HUMANOID

A Major Project Report

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IN

ELECTRONICS & COMMUNICATION ENGINEERING

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CERTIFICATE

This is to certify that the Major Project Report entitled **" Humanoid "** submitted by **Maulik Patel (**Roll No. **12BEC066)** and **Mohak Patel** (Roll No. **12BEC067**)as the partial fulfillment of the requirements for the award of the degree of Bachelor of Technology in Electronics & Communication Engineering, Institute of Technology, Nirma University is the record of work carried out by him/her under my supervision and guidance. The work submitted in our opinion has reached a level required for being accepted for the examination.

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ABSTRACT

This project is to design and develop a "Humanoid Robot" using Arduino Mega. This project combines the knowledge of electronics and electrical. The objective of this project is to design and build a more compact, usable and cheaper robot which can walk in a specific direction and can even detect the obstacles in its way. The main function of Arduino is to generate a pulse width modulation (PWM) signals which are applied to servo motors for achieving the desired rotation. Each servo has different specifications. Therefore, a PWM pulse can have a different effect on servos. The main advantage of controlling the servo motors with PWM signals is that they could be programmed to have an initial position and to rotate with an exact degree with respect to the requirements.

The entire designing of the humanoid robot was done on "Solidworks" and "Autodesk 123D" and aluminum sheet is used as the body of the humanoid. In this project, eighteen servo motors are used along with a gyroscope to maintain the proper body posture. We have even used an Infrared sensor as an obstacle detection circuit. Arduino Mega is attached to the chest portion of the robot. We have used Bluetooth Module HC-05 for giving robot the command to walk in a specified direction.

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Chapter 1
Introduction

With the growth of technology, the need of new devices grows accordingly. Computer and electronic sciences is mostly premier in raising the new technologies. Of course the new technology could affect different engineering fields. For instance, if the robotics and artificial intelligence are considered, it reveals that the technology with its high potential, affected many different fields of studies. Therefore related fields of study can be combined to generate new technologies that could be used in broad fields. The robots play important roles in our lives and are able to perform the tasks which cannot be done by humans in terms of speed, accuracy and difficulty. Robots can be employed to imitate human behaviors and then apply these behaviors to the skills that leads the robot to achieve a certain task.

They do not get tired or face the commands emotionally, and since they are designed by humans. They can be programmed and expected to obey and perform some specific tasks. In some cases the use of a robotic hand becomes remarkable. Robotic is applied in different forms and fields to simulate human behavior and motions. The idea of robotic is to create practical and useful robots that facilitate our daily tasks. Due to the independency of the robots, they have a longer life time comparing with the humans and could be helpful in industry, dangerous tasks and nursing homes.

Most of tools, vehicles, electronic devices and cuisine are built and prepared with the help of industrial robots. For instance, there are industrial robot assembly lines which help in many cases that can operate more accurate and faster than humans. Recently, robots operate in almost all human labors generally in the fields which are unhealthy or impractical for workers.

This fact caused the workers to have more free time to spend on skilled professions including the programming, maintenance and operation of the robots which are quite essential. There are situations where a robot is a replacement for human because the human does not have the capability to work under the specific conditions, such as working in the space, under the water etc. unless the person is equipped with expensive special clothing and equipment. Therefore, while designing a robot, considering the factors such as concept and techniques, artificial intelligence and cognitive science are essential in order to obtain an effective design. Obviously, building a humanoid is not a new idea, but still the design and the specifications can differ from other designs. For instance, the circuitry, degree of freedom (DOF), algorithm, program, attachments, equipment, accuracy and speed, completely depend on the designer’s tact.

1.2 Objective of the Project

The objective of the project is to make the robot walk in a specific direction according to the commands given by the Bluetooth application in the Android phone. If there is an obstacle within 15 centimeters, the infrared sensors will detect it and the robot will stop walking. We can then change the desired path of the robot.

1.3Humanoid robot Details and Summary

The humanoid will be controlled via Arduino Mega and it will be able to walk in a specific direction according to the commands given by the user. The servo motors are popular for their desirable characteristics for robotic application. We have used 18 servo motors in our project and the command will be given by Bluetooth module HC-05. In order to detect the obstacles coming in the way, we have even used Ultrasonic sensors on the head of the humanoid. To maintain the proper body posture while walking, we have used a gyroscope.

1.4Problem statement and solution

The project intends to investigate the design, implementation and control of a humanoid robot using servo motors and Arduino Mega. The main reason of using Arduino is because it provides power supply to the servo motors and also it has the inbuilt provision of pulse width modulation(PWM) pins. A pulse signal could have a different effect on servos with different specifications. Therefore, most of the time it is crucial to be able to give the exact PWM pulse in order to rotate a servo to a specific rotation. The main advantage of controlling the servo motors with PWM signals is that they could be programmed to have an initial position and to rotate with an exact degree with respect to the requirements.

