Team Description Paper: HuroEvolution Humanoid Robot for Robocup 2014 Humanoid League

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Abstract. In this team description paper, our KidSize humanoid robot entitled HuroEvolution is introduced for the Robocup 2013 humanoid league. The HuroEvolution is constructed by a twenty degree-of-freedom biped humanoid robot. A CMOS SCI interface camera system is connected to the UDOO single board computer to perform autonomous image capturing and motion controlling. The functions of the robot include localization for an unknown ball position, walking towards the ball, robot positioning when kicking the ball, kicking the ball toward the goal and getting up autonomously when falling. All these abilities are desired to perform in Robocup 2014 humanoid league. Furthermore, the joint motors are driven by servo motors, which are produced by Robotis company, to reduce the complexity of motion controlling. Finally, four humanoid robots are organized in our team to complete competitions for the Robocup 2014 humanoid league.

Keywords: humanoid robot, soccer robot, image localization, UDOO

1 Introduction

Small size humanoid robot studies were increasing rapidly in the last decade. In recent years, RoboCup [1] is one of the most important competitions within humanoid robot researches. Due to the design limitations of robot size, mechanical structure and control components, the development of kid size humanoid robots become a very challenging task. In addition, the situation in the competition is fast transiting, the humanoid robots have to be justified themselves according to the changes of situation. Therefore, an artificial intelligence (AI) based decision making module is developed by using strategy based rules which are set up in view of the vision system of our robots.

The walking patterns of the robots are based on LIPM model which is generated by an ARM [2] based microcontroller and the motion commands are sent to sixteen Dynamixel RC servo motors [3] on the robot by UART serial port. The hardware of HuroEvolution humanoid robots are composed of a single board computer with Linux based Ubuntu operation system, a conventional webcam, an ARM micro controller, batteries and power regulation modules. The functions of software are image capturing, image recognize, localization of a ball goal, strategies decision, gait pattern generating, accelerometer data acquisition and, finally, motor controlling.

Our laboratory have participate RoboCup competition since 2010. Besides, we have participated the Hurocup of FIRA [4] since 2006. We awarded the forth place of the overall rating of FIRA HuroCup in 2006 (robot name: Taiwan 101 [5] from the team advisor's former university) and third place in 2010. In RoboCup 2010, we reached the quart-final in humanoid kid-size competition. Fig. 1 was taken on Invitational Soccer competition in Beijing of our team and the team NTUT from Taiwan.

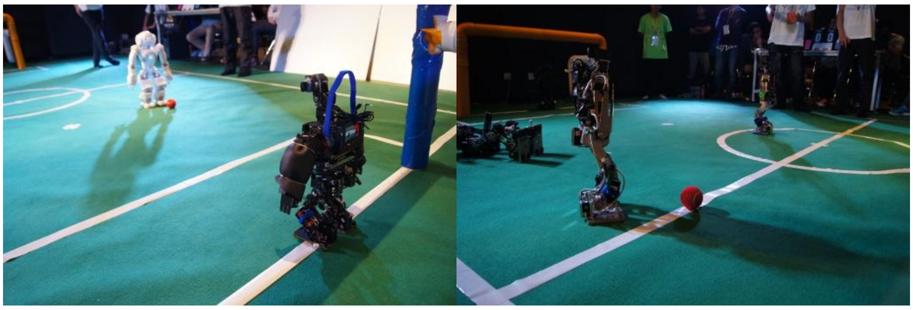

Fig 1. Our robots in Invitational Soccer competition in Beijing, 2013.

2 Mechanical Design

The HuroEvolution robot is designed as a twenty degree-of-freedom (DOF) humanoid robot, where 12 DOF joints are for two legs, 6 DOF joints are for two arms and 2 DOF joints are for head. The mechanical structure is shown in Fig. 2. A conventional web camera is mounted on the head of the robot. An accelerometer is attached on the chest to detect the falling down situation. The structure of our HuroEvolution is shown in Fig. 3.

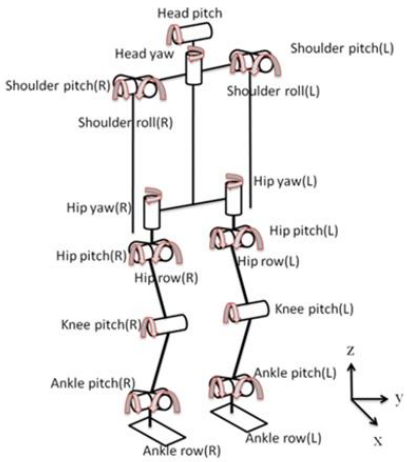

Fig 2. DOF structure of the HuroEvolution.

