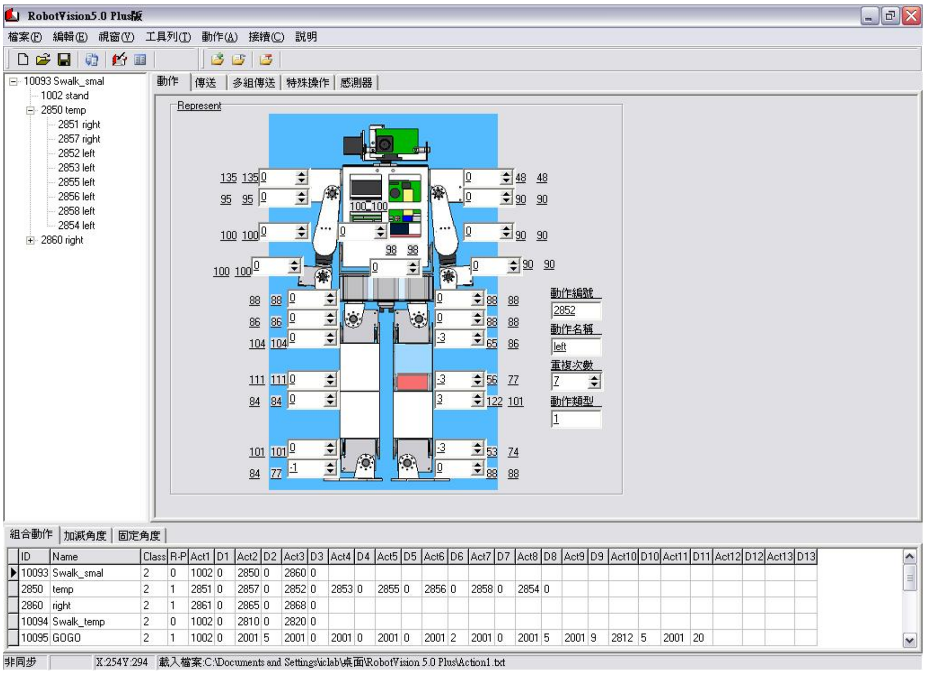


Fig. 4. Window display of the human-machine interface: the real-time module.

6. Experiment

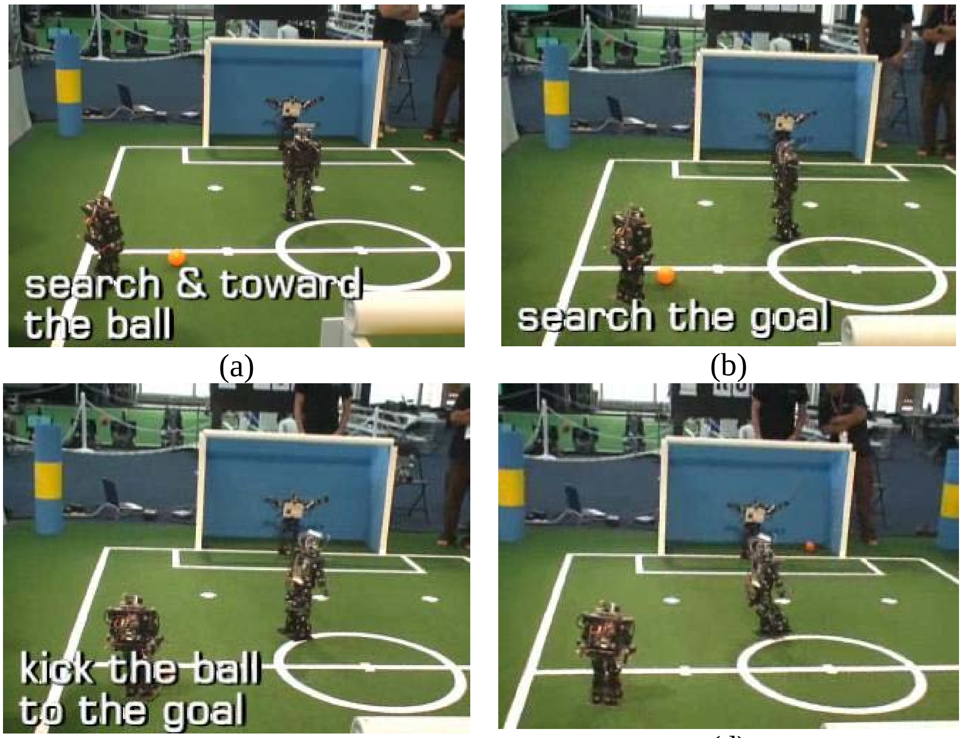
In this section, the preliminary experiment result for the kick ball trajectory is proposed to verify the TWNHR-IV's system performance. Some pictures of TWNHR-IV tracking a ball and kicking the ball are shown in Fig. 5, where these processes are described as follows:

(a) Search and toward the ball.

(b) Search the goal.

(c) Kick the ball to the goal.

(d) Goal.



(a) (b) (c) (d)

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

7. Conclusion

A design and implemented method of a humanoid soccer robot named TWNHR-IV is presented. A biped structure with 24 degrees of freedom is designed and implemented so that TWNHR-IV can get up from a fall, walk forward and backward, turn right and left, and kick the ball. A CMOS sensor, an electronic compass, an accelerometer, and eight pressure sensors are equipped on the body of TWNHR-IV to obtain the information of the environment 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-IV at any direction from the window interface. Based on the platform, we can simulate the motion of TWNHR-IV so that the locomotion control design of the biped robot is fast and efficiency.

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