Team Description Paper: HuroEvolution^{AD} Humanoid Robot for RoboCup 2012 Humanoid League

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Abstract. In this team description paper, our AdultSize humanoid robot entitled HuroEvolution^{AD} is introduced for the RoboCup 2012 humanoid league. The HuroEvolution^{AD} is constructed as a 18 degree-of-freedom biped humanoid robot. An active CMOS USB camera system is connected to a PICO-820 single board computer to perform autonomous image captures and motion controls. The functions within localization of unknown ball position and walking ability are all desired to perform qualifications for RoboCup 2012 humanoid league. As a consequence, an adult size humanoid robot is produced to participate in the competitions for the RoboCup 2012 humanoid league.

Keywords: humanoid robot, autonomous robot, soccer robot, image localization.

1 Introduction

Humanoid robot studies are fast increasing in the last decade. In recent year, RoboCup [1] is one of the most important competitions within humanoid robot researches. Due to the increase of the robot size, mechanical structure stiffness, and large control powers, the development of an adult size humanoid robot becomes a challenging task. On the other hand, competition situations are fast transiting, and humanoid robot are required to be justified according to situation changes. Therefore, an artificial intelligence (AI) based decision making module is developed using strategy based rules. These rules are fired with respect to the vision system of our robot.

On the other hand, the kinematics based walking patterns are generated in terms of an AVR[2] based motion controller, and UART serial motion commands are further generated to control the servo motors. As consequence, the overall hardware components of our HuroEvolution^{AD} humanoid robot is composed of a single board computer with windows XP operation system, a conventional wide-angle camera, an AVR motion controller, battery and power regulations module. The software components consist of the functions of image capture, image recognition, localizations of a ball and a goal, strategies and decisions, gait pattern generations, acceleration data detection, and motor controls.

It is the second year that HuroEvolution^{AD} humanoid robot participates in the RoboCup humanoid league, our kid size humanoid robot (HuroEvolution^{JR}) has the experience of RoboCup kid size humanoid soccer robot competitions in 2010 and 2011. In the last six years, we participated in the HuroCup of FIRA [3] from 2006 to 2011. We awarded the forth place of the overall rating of the FIRA HuroCup in 2006 (robot name: Taiwan 101 [4]) and the third place in FIRA 2010. The current developments of the HuroEvolution^{AD} are designed based on our previous autonomous humanoid robot hands-on experiences. Fig. 1 shows our HuroEvolution^{AD} humanoid robots in RoboCup 2011.

Fig 1. Our adult size humanoid robot in the competition field of RoboCup 2011.

2 Mechanical Design

The HuroEvolution^{AD} is designed as a 18 degree-of-freedom (DOF) humanoid robot; where 5 DOFs are desired for each leg, 3 DOFs are desired for each arm, and 2 DOF for head (active vision sensor). We use conventional servo motors to construct the joints of HuroEvolution^{AD}. Fig. 2 shows the joint of our humanoid robot.

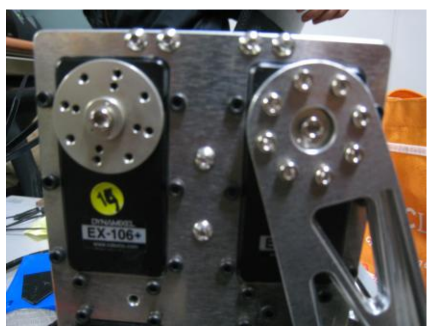

Fig. 2. The joint of humanoid robot**.**

On the other hand, the 2-DOF joint module is also designed for the hip and ankle joints. The 2-DOF joint module provides two dimensional relative motions between two links (rigid bodies). Two active and two passive flanges with collinear and diagonal configuration are designed as the mechanical interfaces of connecting two diagonal rotating links. To achieve diagonal output configuration, two gears with the same specification are used to translate the output axis to the center of the joint module. The diagonal 2-DOF joint module achieves that two rotational axes intersect at one point. Such a 2-DOF joint module is capable of emulating the hip and ankle motions of humans.

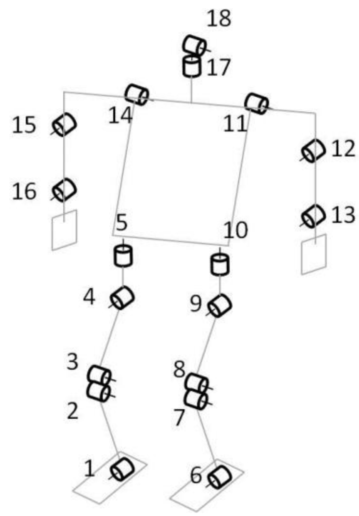

Fig. 3. Kinematic design of HuroEvolution^{AD}.

