Azad Humanoid Robot

Hossein Nezamabadi-pour, Abdol-Ali Moghadam–Saray, Ali Rashidi Moakhar, Moahammad Arabnezhad, Kave Nooraee, Morteza Iranmanesh, S.Rasul Ataee, S.Hamid Alavi, S.Mehdi Alavi, Vahid Ostowar, Majid Noorani, Mohammad-Taghi Amiri-Khorasani

Islamic Azad University of Islam-Shahr, Iran
Shahid Bahonar University of Kerman, Kerman, Iran
www.kermanrobot.com
info@kermanrobot.com

Abstract: In this paper technical description, implementation of Azad robot system has been presented. The robot has been designed as part of our sustained program of simulation of human movements based on the functionality of the mechanism. The research has been focused on the similarities between and humanoid movements, as well as the vision. Using computer vision and Advanced Image processing techniques, the robot can detect and recognize the ball in the captured color image and also we have implemented a rule-based inference system as an expert system to increase robot flexibility. In addition, Fuzzy controller has been used to control the stability of the robot by gyro sensors.

1. Introduction

Intelligent robotics, as a frontier branch of AI, has been an active area of research for many years. Study of the cooperation between a camera and a robot started many years ago [1-2]. Since then, there have been numerous research projects conducted to study fast and reliable coordination between a camera and a robot [3-6].

The present research is an effort to devise an intelligent model for humanoid robotic perception and manipulation. As a detailed viewpoint, the major core of this research is to integrate different intelligent concepts to perform robotic coordination and manipulation to produce a working humanoid. The Azad team currently consists of students and researchers from different academic centers: Islamic Azad university of Islam-Shahr, Shahid Bahonar university of Kerman. The team was formed in 2002. We participated in RoboCup 2005 Osaka, humanoid Kid Size competition by the name of Persia B team and in RoboCup 2006 Bremen, by the name of NICICO team and in the RoboCup2007 Atlanta by the name of Persia team.

Azad research group follows a converged research program on development of a fully automated walking pair of legs for disables. Based on our previous prototypes and experiments [7], we have focused our research on development of a simple mechanism of movement of various past of the body with maximum similarity to that of human movements, and at a reasonably high speed. Our approach was analyzing sampled photographs of a human body while moving. Based on displacement of Center Of Mass (COM) of each part, and the body itself, we have developed a very flexible, parametric flowchart that can move the robot without engaging too much in dynamic equations. For the robust object detection, our vision system uses the shape information besides the color information of ball. However, the Azad team project includes many aspects of mechanics, electronics and software development.

The rest of the paper contains a summarized description of each component of the Azad. Hardware architecture is described in section two. Section three presents the proposed software structure. Finally a conclusion is given in section 4.

2. Hardware Architecture

Fig. 1 shows our soccer robot, Azad. Azad includes motion mechanism, Shooting and dribbling mechanism. This is designed to have a multi-purpose capability. This robot is equipped with Industrial control board, camera, other balancing sensors, microcontroller boards, servo motors and etc. Fig. 2 shows picture of the robot.

