Kid-Size Humanoid Soccer Robot Design by TKU Team

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Abstract. A brief description of a kid-size humanoid soccer robot named TWNHR-IV to attend the humanoid league of RoboCup 2009 is described. The height of TWNHR-IV is 46 cm and the weight is 3.6 kg with batteries. It is designed by the TKU team of Intelligent Control Laboratory in Tamkang University (TKU). First, a mechanical structure with 26 degrees of freedom for this kid-size humanoid robot is described. Then, a system structure is presented, where two processors: a 16-bit DSP and a 32-bit NIOS processor are used. A CMOS sensor, a digital compass, an accelerometer, and eight pressure sensors are used to obtain the information of the environment. A human-machine interface is implemented to study the locomotion control design. 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.

Key words: Robot soccer game, Soccer robot, Humanoid robot, Autonomous robot.

1. Introduction

Robot soccer game is a good test platform to examine the robotics and the artificial intelligence of robot. 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 humanoid soccer 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]. In 2004, the TKU team of Intelligent Control Laboratory in Tamkang University (TKU) began to design and implement a kid-size humanoid robot. In this paper, a brief description of TWNHR-IV (TaiWaN Humanoid Robot-IV) 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

The structure of the kid-size humanoid robot TWNHR-IV is described. A photograph of TWNHR-IV is described in Fig.1 and its specifications are described in Table 1. In order to let TWNHR-IV play the soccer game, three basic skills are designed and implemented on it: environment perception, move ability, and artificial intelligence. The details hardware and control software design will be presented in following sections.

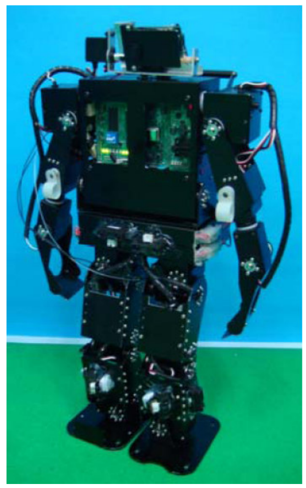


Fig. 1. Whole view of TWNHR-IV.

Table 1. Specifications of the TWNHR-IV

Specifications				
Height		46 cm		
Weight		3.6 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 the mechanism design of TWNHR-IV, 26 degrees of freedom (DOF) are design and implemented. The DOF diagram of the head, waist and trunk, arms, and legs are described in Fig.2, where each degree is described by the number. There are 2 DOF on robot's neck, 2 DOF on the waist and trunk, 4 DOF on each arm and 7 DOF on each leg. The mechanical structure is designed and implemented so that the implemented humanoid robot can find the ball, walk forward, turn right-and-left, and slip right-and-left, and stand up.

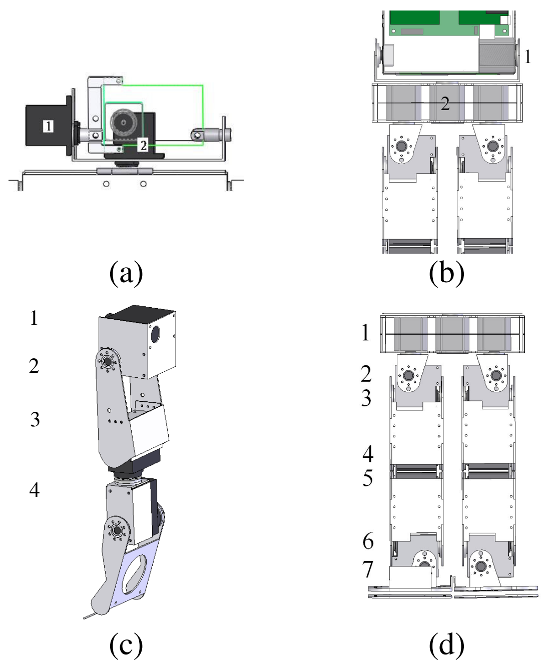


Fig. 2. Mechanism and DOF of TWNHR-IV: (a) Head, (b) Waist and trunk, (c) Left arm, and (d) Legs.

4. Electronic System

In the electronic design of TWNHR-IV, the system block diagram is described in Fig. 3. This system contains two processors: μ'nsp and NIOS. μ'nsp is a 16-bit DSP processor which is used to process image information and decide strategy. NIOS is a 32-bit embedded soft-core processor which is used to control the motion of actuators and receive the data of the other sensors such as the electronic compass, pressure sensor, and accelerometer. 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.

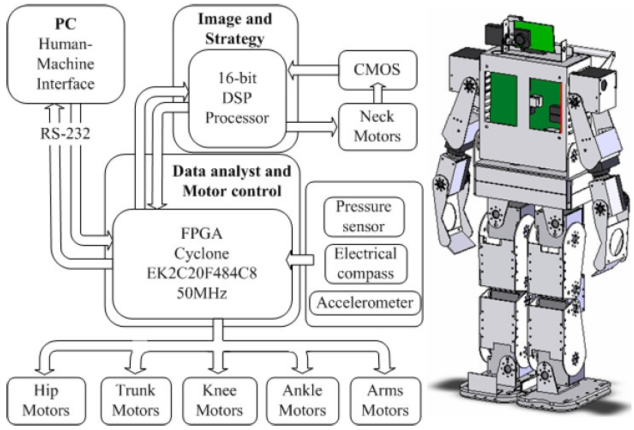


Fig. 3. Diagram of TWNHR-IV's electrical system.