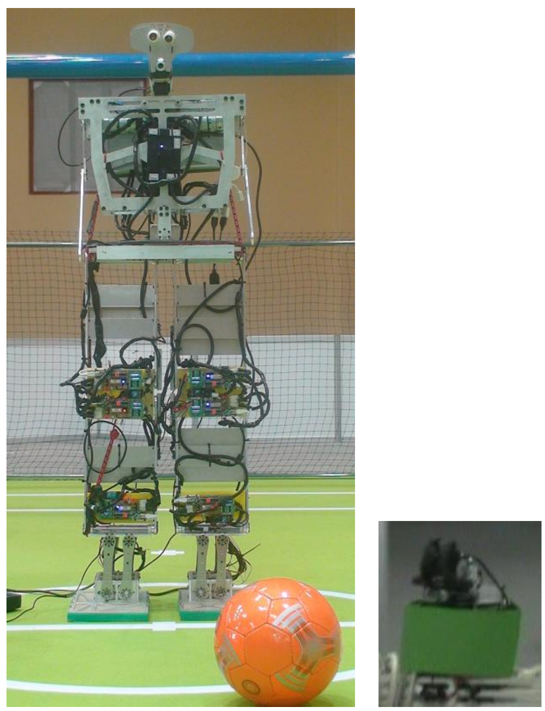

Fig. 4. Photos of assembled HuroEvolution^{AD} (left-hand-side) and the active vision sensor (righ-hand-side)

3 Hardware design

Hardware modules of the HuroEvolution^{AD} humanoid robot are a single board computer, a wide angle camera, an accelerometers module, an AVR embedded motion controller, and RC servo motors. The hardware architecture is shown in Fig. 5, and the hardware specification is shown in Table 1. These modules are further introduced as follows.

Table 1. Hardware specification

ROBOT Name	HuroEvolution^{AD}	
Height of Robot	135 cm	
Weight of Robot	20 kg	
Walking Speed	Maximum: 5 cm/s	
Type of motor Torque Speed	RX-28(Servo motor) 28.3kg/cm~ 37.7kg/cm 0.126 sec/60°	EX-106(Servo motor) 84kg/cm~ 106kg/cm 0.143 sec/60°
Degree of freedom	18 With Leg: 5 x 2 (EX-106 Servos) Arm: 3 x 2 (EX-106 Servos) Head: 2 (RX-28 Servos)	
Computing unit	PICO820 (Single Board Computer) Processor: Intel® ATOM™ processor Z530 Operating System: Windows XP	
Motion Controller	AVR ATmega1281	
Camera	DFM 22BUC03-ML Frame rate: 90fps Total Picture Element 640 (H) x 480 (V)	
Batteries	1 x Li-Fe 24V 6900mAh	
Accelerometer	ADXL345	