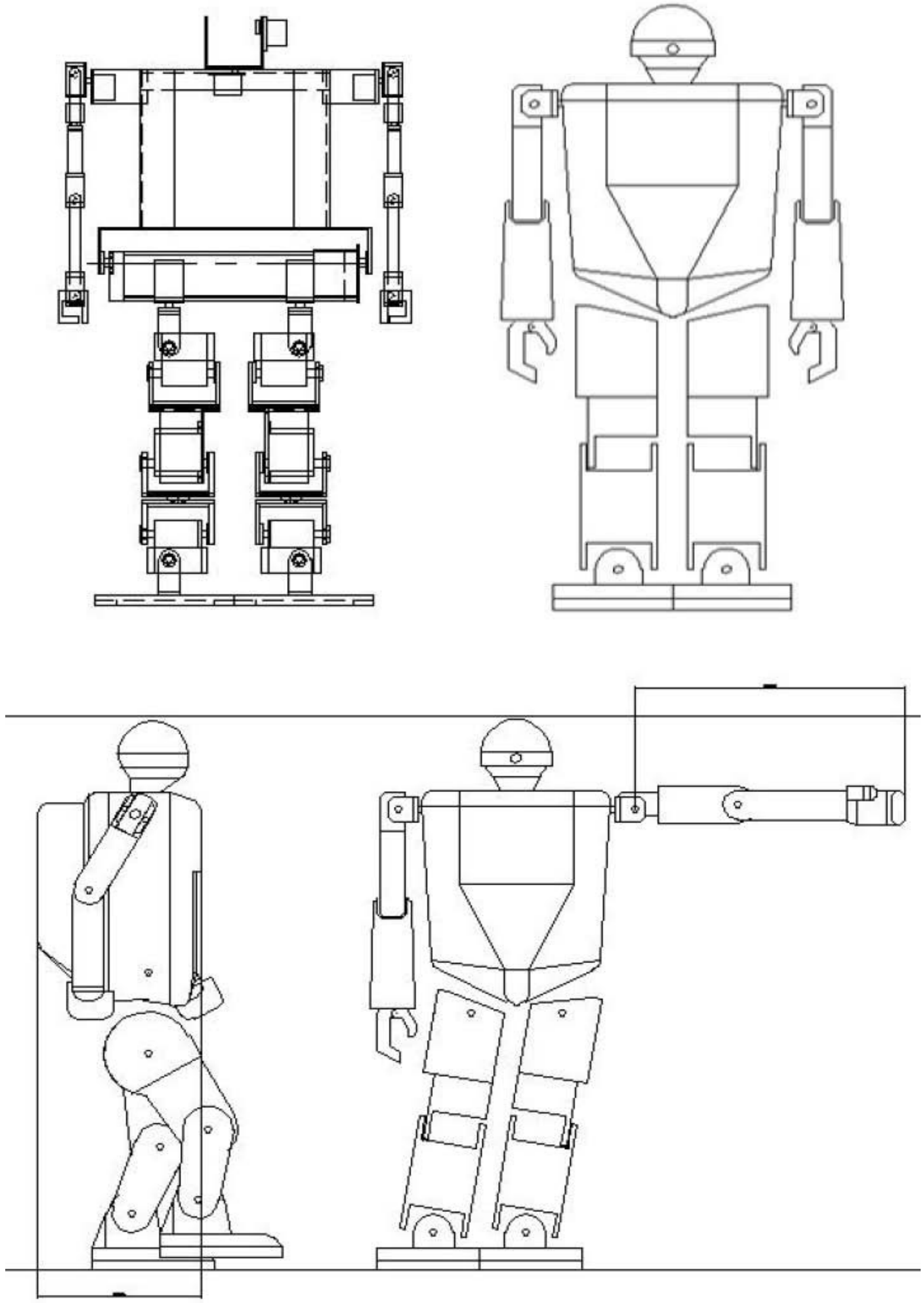

Fig. 1. Draft of Azad design in different views

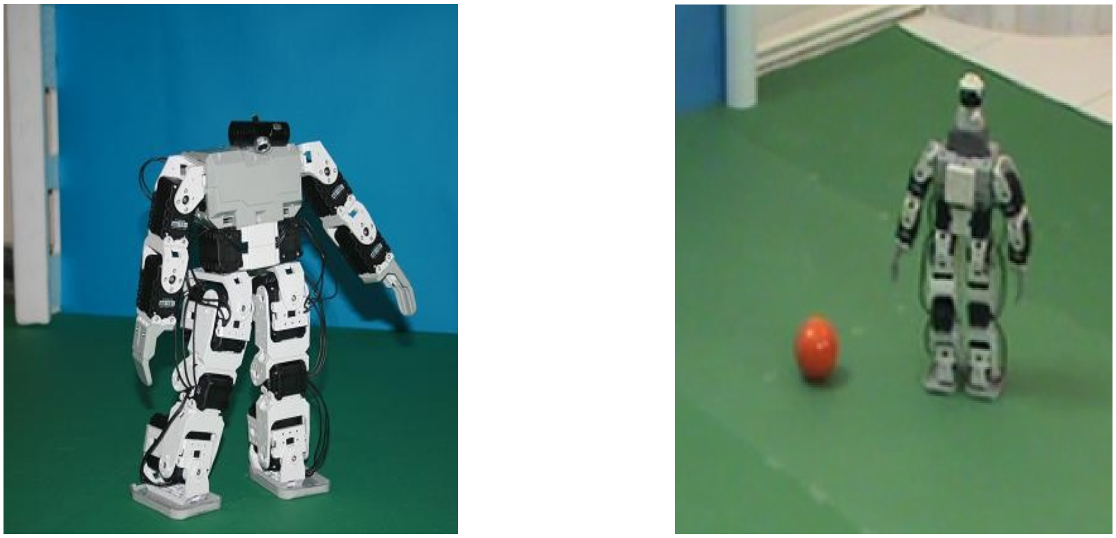

Fig. 2. Images of the robot in different positions

2.1 Central Processing Unit

The central processing system of Azad is an industrial control board (ICB) to make the robot light and consume less power for image processing. The camera takes picture and sends it for main processor. We selected AVR microcontrollers as processor of low level structure. Total functions of the robot are controlled by ICB which has unix based OS. Fig. 3 shows the hardware interaction of Azad components.

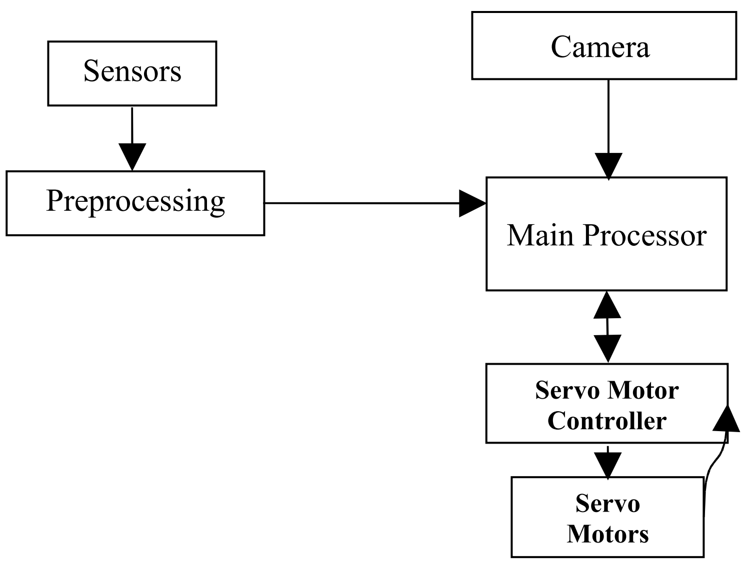

Fig. 3. The Hardware interaction of Azad components.

2.2 Microcontrollers [8]

The processing sensor's signal including camera, decision making and ordering high level commands like "walk", "Turn left" or "shoot" are preformed by central ICB. To achieve high level reliability we used two microcontrollers which control walking procedure. Input signals of these microcontrollers come from central processor unit and these small processors interpret the high level commands produced by central unit and generate suitable signals to move robot, control the position of COM to maintain stability. Preprocessing unit for sensors implemented by microcontroller too.

2.3 Actuators

With the aid of 18 servomotors, Azad moves smoothly, having 18 degrees of freedom. All servos, equipped with internal position and speed control, which are characterized for maximum torque and minimum weight and minimum size. The robot relies on AX-12+ servo motors which have the following properties [12]:

1. Weight (g) 55.
2. Gear Reduction Ratio 1/254.
3. Input Voltage (V) 7V to 10V.
4. Final Max Holding Torque (kgf.cm) 12 to 16.5.
5. Sec/60degree 0.269 to 0.196.

Dynamixel AX-12+ supported services: Precision Control, Compliance Driving, Feedback, Alarm System, Distributed Control, etc.

2.4 Vision

A camera has been connected to the ICB directly. Detection of ball, goals and other markers are performed by ICB, developed by our own team. In this year we equipped our robot to a camera which has a good characteristic and suitable for robotic applications.

2.5 Power supply

3.7 V cells, 4Ah batteries has been used for supplying ICB, microcontroller and combination of these cells used as the power supply of servo motors.

2.6 Specifications

We can finalize the hardware specifications of Azad as follows:

Name of robot : Azad

Height (H) : 47 cm

Weight : about 2kg.

