

A Step Towards Humanoid Walking Robot

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Abstract: The study presented in the paper gives an approach to a robot controlled by Arduino. This paper describes a small humanoid robot which is an excellent first step for initiation into the field of Humanoid Walking Robots. A Robot which is programmable, multi-functional device which is preliminary designed to do work like human such as walking, dancing, punching and other can also be coded. It is accessible by USB and Bluetooth both. This gives a brief idea about the controlling and operation of robot.

Keywords: Arduino, 18 Servo Controller, Bluetooth, USB Connection.

1. Introduction

A humanoid robot is a robot with its body shape built to resemble the human body. The design may be used for functional purposes, such as interacting with human tools and environments, for experimental purposes, such as the study of bipedal locomotion, or for other purposes. In general, humanoid robots have a torso, a head, two arms, and two legs, though some forms of humanoid robots may model only part of the body, for example, from the waist up. Some humanoid robots also have heads designed to replicate human facial features such as eyes and mouths.

The features of humanoid robots can be summarized as follows; 1. Humanoid robots can work in the environment for humans as it is, 2. Humanoid robots can use tools for humans as it is, and 3. Humanoid robots has a human-like shape.

First feature of humanoid is that the environment of the modern society is designed for humans. For example, the width of corridor, the height of a stair, and the position of a handrail are determined to fit the size and motions of humans. Therefore, we need not modify the human environment for a robot to operate when the robot has a human shape and move like a human. An uneven floor has to be made flat, a narrow passage should be removed and a lift must be available when a robot moves on wheels. It should be more economical to develop humanoid robots than to modify the whole environment.

The second feature should imply a similar effect. Most of tools for humans are designed to be used by humans. For example, the size and shape of chairs are determined to sit on them, and the height of dining tables are decided to eat on them. A driver's cockpit is designed to control a car. The shape of a screw driver or scissors can be operated best by articulated

fingers. Thus this second feature is very important to consider as well as realization in now-a-days for better understanding of it. It should be more economical to used humanoid robots than to re-design numerous tools.

The third feature explains that A robot is easily personified when the robot looks like a human. The further a robot is from a human shape, the less humans feel a human in the robot. A human-like shape is very important to realize a partner robot that can make us enjoy. The third feature must be the primary account why many robots look like humans in scientific fictions.

This paper gives an idea that Humanoid robots are robots with an anthropomorphic body plan and human-like senses, are enjoying increasing popularity as research tool. More and more groups worldwide work on issues like bipedal locomotion, dexterous manipulation, audio-visual perception, human-robot interaction, adaptive control, and learning, targeted for the application in humanoid robots. These efforts are motivated by the vision to create a new kind of tool: robots that work in close cooperation with humans in the same environment that is designed to suit our needs. While highly specialized industrial robots are successfully employed in industrial mass production, these new applications require a different approach: general purpose humanoid robots. The human body is well suited for acting in our everyday environments. Stairs, door handles, tools, and so on are designed to be used by humans.

A robot with a human-like body can take advantage of these human-centred designs. The new applications will require social interaction between humans and robots. If a robot is able to analyse and synthesize speech, eye movements, mimics, gestures, and body language, it will be capable of intuitive communication with humans. Most of these modalities require a human-like body plan. A human-like action repertoire also facilitates the programming of the robots by demonstration and the learning of new skills by imitation of humans, because there is a one-to-one mapping of human actions to robot actions. Last, but not least, humanoid robots are used as a tool to understand human intelligence. In the same way biomimetic robots have been built to understand certain aspects of animal intelligence, humanoid robots can be used to test models of aspects of human intelligence and can be made an easy to use device.

2. Literature survey

Robot is fabricated by using components like microcontrollers and motors. This increases their speed of operation and reduces the complexity. It also brings about an increase in productivity which makes it easy to shift to hazardous materials. In the implementation process, the necessary components of structure ICs, blocks and power supply are all assembled on the Arduino. The Robotic Arm is designed using the Microcontroller i.e. ATMEGA328 Microcontroller using Arduino programming. This process works on the principle of interfacing servos and potentiometers. This task is achieved by using Arduino board. Potentiometers play an important role. The remote is fitted with potentiometers and the servos are attached to the body of the robot. The potentiometer converts the mechanical motion into electrical motion. Hence, on the motion of the remote the potentiometers produce the electrical pulses, which are en-route for the Arduino board. The board then processes the signals received from the potentiometers and finally, converts them into requisite digital pulses that are then sent to the servomotors. This servo will respond with regards to the pulses which results in the moment of the arm.