Chapter 2

Literature Review

2.1 Building the Kinematic Structure

The first step of designing a robot is to decide the dimension and workspace configuration according to the requirements. The next step is to decide the specification of each actuator. The structural body of the robot is built with aluminum sheets of 2 millimeters thickness. The reason for choosing the specific thickness is because it is more malleable and can be folded into different shapes. Also it would be strong enough to create the entire body of the robot and keep and hold all the parts together.

Although the idea of using stepper and gear motors is brilliant, but physical movement of the robot is done by using servo motors. The advantage of the servos is that they could be programmed to return to their initial position. Since the servo motors operate using the signals received from the microcontroller, they could be programmed according to the requirements. However, this characteristic of the servo motors is actually a disadvantage, because the chance of sending and receiving a wrong signal is high which causes the servo to operate incorrectly.

The basic designing of the robot was done on “Autodesk 123D” and “Solidworks”. All the parts of the robot were drawn by a marker pen on the aluminum sheet and cut accurately.Water jet cutting technology was used to cut the aluminum sheet in specific dimensions and to create necessary holes and cuts to connect the parts to each other and to keep the actuators tightly.

Figure 2.1: Components

The basic designing of the humanoid robot in “Solidworks” is shown in the Figure 2.1. The dimensions can differ for different designs, but this should be mentioned that the dimensions given in this study are chosen with respect to the servo motors which are used in the robot. The power, torque and size of the servo motors can affect the dimensions. For instance if the servo motor used in the hip is changed with a less powerful servo, the length of hip should be decreased accordingly, because the servo may not have enough power to pull the hip up.

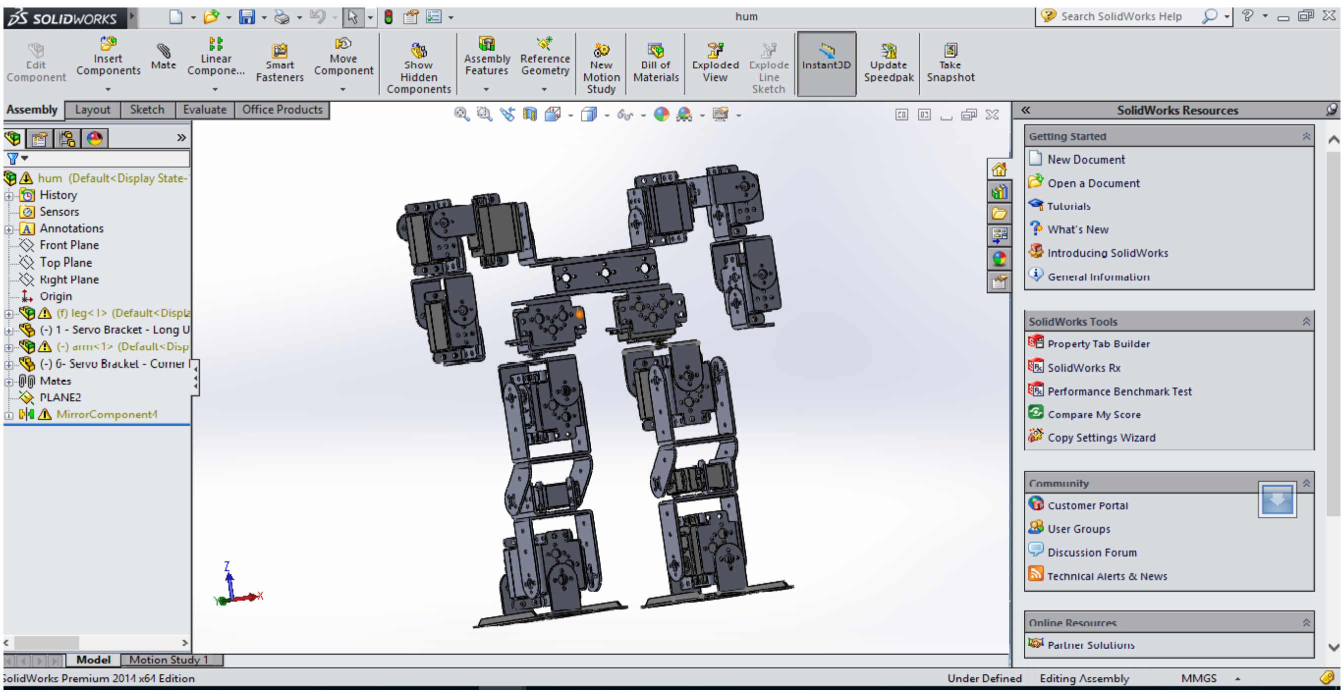

Figure 2.2: Humanoid designing in ‘Solidworks’

On the other hand, if a longer hip is required to enlarge the workspace of the robot, the height of legs and torso from the base should be changed respectively in order to maintain the physical balance of the robot. In general, if one part of the structure is changed in dimension, the change should be applied for all parts of the robot accordingly in order to eliminate the instability problem.

