**In the name of God**


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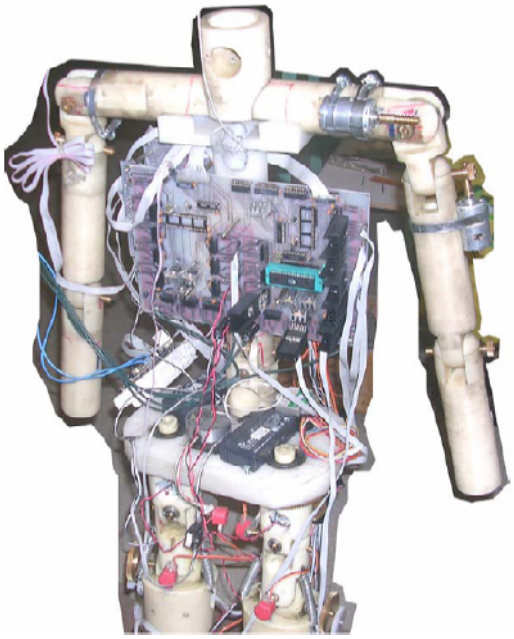
## .Abstract

This paper describes the designing of a humanoid robot called "Dara" in Semnan University by team IRAN FAN AVARAN which wants to participate in the Humanoid League of Robocup 2006 in Germany. The main purpose of this project is to build a humanoid robot to simulate the behavior of human and going to use this generation of robots in some special works instead of human.
This mechatronic project contains the implementation of Control Algorithms, Mechanical Design, and Electronic Control Boards under operating multiple processors together.
In designing of this robot has tried to use some mechanism, control algorithms, mechanical structures and electrical exciters which didn't has still used in similar projects.

## 1. INTRODUCTION

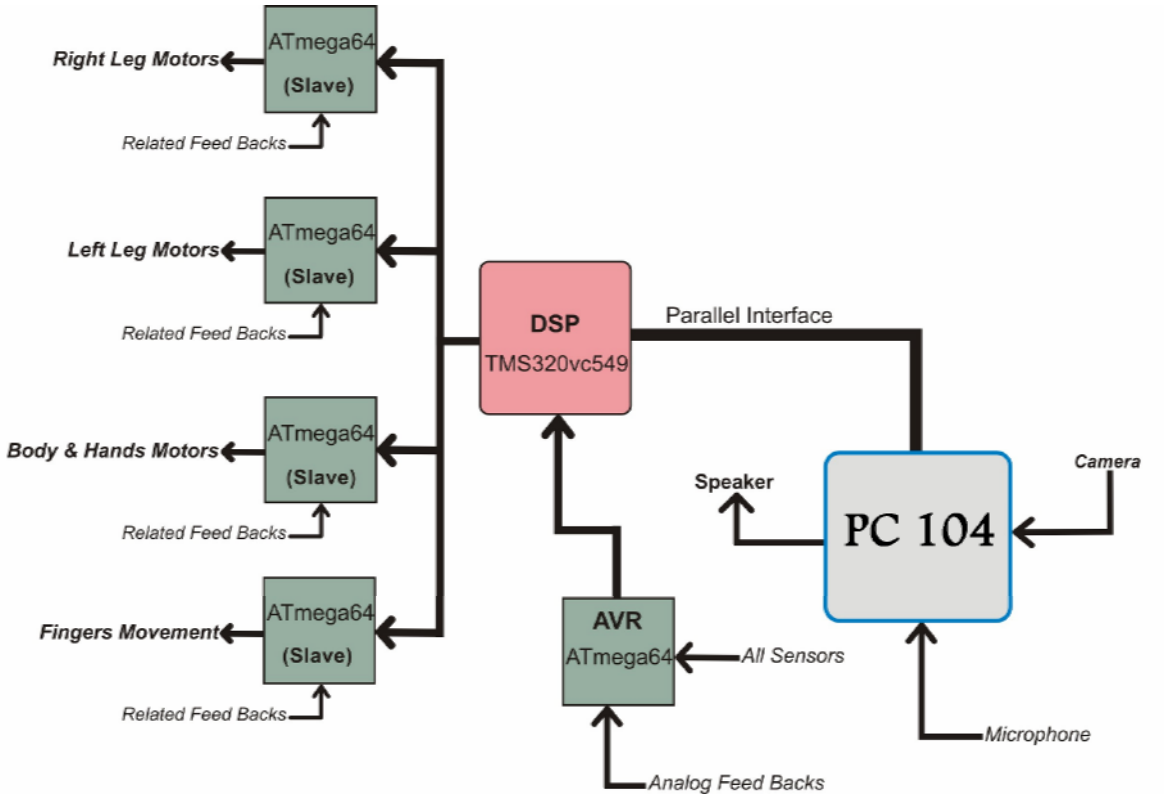
As this project has defined, it contains a biped robot with 140cm height that can see environment, hear voices and process them. This robot can recognize and execute some pantomime or vocal orders, like pointing to right, pointing to left, saying "forward", "sit down", "stop", "Dara"…
The team started research and theoretical working on this project in 2002. After several months' collection of information about same projects in the world and designing the mechanical and electronic system, we started to construct the primary robot in 2003.Picture number one shows this robot. Because of appearance some problems in mechanical construction step and causing later difficulties we decided to design a new structure. In the following we describe specification of the new humanoid robot, called "Dara".