3. Part description

All The humanoid robot consists of several parts as described in table below:

Table 1
Parts of humanoid robot

Parts Name	No.
Arduino Uno R3 based Bluetooth + USB 18 Servo Controller	1
Lithium Ion Rechargeable Battery 7.4V 2200 mAh	1
Metal Gear Standard Servo Economy	9
Multipurpose Aluminium Standard Servo Bracket	8
Short U Shape Aluminium Servo Bracket	1
Long U Aluminium Servo Bracket	2
Oblique U Shape Aluminium Servo Bracket	2
Interconnect Aluminium Servo Bracket	4
L Shaped Interconnect Servo Bracket	4
Large U Beam Aluminium Servo Bracket	1
Robot feet Aluminium Servo Bracket	2
Miniature Ball Radial Bearing	4
Metal Horn for Servo 25T	9
Screw and screw cap	

A. Arduino Uno R3 based controller

Controller is variant of our USB servo controller for wireless applications. This device can be operated wirelessly on Bluetooth or through USB connection. This also means that it can receive signals from any devices like PCs, Laptops, Mobile phones with Bluetooth and Java, Android and windows smartphones etc. Arduino Uno R3 based Bluetooth + USB 18 Servo Controller is ideal for making Autonomous and PC based systems which run over Hobby Servo motors. The software helps to develop the complex sequences in real time on the hardware like robotic arms, walkers, bipeds and any other servo controlled system. It also generates Arduino based code for the

code for the developed sequence which can be deployed on the controller on board thereby making the robot autonomous.

1) Features

- Bluetooth interface for wireless control of robots.
- Controls 18 hobby servos from PC and Microcontroller
- USB interface
- Software exports servo sequences to Arduino Uno for running servo sequences
- Independent range setting for each servo
- Independent offset, Maximum, Minimum and Direction setting for each servo
- 0.5-microsecond resolution
- 50 Hz update rate
- Small size of 80 X 47 mm
- Plug and Play, Auto detection of hardware
- Servo sequencer with speed, delay, goto and many other features
- Home and neutral position setting

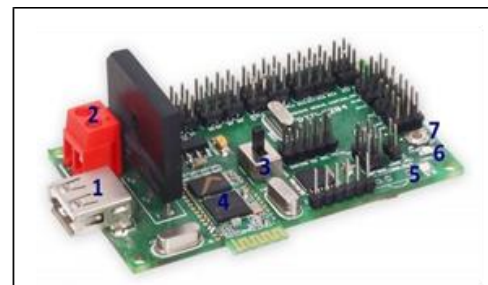


Fig. 1. Arduino Uno R3 Based Bluetooth & USB 18 Servo Controller

2) Parts Name

1. USB Connector for connecting USB Cable to PC
2. Power Connector 5 - 7.5 V DC
3. Switch for Switching Between Bluetooth and USB Mode.
4. Bluetooth Module
5. Bluetooth Status LED
6. LED on Pin 13 of Circuit Board as in Arduino
7. Reset Switch

B. Lithium-Ion Rechargeable Battery

Lithium-Ion Battery is used for robotic applications. Very light weight and small size compared to Ni-Cd, Ni-MH and Lead acid batteries. Very long life without losing charging capacity. Thus Li-on batteries are better than other and therefore they should be used due to its better performance and efficiency.

1) Battery Features

- Very Small in size and weight compared to Ni-Cd, Ni-MH and Lead Acid Batteries
- Discharge current upto 4.4A
- Full Charge in 40 to 90 minutes depending upon special charger
- Long life with full capacity for upto 1000 charge cycles

- 2 x Li-ion 3.7V 2200mAh cells (2S1P)
- Low maintenance
- Dimensions: 65 x 36 x 18 mm

2) *Li-Ion Cell Specifications*

- 3.7V 2200mAh
- Weight 40 grams
- Maximum safe discharge current 4400mA
- Maximum charging voltage 4.2V (Do not overcharge the cell, it may explode or be internally damaged.)
- Maximum charging current 2200mA



Fig. 2. Li-on Battery

C. *Servo Motor*

A servo motor is an electrical device which can push or rotate an object with great precision. If you want to rotate an object at some specific angles or distance, then you use servo motor. It is just made up of simple motor which run through servo mechanism. If motor is used is DC powered then it is called DC servo motor, and if it is AC powered motor then it is called AC servo motor. We can get a very high torque servo motor in a small and light weight packages. Due to these features they are being used in many applications like toy car, RC helicopters and planes, Machine etc.