The final look of the humanoid robot can be seen in Figure 2.2. It even includes the gyroscope and Infrared sensor. The Bluetooth module HC-05 and Arduino Mega are attached on the back of the humanoid robot.

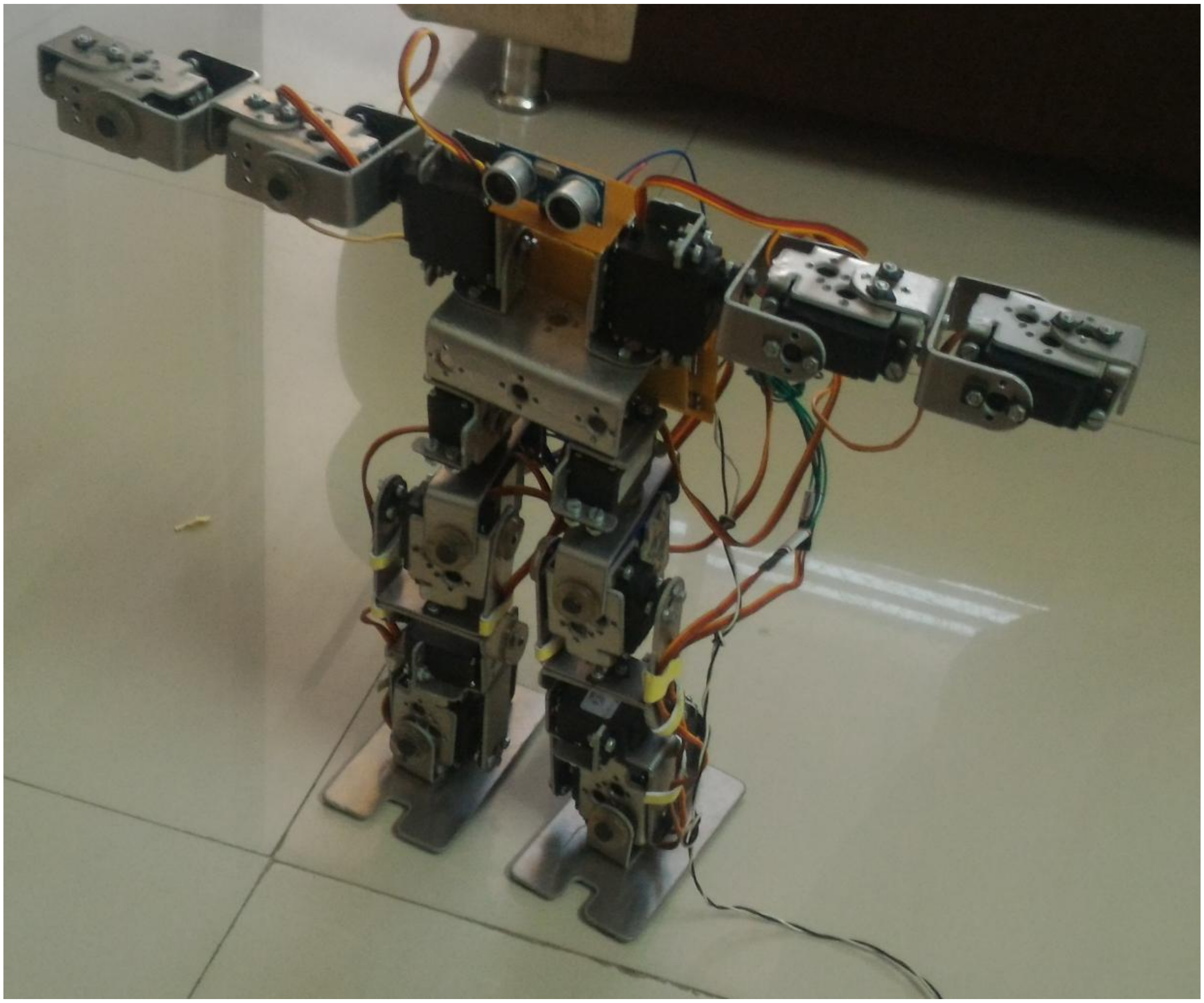

Figure 2.3: Final look of Humanoid

2.2 Hardware implementation

In the Humanoid robot, Arduino Mega 2560 is chosen as the main processor. This is because it has a good range of interfaces, including analogue and digital pins, pulse width modulation (PWM) and in-circuit debugging. Some more features regarding Arduino Mega and other electronics components like Servo motors, Bluetooth Module HC-05, Infrared Sensor and gyroscope which are used in our project is explained in the following topic.