Picture 1

## 2. System in a shot

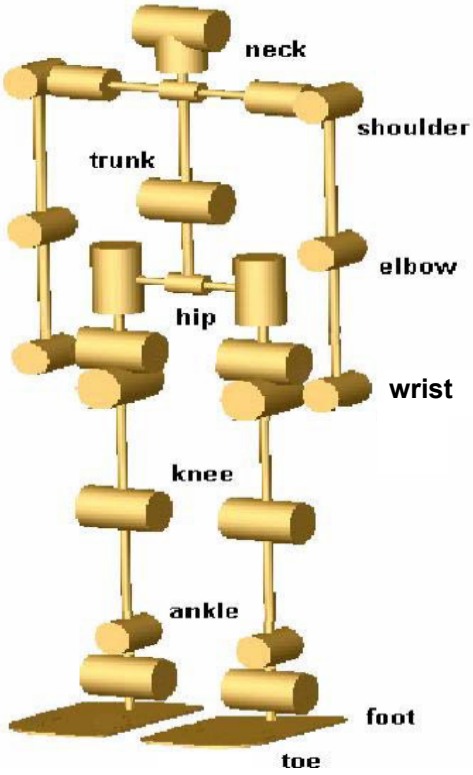
The Electronic system is a set of processors that work with each other coordinately.
According to the picture 2, one embedded computer is responsible for processing the environment's information which is detecting with camera and microphone. The computer distinguishes the task, and then Sends related commands according to our protocol to Main Processor.
Main processor is a DSP from TMS320c54 family that receives the commands from computer. Also it receives the feedbacks from joints and sensors from by an AVR microcontroller. After processing the data, DSP send the necessary comment to some slave AVR micro controllers which are responsible for movement all parts of the robot.