5. Human-Machine Interface

As shown in Fig.4, a human-machine interface is designed and implemented by BCB to control and monitor the locomotion of TWNHR-IV. This interface is designed to be a convenient develop platform to shorten the develop time of the locomotion control design. Besides, this interface also provides a real-time motion design module. User can see behavior of robot right away.

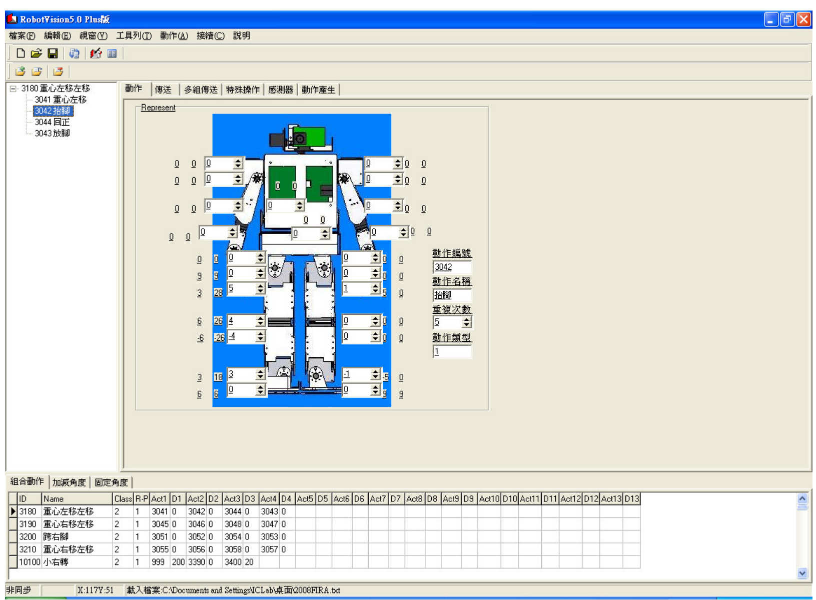
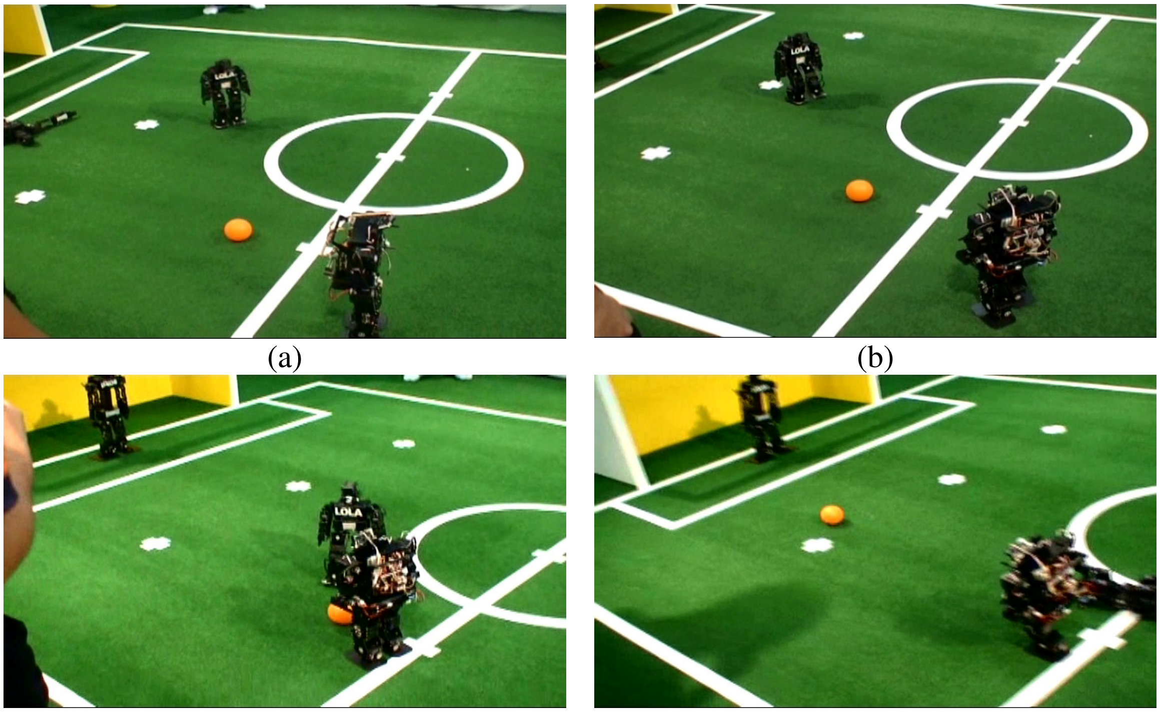


Fig. 4. Window display of the human-machine interface: the real-time module.

6. Experiment

In order to verify the TWNHR-IV's ability, some pictures of TWNHR-IV tracking a ball and kicking the ball are shown in Fig. 5, where these status are described as follows:

(a) Localization of unknown ball position.
(b) Walking ability towards the ball.
(c) Robot positioning at the ball for kicking.
(d) Kicking the ball towards the goal.



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

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

7. Conclusion

A brief description of a kid-size humanoid soccer robot named TWNHR-IV is presented. A mechanism structure with 26 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 so that 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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