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

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Abstract. A humanoid soccer robot named HIWIN MAN and designed by the TKU team with Hiwin Company to attend the humanoid league of RoboCup 2011 is described. A platform for the study of biped walking control is designed and implemented. First, a mechanical structure with 23 DOF (degrees of freedom) for this humanoid robot is described. The architecture and electronic components for system are also presented, webcam, gyro and accelerometer can help robot to obtain the information from the environment, communicate with other robots by wireless network. 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, HIWIN MAN 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 HIWIN MAN and designed by the TKU team to attend the humanoid league of RoboCup 2011 is presented. In order to let HIWIN MAN 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 HIWIN MAN have a high ability of environmental detection, a webcam, a gyro and an accelerometer are equipped on the body of

HIWIN MAN to obtain the information of the environment so that HIWIN MAN 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 TKU Board. It can process the data obtained from the other sensors. It can also process the high level artificial intelligence, such as the navigation. HIWIN MAN 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 HIWIN MAN

A structure of the humanoid robot HIWIN MAN is described in this section. HIWIN MAN 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 great opportunity to verify the ability of HIWIN MAN. 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 HIWIN MAN. Table 1 shows the specification of HIWIN MAN. The details of hardware and software designed will be presented in following sections.

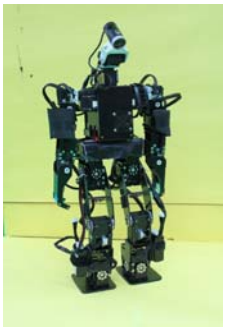


Fig. 1. Whole view of HIWIN MAN

3. Mechanism Architecture

The robot searches a ball and two goals, and it can move 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 HIWIN MAN

Specifications				
Height		55 cm		
Weight		3.7kg		
Walking Speed		15 cm/sec		
Mechanism System				
		Number of DOF	Actuator Torque (kg/cm)	Actuator Speed (sec/60°)
Head	Neck	2	16.5	0.196
Trunk	Waist	1	37.7 64.4	0.126 0.188
Legs	Hip	3 (×2)		
	Ankle	2 (×2)		
	Knee	1(×2)	38.52	0.129
Arms	Shoulder	2 (×2)	16.5	0.196
	Elbow	1 (×2)		
	Wrist	1 (×2)		
Total		23		
Electronic System				
Sensors	Webcam	320x240 resolution		
	Accelerometer	3-axis		
	Gyro	300 degree/sec		
Processors	RoBoard	Intel Pineview-D510 Processors, 45nm process		
Power	Lithium Battery	1 DC Power Jack with 9-24V Power Input		

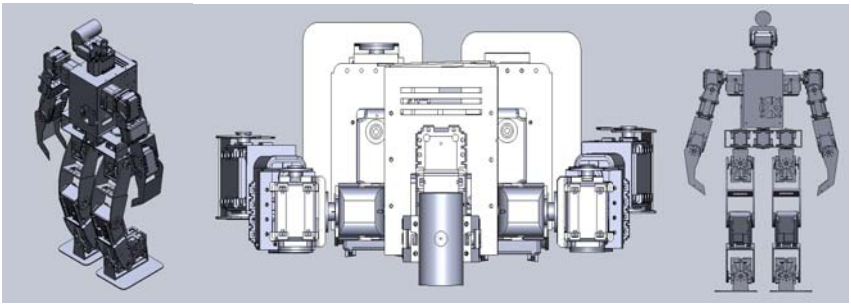


Fig. 2. Mechanical design of HIWIN MAN

4. Electronic System

In the electronic system design of the robot, the block diagram of electrical system for HIWIN MAN is described in Fig. 3. NIOS II is a centre process of the robot, it control 23 motors and receive data from gray and accelerometer, it also can connect with TKU Board. TKU Board which contains traditional microcontroller and full function computer is used to build the system of the humanoid robot. TKU Board has an Intel Pineview-D510 Processors, 45nm process with 2G DDR2 667 RAM. Many functions are implemented on TKU Board chip to process the image and control the robot.