Picture 2

## 3. Mechanical Structure

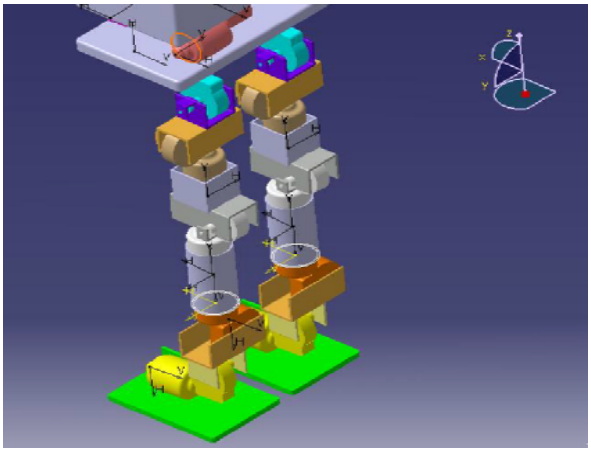
The height of this robot is almost 140cm. consisting of twenty three joints or Degrees Of Freedom: six DOFs per leg on position-wise three DOFs at each hip, one DOF at each knee, and two DOFs at each ankle; one at trunk, four at each hand and two at neck , picture 3,shows total 23 degrees of freedom, without fingers freedom.
For designing structure and modeling of each part of the robot we used CATIA software. Picture 4 shows some parts of the robot in Catia environment.



Picture 3

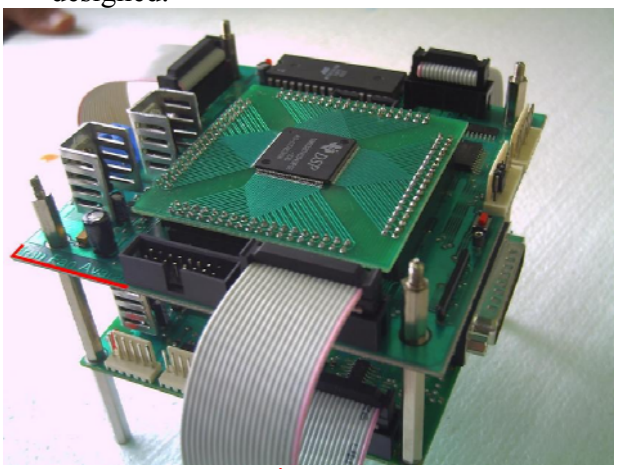
## 4. Sensors

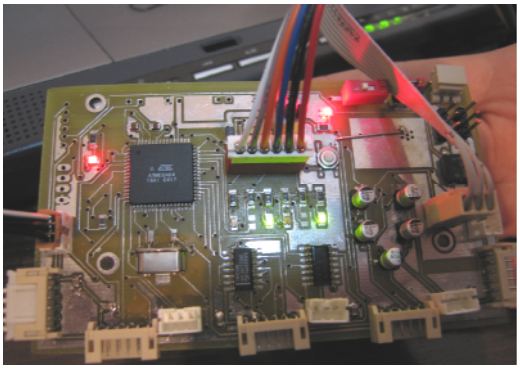
One of the important parts for industrial system is sensor for optimizing control system and make system more intelligent.
Except camera and microphone as vision&voice receivers, we used Touch and Force sensors for some parts of the robot used in balance calculation and some reactions.


Picture 4

## 5. Hardware in Detail

The communication between processors in our system has its own protocols. The data communication between computer and DSP is Parallel port combining with handshaking!
The data communication between AVR and DSP is selected synchronous serial. Because of difference between synchronous serial protocol of DSP and universal synchronous serial protocol of AVR an Altera FPGA, 7000 series is used to convert two protocols each other. Pictures 5 & 6 show the processor boards, DSP and local AVRs which has designed.


Picture 5



Picture 6

For recognition degrees, speeds and acceleration of each joint we used linear potentiometer. The analogue signals sent to AVR microcontrollers, every part of the robot has its local AVR. After converting the signals to digital, the data store in a special database to use in control algorithms.
The sampling period of joints is 1.5ms.

## 6. Control

The control section consist three parts: Balance control, velocity control and position control.
Essential for the walking of a biped robot is the balance control. An efficient algorithm of balance control is necessary to achieve dynamic walking control. Walking motion of biped can be determined by the hip trajectory and the swing foot trajectory. The stability can be characterized by the Zero Moment Point (ZMP) criterion.
In this work a fuzzy algorithm is proposed to control the lateral plane movements for the robot. The algorithm is based on a fuzzy PD control algorithm, were the output gain is incremental and sensible to error. This feature guaranties a smooth balance control response and a correct interaction between the walking algorithm and the lateral plane control.