Fig. 3. Photo of the HuroEvolution

3 Hardware design

The hardware of HuroEvolution robots consist of six models, which are UDOO single board computer, conventional web camera, ARM based microcontroller, accelerometer sensor board, foot pressure module and RC servo motors. The hardware architecture is shown in Fig. 4, and the hardware specification is shown in Table 1. The following are further introduced for these modules:

1. Single board computer: Due to power consumption and size concerns, an UDOO single board computer is used. The UDOO computer is a mini PC which is a Linux based system with an Arduino compatible ARM embedded board. The CPU of the computer is ARM i.MX6 Freescale processor and the operation system is Linux Ubuntu 12.04. Finally, the UDOO computer to generate real-time gait patterns for the robots.
2. Conventional web camera: In this team project, a conventional web camera (Autofocus CMOS Camera[6]) is mounted to capture images in front of the robot.
3. ARM microcontroller: The ARM based microcontroller is used to calculate real-time gait patterns which are either a kinematics or training based motions. The input of the gait motion generator is a "gait decision" and the outputs are a set of synchronized motor position commands via UART communications.
4. Accelerometer sensor board: In this board, an accelerometer with LSM303 [7] is used to detect the falling down situations. The sensor data is collected by the ARM microcontroller via I2C communication. The microcontroller will use these data to
5. Foot pressure module: The FSR sensors are mounted on the foot of the HuroEvolution robots. The data is collected by the ARM microcontroller via ADC ports. These sensors are used to measure the C.O.P. of the robot to let the robot walk stably.
6. RC servos: Each robot has sixteen RC servos to perform the desired gait motions.

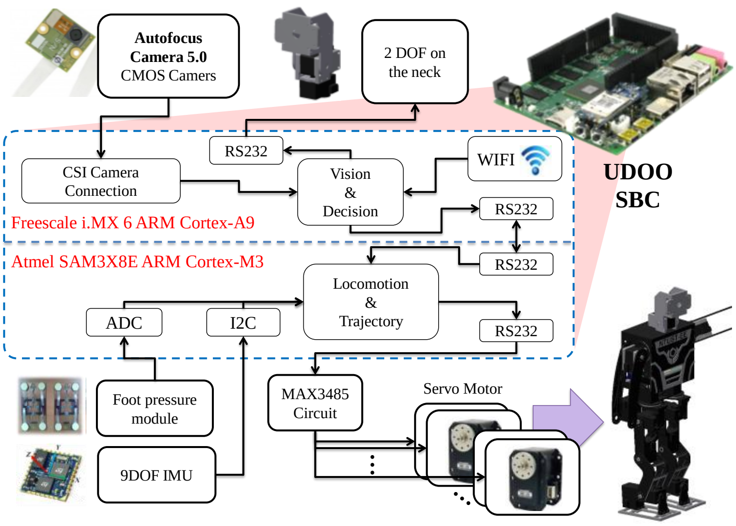

Fig. 4. Hardware architecture

4 Software design

The software includes image capturing module, image recognition, localization of ball and a goal, strategies decision, gait pattern generation, acceleration data detection and motor controlling. These modules are implemented on either the UDOO computer or gait generating board. The followings are the further descriptions.

1. Image capturing and recognition: This module is responsible for recognizing for the ball and goal. If the ball and goal cannot be recognized, the robot may rotate itself or move forward to try to find them.

Table 1. Hardware specification

ROBOT Name	HuroEvolution
Height of Robot	460mm
Arm length	600mm
Weight of Robot	2.8kg
Walking Speed	Maximum: 22 cm/s
Type of motor Torque Speed	MX-28(Servo motor) 2.3N.m~ 3.1N.m 67rpm
Degree of freedom	20 With Leg: 6 x 2 Arm: 3 x 2 Head: 2
Computing unit	UDOO(Single Board Computer) Processor: Freescale i.MX 6 ARM Cortex-A9 CPU Quad core 1GHz Operating System: Ubuntu
Motion Controller	UDOO(Single Board Computer) Processor: Atmel SAM3X8E ARM Cortex-M3 CPU
Camera	Autofocus Camera 5.0 ● Image transfer rate ■ VGA (320x480) @120fps ■ VGA (640x480) @90fps ■ 720p @60fps ■ 1280x960 @45fps ■ 1080p @30fps ■ QSXGA (2592x1944) @15fps ● Sensitivity: 600mV/lux-sec ● Video capture in Full Field of View (FOV): ● double sensitivity,improved signal-to.noise ratio (SNR) ● Post-binning re-sampling filter for sharper, ● crisper contours and colours ● Internal anti-shaking engine
Batteries	1 x Li-Po 11V 1500mAh , 1 x Li-Po 14.8V 1500mAh
Accelerometer	LSM303, L3G4200D

2. Localization of a ball and a goal: This module is responsible for determining the direction of the ball, the goal and the approximate distance of each of them.
3. Strategies and decision: 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 generation: Several basic gait patterns such as "moving forward", "side-shifting", "rotating itself", "standing up from a fall", "backward walking", and so on are generated via a ARM microcontroller. In the current version, the gait patterns may be generated from kinematics or on-site training modes.
5. Acceleration data detection: A I2C communication packet is decoded to retrieve the acceleration data so that the falling down situation can be detected.
6. Motor control: Due to the use of Robotis Dynamixel RC servos, the motor control is implemented by using a sequence of serial communication packet.

5 Conclusion and Future Work

Humanoid robotic research is a very challenging research topic. Our laboratory has devoted over 5 years in the development of humanoid robot from small size humanoid robots [5, 8], full size humanoid robot [9], parallel kinematics based humanoid robot [10] and hybrid-structure humanoid robots [11]. We also participate the FIRA competitions several years. We are now trying to extend our research interests to the most important humanoid robot competition, Robocup. We believe the participations of Robocup will improve our research potential via sharing and learning with other teams. The current version is just a prototype to submit for the qualification. In the future, fast and stable humanoid locomotion is an important issue for us to improve Finally, modular, flexible as well as reusable software and control architectures are also had to be justified to increase the efficiency of on-site adjustments on the competition field.

6. Reference

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