2.2.1 Arduino Mega 2560

The Mega 2560 is a microcontroller board based on ATmega2560. It has 54 digital input/output pins (of which 15 can be used as PWM output pins), 16 analog input pins, 4 UARTs (hardware serial ports), a

16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. The operating voltage is 5V and its recommended input voltage is 7-12V. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.

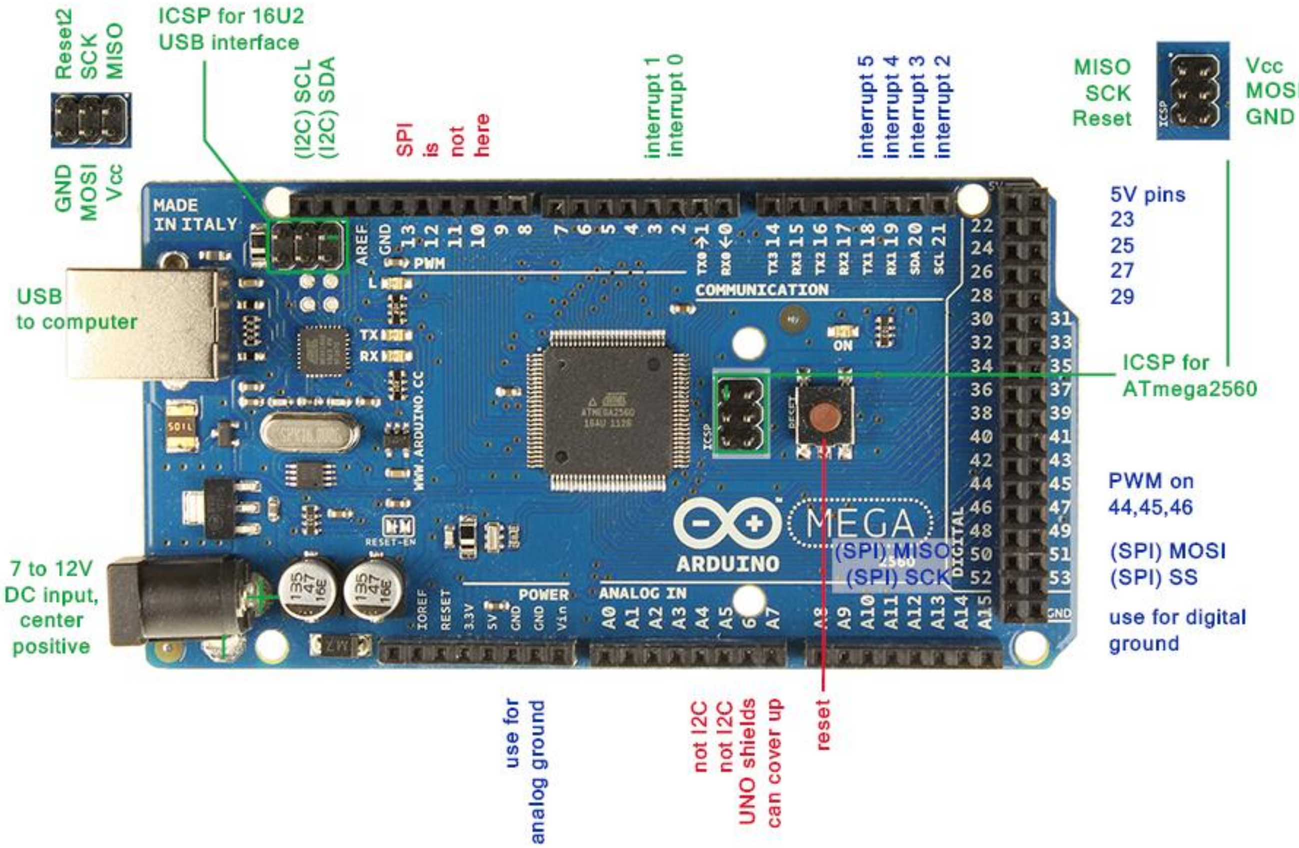

Figure 2.4: Arduino Mega 2560

Microcontroller	ATmega2560
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limit)	6-20V
Digital I/O Pins	54 (of which 15 provide PWM output)
Analog Input Pins	16
DC Current per I/O Pin	20 mA
DC Current for 3.3V Pin	50 mA