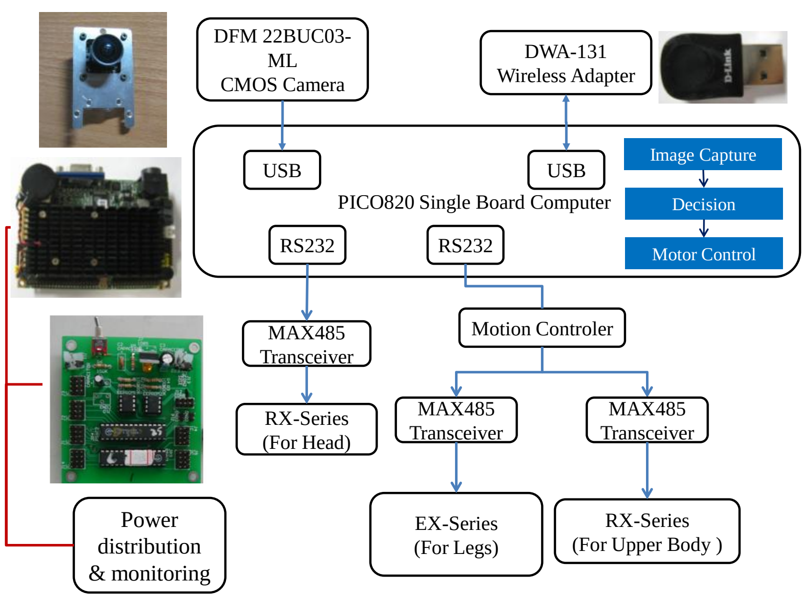

Fig. 5. Hardware architecture

1. Single board computer: An Axiomtek PICO-820 single computer board is used in this project. The single computer board uses the Microsoft Windows XP as its operation system. The software modules of image capture, image recognition, falling down detection, and gait generation are all implemented based on this single board computer.
2. Conventional camera: In this team project, a conventional camera (DFM 22BUC03-ML [5]) is desired to capture images in front of the robot.
3. AVR motion controller: The AVR motion controller is used to control the angular position of RC motors. All motor controllers are connected via serial communications which can reduce the complexity of cable wiring.

4. Accelerometer module: An accelerometer with ADXL345 [6] is used for this project to detect the falling down situations. When the falling down signal is detected, the control system turns off the power to protect the motion controllers.
5. Servo motors: The conventional servo motors are used to actuate each joint of HuroEvolution^{AD}. All of motors are the product of Robotis. The servo motors provide robust motion performance. It reduces the development time of our robot.
6. Head control motors: head control motors are configured by two Robotis RX-28 RC servo motors, which provide the webcam pitch and yaw motions.

4 Software design

In addition to the hardware, the software components are also introduced. The software components consist of the modules of image capture, image recognition, localizations of a ball and a goal, strategies and decisions, gait pattern generations, acceleration data detection, and motor controls. These modules are implemented with the PICO-820 or AVR motor controller. They are further described in the follows.

1. Image capture and image recognition: This module is responsible of retrieving the pixel regions of the ball and goal[7]. If the ball and goal cannot be recognized, the robot may rotate itself or move forward and try to find them.
2. Localizations of a ball and a goal: This module is responsible of retrieving the directions of the ball and goal as well as the approximate distance of the ball and goal.
3. Strategies and decisions: To finish a competition, a rule based decision subsystem is developed according to different strategies. In addition, a simple coordinated subsystem is further introduced to define the role of robots.
4. Gait pattern generations: Several basic gait patterns such as “moving forward”, “side-shifting”, “rotating itself”, and “backward walking” are generated by using the AVR embedded motion controller. At the same time, the kinematics based locomotion is also simulated and verified by using the Matlab, as shown in Fig. 7.
5. Acceleration data detection: A serial communication packet is decoded to retrieve the acceleration data so that the falling down situation can be detected.
6. Motor control: Due to the uses of AVR motor controllers and servo motors, the motion control is implemented using a sequence of serial communication packet.

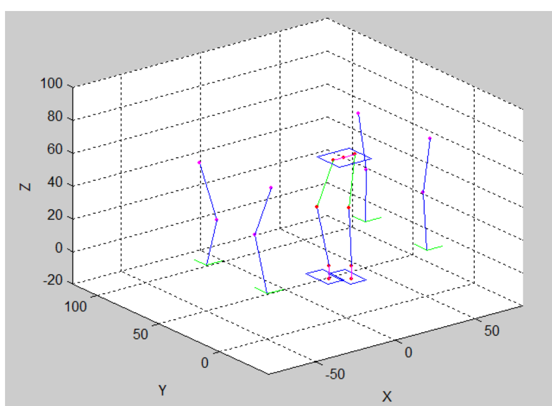

Fig. 6. 3D simulations of kinematics based locomotion.

5 Conclusion and Future Work

Adult size humanoid robotic research is a very challenging research topic. Our laboratory has devoted 6 years in the development of humanoid robot from small size humanoid robots [4, 7], adult size humanoid robot [8], parallel kinematics based humanoid robot [9], and hybrid-structure humanoid robots [10]. We also participated in the FIRA competitions for 6 years and RopboCup kid size league for 1 year. We are now trying to extend our research interests to the most challenging humanoid robot competition, RoboCup Adult Humanoid League. We believe that the participations of RoboCup will induce more research potentials for our team via sharing and learning with other teams. The current version is just a prototype to be submitted for the qualification. In the future, walking speed improvements and weight reduction are important tasks for us before the RoboCup 2012 annual event. On the other hand, self-adjustable humanoid locomotion is another issue for use to improve the walking performance. Finally, modular, flexible as well as reusable software and control architectures are also to be justified to increase the efficiency of on-site adjustments in the competition field.

6. Reference

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