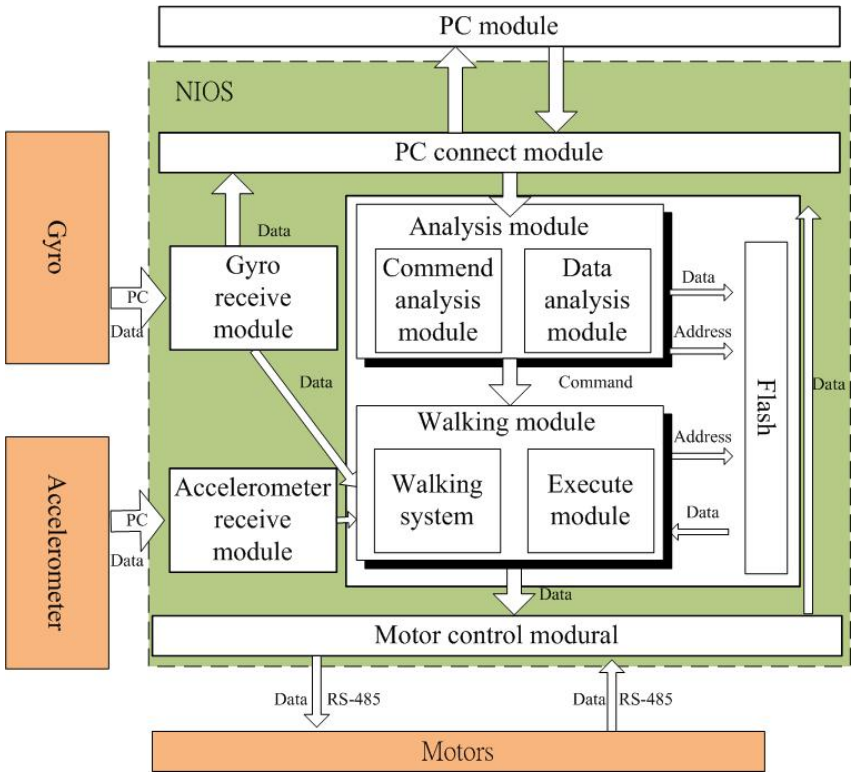


Fig. 3. Block diagram of HIWIN MAN's electrical system

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 HIWIN MAN'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.