Flash Memory	256 KB of which 8 KB used by bootloader
SRAM	8 KB
EEPROM	4 KB
Clock Speed	16 MHz
Length	101.52 mm
Width	53.3 mm
Weight	37 g

Figure 2.5: Technical Specifications

2.2.2 Servo Motors

Servo refers to an error sensing feedback control which is used to correct the performance of the system. Servo or RC Servo Motors are DC motors equipped with a servo mechanism for precise control of the angular position. The servo motors usually have a rotation limit from 90° to 180°. But the servos do not rotate continually. Their rotation is restricted in between fixed angles.

The RC Servos are used for precision positioning. They are used in robotic arms,legs, sensor scanners and in RC toys like RC helicopter, airplanes and cars. Unlike DC motors, with servo motors you can position the motor shaft at a specific angle using control signals. The motor shaft will hold at the position as long as the control signal is not changed.

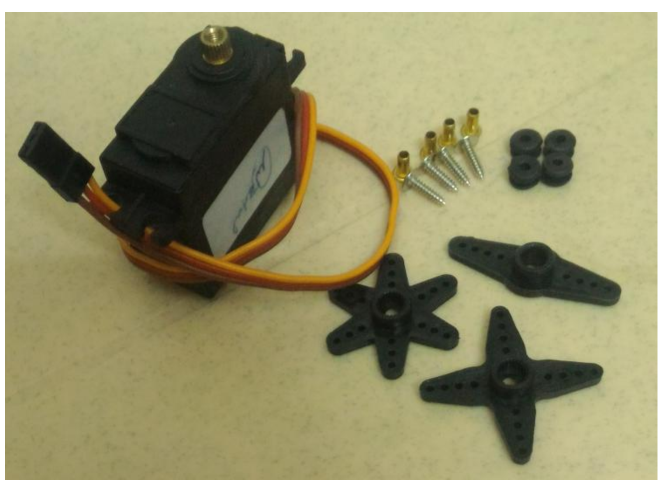

Figure 2.6: Servo Motor

The Servo Motors comes with three wires or leads. Two of the wires are to provide ground and positive supply to the servo DC motor. The third wire is for control signal. These wires of servo motor are color coded. The red wire is DC supply lead and must be connected to a DC voltage supply in the range of 4.8 V to 6V. The black wire is provided to ground. The color for third wire (to provide control signal) varies for different manufacturers. It can be yellow (in case of Hitec), white (in case of Futaba), brown etc.

Unlike DC motors, reversing the ground and positive supply connections do not change the direction (of rotation) of a servo. This may, in fact, damage the RC servo motors. That is why it is very important to properly account for the order of wires in servo motor.

A servo motor mainly consists of DC motor, a gear system, a position sensor which is mostly potentiometer, and control electronics. The DC motor is connected with gear mechanism which provides feedback to position sensor which is mostly potentiometer. From gear box, the output of the motor is delivered via servo spline to servo arm. The potentiometer changes its position corresponding to the current position of motor. So the change in resistance produces an equivalent change in voltage from potentiometer. A PWM signal is fed through the control wire. The pulse width is converted into an equivalent voltage which is compared with that of the signal from the potentiometer in an error amplifier.

The servo motor can be moved into a desired angular position by transmitting PWM signals on the control wire. The servo understands the language of PPM (pulse position modulation). A pulse width varying from 1 millisecond to 2 milliseconds in a repeated time frame is sent to the servo motor for around 50 times in a second. The width of pulse determines the angular position.

For example, pulse of 1 millisecond moves the servo towards 0°, while 2 milliseconds wide pulse would take it 180°. The pulse width between angular positions can be interpolated accordingly. Thus pulse of width 1.5 milliseconds will shift the servo to 90°.

It must be noted that these values are only approximations. The actual behavior of servos differs based on their manufacturer. A sequence of such pulses (50 in one second) is required to be passed to the servo to sustain particular angular position. When servo receives a pulse, it can retain the corresponding angular position for the next 20 milliseconds. So a pulse in every 20 millisecond time frame must be fed to the servo motor.