Hcom : 21 cm.

Sole : 11 * 6 cm.

Arms streched horizontal : 49 cm.

Leg length : 23 cm.

Number of degrees of freedom (DOF) : 18

Actuators : 18 Dynamixel AX-12+ motors.

Processing board Controllers : AVR(Atmel)

Manufacturer, model : Atmel, ATMega 128.

3. Software Architecture

The software of Azad is divided into 4 task-oriented modules which are vision, main system, behavior control and camera controlling. Fig 4 shows the software relational Azad components.

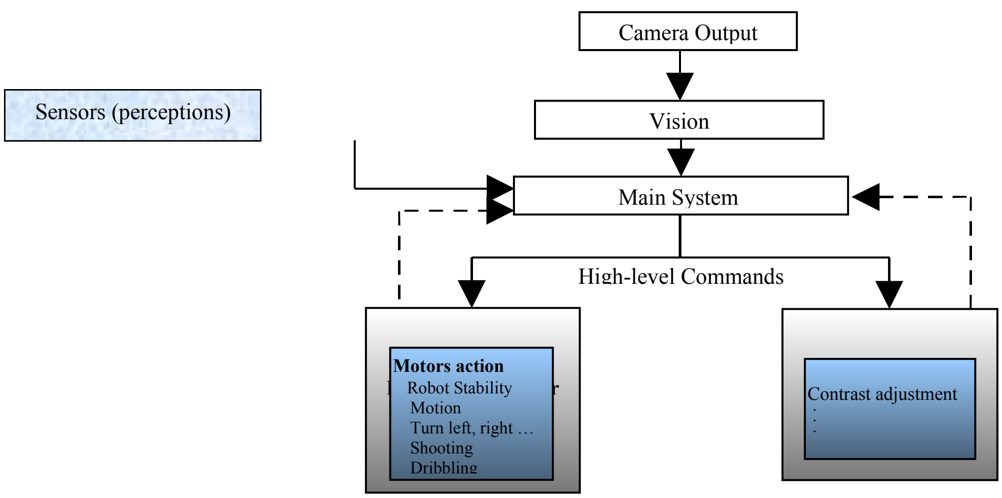

Fig. 4. The software relation of Azad components.

3.1 Vision

The vision module receives two low level inputs which are the raw image from the robot's camera and state angles from the robot motor controllers of the heads. The output of vision module includes a list of relevant game field objects which recognized into the color image, and is transmitted to the rule-based interface system module. For each detected object an estimate of their camera–relative and robot-relative coordinates are provided. Therefore, this year our robot has drastic changes compared to Robocop 2007.

3.2 Main System

In our previously developed robots [5-7], the position of each individual motor was directly determined by human experts so that the whole body of the robot moves from one poses to another. Obviously, that was a tedious and time-consuming task for human because it needed many calculations. Also, the robot could

only move to the pre-defined positions and was unable to choose a completely new pose. In other words, the sequence of movement was limited to those which have already been defined.
We are currently developing a new expert system to derive the new pose of the robot based on its initial position. The most important constraint is to keep the balance of the robot while changing its pose. In this method, human expert does not influence the decision mechanism. Instead, the expert system takes the responsibility of controlling the robot's pose.
Main system module receives information from the vision, behavior control and camera controller modules and process them using a set of rules. This module is the main section of software. The proposed rules for main system have been turned by various experiences and they are independent of game field conditions. The output of this module is a set of high level commands that send to Behavior control and camera controller modules. Some of high level commands which are produced by main system module are:

- *Go to ball with some orientation*
- *Shooting ball*

3.3 Behavior Control

This module receives information (high level commands) as a code from main control module and robot stability information from related sensors. Here, we have used a microcontroller. Total functions about Robot Behavior such as stability motors actions, shooting; dribbling, motion and etc are controlled in this section

4. Conclusions

The major achievement of this research can be summarized as a novel idea for automatic derivation of the new pose of the robot based on its initial position. In this paper, we present the details of Azad robot. We have implemented a rule-based inference system as an advanced system to increase robot flexibility, so total power consumption and weight are decreased; making the robot more stable and reliable as the result of our research. With respect to our pervious work, this year we prepare a more advanced robot.

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