Fig. 3. Servo motor

1) *Features*

- Required Pulse: 3-5 Volt Peak to Peak Square Wave
- Operating Voltage: 4.8-7.2 Volts
- Operating Temperature Range: -10 to +60 Degree C
- Operating Speed (4.8V): 0.18sec/60 degrees at no load
- Operating Speed (6V): 0.16sec/60 degrees at no load
- Operating Speed (7.2V): 0.14sec/60 degrees at no load
- Stall Torque (4.8V): 11kg/cm
- Stall Torque (6V): 13.5kg/cm

- Stall Torque (7.2V): 16kg/cm
- 360 Modifiable: Yes
- Potentiometer Drive: Indirect Drive
- Bearing Type: Double Ball Bearing
- Gear Type: All Metal Gears
- Connector Wire Length: 12"
- Dimensions: 1.6" x 0.8"x 1.4" (41 x 20 x 36mm)
- Weight: 56gm

2) *Servo Mechanism*

It consists of three parts

- Controlled device
- Output sensor
- Feedback system

It is a closed loop system where it uses positive feedback system to control motion and final position of the shaft. Here the device is controlled by a feedback signal generated by comparing output signal and reference input signal.

Here reference input signal is compared to reference output signal and the third signal is produces by feedback system. And this third signal acts as input signal to control device. This signal is present as long as feedback signal is generated or there is difference between reference input signal and reference output signal. So the main task of servomechanism is to maintain output of a system at desired value at presence of noises.

3) *Working principle of servo motor*

A servo consists of a Motor (DC or AC), a potentiometer, gear assembly and a controlling circuit. First of all, we use gear assembly to reduce RPM and to increase torque of motor. Say at initial position of servo motor shaft, the position of the potentiometer knob is such that there is no electrical signal generated at the output port of the potentiometer. Now an electrical signal is given to another input terminal of the error detector amplifier. Now difference between these two signals, one comes from potentiometer and another comes from other source, will be processed in feedback mechanism and output will be provided in term of error signal. This error signal acts as the input for motor and motor starts rotating. Now motor shaft is connected with potentiometer and as motor rotates so the potentiometer and it will generate a signal. So as the potentiometer's angular position changes, its output feedback signal changes. After sometime the position of potentiometer reaches at a position that the output of potentiometer is same as external signal provided. At this condition, there will be no output signal from the amplifier to the motor input as there is no difference between external applied signal and the signal generated at potentiometer, and in this situation motor stops rotating.

4) *Controlling Servo Motor*

All motors have three wires coming out of them. Out of which two will be used for Supply (positive and negative) and one will be used for the signal that is to be sent from the MCU.

Servo motor is controlled by PWM (Pulse with Modulation) which is provided by the control wires. There is a minimum

pulse, a maximum pulse and a repetition rate. Servo motor can turn 90 degree from either direction from its neutral position. The servo motor expects to see a pulse every 20 milliseconds (ms) and the length of the pulse will determine how far the motor turns. For example, a 1.5ms pulse will make the motor turn to the 90° position, such as if pulse is shorter than 1.5ms shaft moves to 0° and if it is longer than 1.5ms than it will turn the servo to 180°.

Servo motor works on PWM (Pulse width modulation) principle, means its angle of rotation is controlled by the duration of applied pulse to its Control PIN. Basically servo motor is made up of DC motor which is controlled by a variable resistor (potentiometer) and some gears. High speed force of DC motor is converted into torque by Gears. We know that $WORK = FORCE \times DISTANCE$, in DC motor Force is less and distance (speed) is high and in Servo, force is High and distance is less. Potentiometer is connected to the output shaft of the Servo, to calculate the angle and stop the DC motor on required angle.

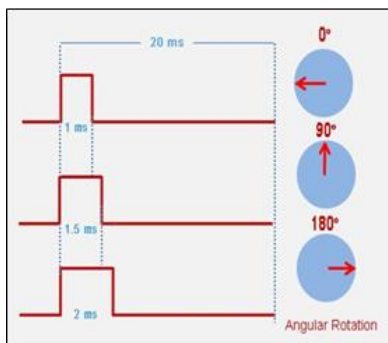


Fig. 4. Controlling of servo motor

Servo motor can be rotated from 0 to 180 degree, but it can go up to 210 degree, depending on the manufacturing. This degree of rotation can be controlled by applying the Electrical Pulse of proper width, to its Control pin. Servo checks the pulse in every 20 milliseconds. Pulse of 1 ms (1 millisecond) width can rotate servo to 0 degree, 1.5ms can rotate to 90 degree (neutral position) and 2 ms pulse can rotate it to 180 degree.