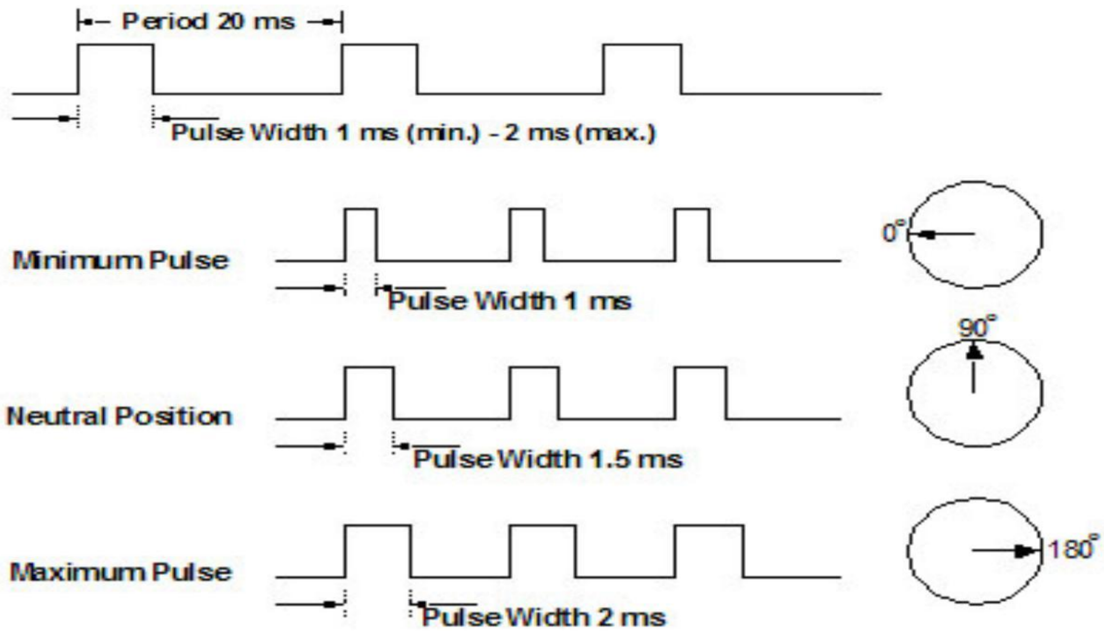

Figure 2.7: Effect of pulse width on direction of servo motor

2.2.3 Bluetooth Module HC-05

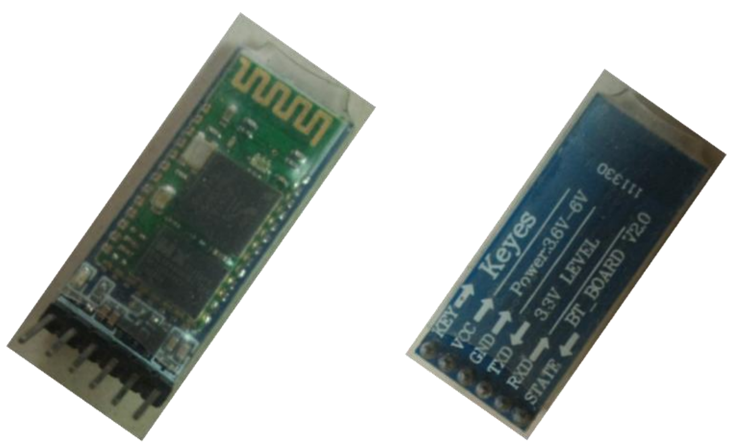

Figure 2.8: BT HC-05

Bluetooth protocol: Bluetooth Specification v2.0+EDR

Frequency: 2.4GHz ISM band

Power supply: +3.3VDC 50mA

Modulation: GFSK (Gaussian Frequency Shift Keying)

Emission power: 4dBm, Class 2

Sensitivity: -84dBm at 0.1% BER

Speed: Asynchronous: 2.1Mbps (Max) / 160 kbps Synchronous: 1Mbps/1Mbps

Security: Authentication and encryption

Profiles: Bluetooth serial port

Power supply: +3.3VDC 50mA

Working temperature: -20 +75 Centigrade

Dimension: 26.9mm x 13mm x 2.2 mm

The serial o/p of the Bluetooth module will be received by Arduino which has been programmed to receive the data serially. The received data from the Bluetooth module is compared with the predefined data by Arduino and if the match is found then the required action will be performed.

Step to connect:

1) Connect the wiring, while the device is not connected, the module board has a white LED flashing.

2) At the PC side, search “Bluetooth device”.

3) Find a name called "HC-05" device.

4) Connect it , the default passcode is "1234".

5) While connection is ok, you can see the LED blinking.