DSP, the main processor is responsible calculating the Center Of Mass (COM), ZMP and management & synchronize overall the three control parts.

## 7. Actuators

Actuators which are used in this robot are three types:

**7-1.** DC geared motor with 35v and 20A max and torque of 12 Nm, for the legs and hip

**7-2.** DC geared motor with 12v and 6A max and torque of 8.5 Nm, for hands and trunk

**7-3.** Stepping motor with 24v, 0.3A and torque of 5 kg-cm, for neck

## 8. Simulation

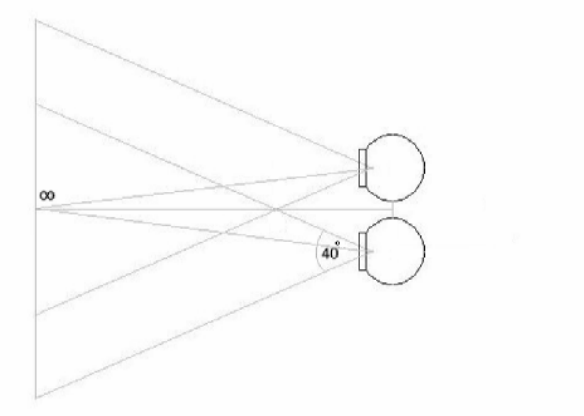
Modeling and simulation of the robot can greatly assist in making progress on all levels of design, implementation and operation.
In this project some parts of simulation and modeling the robot dynamics as well as measures for stability and performance of legs locomotion has done by Matlab GUI.

## 9. Image processing

One of the most important part of the robot is its eyes, because of distinguish its position and environment and also for navigation.
We take a picture from a CCD camera and process our image in the industrial computer.

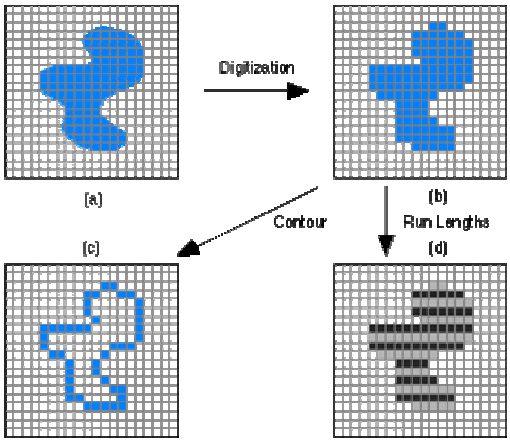
Because of need to distance recognition we should have two eyes, this allows us to see two different images from two points of view. Then by analyzing the differences between these two images we are Able to deduct some characteristics of the 3D world

around us. In the picture 7 the structure of two cameras is shown.




Picture 7

Two main algorithms which we have used are Chain code and SUSAN. When dealing with a region or object, several compact representations is available that can facilitate manipulation and measurements on the object. In each case we assume that we begin with an image representation of the object as shown in picture 8. Several techniques exist to represent the region or object by describing its contour.




Picture8

We implemented image processing algorithms by Delphi software

## 10. Voice recognition

We have made specific software for processing voices and recognition some vocal order like "stop", "sit down", "right"," left"…
This goal has achieved by Delphi software. Because of need to considering so many factors for correct recognition we defined special users in the software to can talk and order the robot. So the robot only executes vocal orders of few people.

## 11. Conclusion

As described, based on our four years scientific researches, experiments and experiences, we have designed Dara, the humanoid robot.
It has 23 degrees of freedom and has new design in mechanism & electronic system as compared to other humanoid robots, because many parts of this project have designed by our own team. Also it has designed with low cost components and actuators.
The robot is equipped with vision and hearing, it is fuzzy controlled and can improve and develop for using in human world.
Now we are making it ready for Robocup 2006 competition.