All servo motors work directly with your +5V supply rails but we have to be careful on the amount of current the motor would consume, if you are planning to use more than two servo motors a proper shield should be designed.

D. Servo Bracket

Servo brackets are used to construct different body parts of robot. There are many kinds of brackets used for different application.

Multipurpose Aluminium Standard Servo Bracket

- Short U Shape Aluminium Servo Bracket
- Long U Aluminium Servo Bracket
- Oblique U Shape Aluminium Servo Bracket
- Interconnect Aluminium Servo Bracket
- L Shaped Interconnect Servo Bracket

- Large U Beam Aluminium Servo Bracket
- Robot feet Aluminium Servo Bracket



Fig. 5. Servo bracket

E. Servo Controller Software

A servo controller is a dedicated board that helps the user to control servos based on the commands sent to it from an external device such as a computer or microcontroller. Using a dedicated servo controller frees up memory on a microcontroller which would be used to constantly update the servo's positions.

Enables the user to control upto 18 servos with serial commands issued from PC or another Arduino. You can also set various parameters like minimum, maximum, reset angles, speed and save these parameters permanently. You can also enable / disable individual servo as well as set the position as desired.



Fig. 6. Servo controller

1) 18 Servo Controller Features

- Bluetooth interface for wireless control of robots
- Controls 18 hobby servos from PC and Microcontroller
- USB interface
- Software exports servo sequences to Arduino Uno for running servo sequences
- Independent range setting for each servo
- Independent offset, Maximum, Minimum and Direction setting for each servo
- 0.5-microsecond resolution
- 50 Hz update rate
- Small size of 80 X 47 mm

- Plug and Play, Auto detection of hardware
- Easy to use software
- Servo sequencer with speed, delay, goto and many other features
- Home and neutral position setting

2) *Servo Controller Connection Section*

This Sections is for Connecting the Hardware i.e. Servo Controller with the Software. The Product comes with 2 variants one is having only USB Connection and other one is having USB + Bluetooth Connection. By default, it is configured to connect in Bluetooth Mode but you can select any option as required.



Fig. 7. Connection type

3) *Servo Label Section*

This Section is Servo Label Section which contains the Label for each Servo Motor. You can Change the Label by Clicking on the respective Label.

4) *Servo Control Section*

This Section Controls the Servo Motors. For each Servo Motor there is a Slider provided so that the user can slide the Slider and control the Servo Motor when it is connected to Servo Controller. At the Bottom of this Section the values show the current position of Sliders or Motors. Also there is a Centre Button provided for each Servo to make the position of Slider or Motor to the Centre Position.



Fig. 8. Servo sequencer

5) *Sequence Window/ Program Window*

All the Sequences which are generated or modified using the

servo sequence sections can be seen in this window. Moreover, for running the specific Step you can double click the Line in this Window to run that step.

6) *Servo Settings and other Options*

The different Buttons in this Section are explained below: Open File: To open already saved file. Save File: To save Current File. Reset Labels: Reset the Labels of the Servos given by the User.

Settings: This Menu is the very important with the view point of controlling the Servos. On Clicking on this Button will open a new Window as shown below: This Menu is the very important with the view point of controlling the Servos.

7) *Function Control Section*

While generating the sequences one can also create the Functions as per the requirement. For example, in Biped Robot one can generate different functions for Forward, Reverse etc. Once the functions generated you can directly call the required function from this Section.

8) *Servo Idle Section*

By default, when executing servo movement commands like double clicking on code line or while running a program, servo controller will update values of all 18 servos. In some cases, this can be problem specially while using functions.

9) *Saving Configuration and Generating Arduino Code*

In this Section the first Button is of Save Configuration to Controller. The Configurations Settings made for each Servo (for example: Centre Position, Maximum Position, Minimum Position etc.) can be directly saved to Controller by clicking on this Button. Once the sequence is generated for the required application and the file is saved you can generate the Arduino Code for your sequence which can directly be deployed into the same Servo Controller Board as it is Arduino based Controller. This will make your robot autonomous means you don't need PC Software for running the same sequence generated by you. Let us see how to generate the Arduino Code.

4. Conclusion

Nowadays robotic technology has a major role in the advancement of technology. Most of the workers are moving towards the service sector and not to the industrial sector. As a result, there exists a scope for automating all the operations carried out by the workers in industries.

The robot developed is more user friendly and less costly. It will perform the desired operation very smoothly. It can be controlled easily by USB or Bluetooth.

It has been well documented that there will be increase in the number of robots over the next decade. According to the Boston Consulting Group, by 2025, robots will perform 25% of all labour tasks. This is due to improvements in performance and reduction in costs.

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