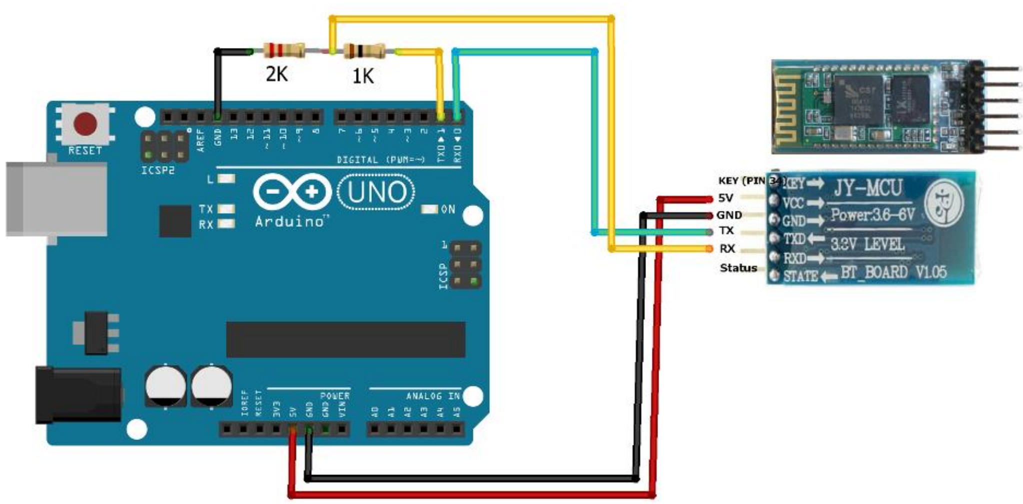

Figure 2.9: Circuit diagram of BT connection

The Bluetooth module HC-05 is a 3.3V system while Arduino Mega is a 5V system. The HC-05 breakout board which we are using here accepts 5V power and converts it to 3.3V to power the HC-05 module but it does not level-shift output from Arduino's pins to 3.3V from the 5V. There is another way to handle the level-shifting. The simplest way is voltage divider made from two resistors but you can use a level shifter such as the CD4050 level shifter IC. We use 2K & 1K resistors as a voltage divider to drop the Arduino's 5V TX pin to 3.3V, which is operating voltage of HC-05 pins.

2.2.4 MPU-6050 Accelerometer + Gyro

The InvenSense MPU-6050 sensor contains MEMS accelerometer and MEMS gyro in a single chip. It is very accurate and precise, as it contains 16-bits analog to digital conversion hardware for each channel. Thus it captures the x, y, and z channel at the same time. The sensor uses I2C-bus to interface with the Arduino.

The MPU-6050 is not very expensive, especially given the fact that it combines both an accelerometer and a gyroscope.

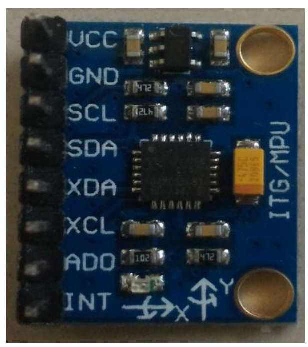

Figure 2.10 : MPU-6050

2.2.5 Ultrasonic sensor HC-SR04

Figure 2.11: HC-SR04

Ultrasonic ranging module HC - SR04 provides a 2cm - 400cm non-contact measurement function, the ranging accuracy can reach up to 3mm. The modules includes ultrasonic transmitters, receiver and a control circuit. The basic principle of work:

1. Using a trigger for at least 10us high level signal
2. The module automatically sends a signal of 40 kHz and detect whether there is a pulse signal returning back.
3. IF the signal is back, through the high level, the time of high output duration is the time from sending ultrasonic to returning.