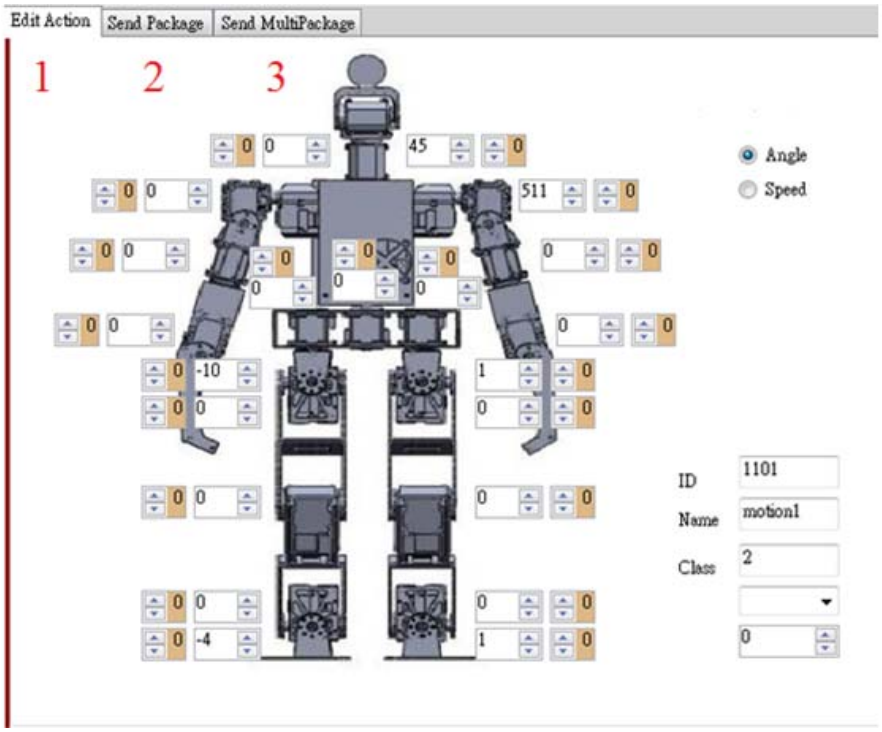
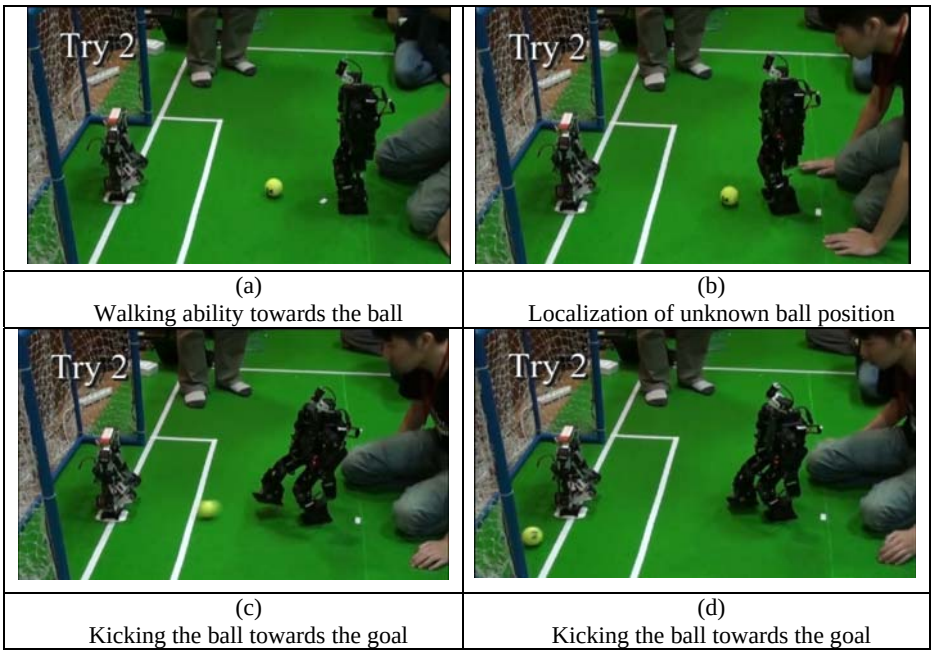


Fig. 4. Display of the human-machine interface**.**



(a) Walking ability towards the ball

(b) Localization of unknown ball position

(c) Kicking the ball towards the goal

(d) Kicking the ball towards the goal

Fig. 5. Photographs of HIWIN MAN searches a ball and kicks the ball**.**

7. Conclusion

A design and implemented method of a humanoid soccer robot named HIWIN MAN is presented. A mechanical structure with 23 DOF is designed and implemented so that HIWIN MAN 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 HIWIN MAN 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 HIWIN MAN at any direction from the window interface. Based on the platform, we can simulate the motion of HIWIN MAN so that the locomotion control design of the biped robot is fast and efficiency.

Acknowledgment

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References

1. Wong, C.C., Huang, K.H., Hu, Y.Y., Chan, H.M., Chen, H.C., Hung, C.H., Jiang, C.C., Hsu, W.N.: Humanoid Soccer Robot Design by TKU Team for Humanoid League of RoboCup 2010. RoboCup International Symposium 2010 (2010).
2. Huang, Q., Li, K., Nakamura, Y.: Humanoid Walk Control with Feedforward Dynamic Pattern and Feedback Sensory Reflection. In: IEEE International Symposium on Computational intelligence in Robotics and Automation, pp. 29-34, (2001)
3. Sugihara, T., Nakamura, Y., Inoue, H.: Real time Humanoid Motion Generation through ZMP Manipulation based on Inverted Pendulum Control. In: IEEE International Conference on Robotics and Automation, p.p. 1404-1409, (2002)
4. Furuta, T.: Design and Construction of a Series of Compact Humanoid Robots and Development of Biped Walk Control Strategies. In IEEE International Conference on Robotics and Autonomous Systems, p.p. 65-88, (2001)
5. Vukobratovic, M., Frank, A. A., Juricie, D.: On the Stability of Biped Locomotion, In: IEEE Trans. Bio-Med. Eng. 17 p.p. 25-36, (1970)