Test distance = (high level time×velocity of sound (340M/S) / 2

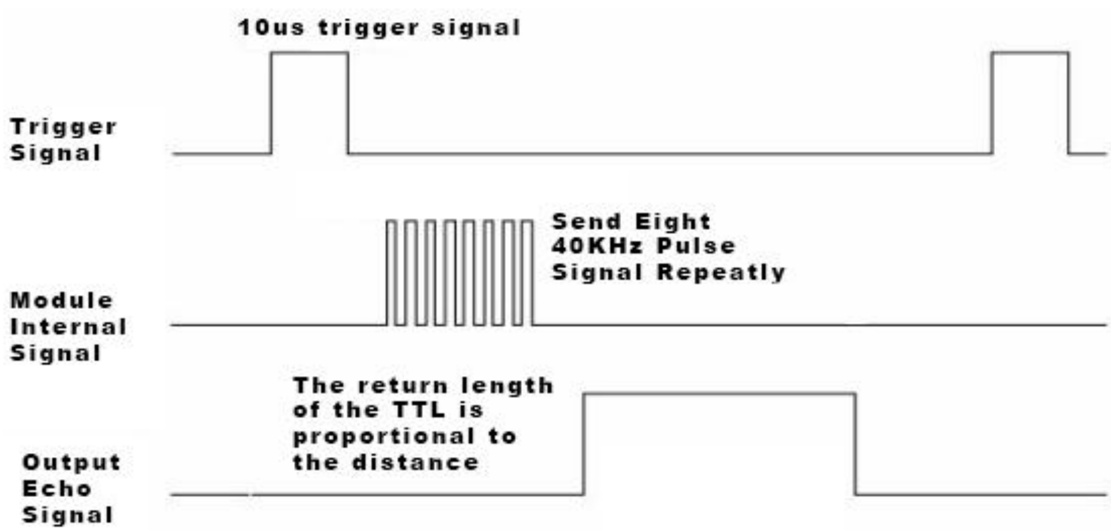

Figure 2.12: Timing diagram of Test signal

Chapter 3

Implementation and Motion study

The electronic circuit of the robot arm is simulated and tested on Proteus simulation software. Considering the results and behavior of the system derived from the simulation of the user button control diagram as shown in Figure 3.1, the actual circuitry is designed and implemented on bread board. Figure shows the implementation of figure on bread board. It should be mentioned that since the shoulder servos operate simultaneously, S2 and S3 are both connected to the pin A4 of the arduino to receive an identical PWM. As seen in Figure 24, 18 servo motor is operated with arduino mega.

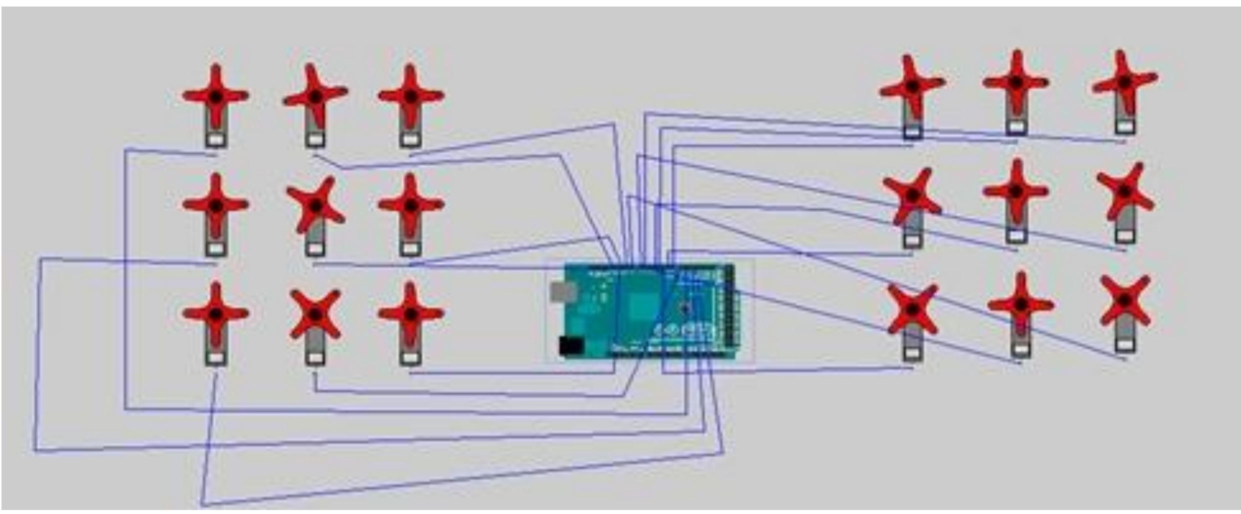

Figure 3.1: Circuit diagram of Humanoid robot

Setup the hardware connections with Arduino and servo motors. The continuous rotation servo motors are the kinds of servo motors that could not be controlled or set at a particular angle unlike normal servos. The Servo motors have three wires coming from them : Red- Power , Black -Ground, White/Yellow- PWM /PPM Signal. The left RC servo motor (white/yellow wire) is hooked up to Arduino digital pin 9 and right RC servo motor (white/yellow wire) to Arduino digital pin 10. The black wires of both motors are connected to Arduino GND and red wires to positive terminal of the battery holder. Connect Rx pin of Bluetooth module to Tx pin (digital pin 1) of Arduino and TX pin of the module to the Rx pin of the Arduino (pin 0). Connect the Vcc and Gnd of the module to the arduino. Connect negative terminal of the battery holder to Arduino GND. The connections will look like this :

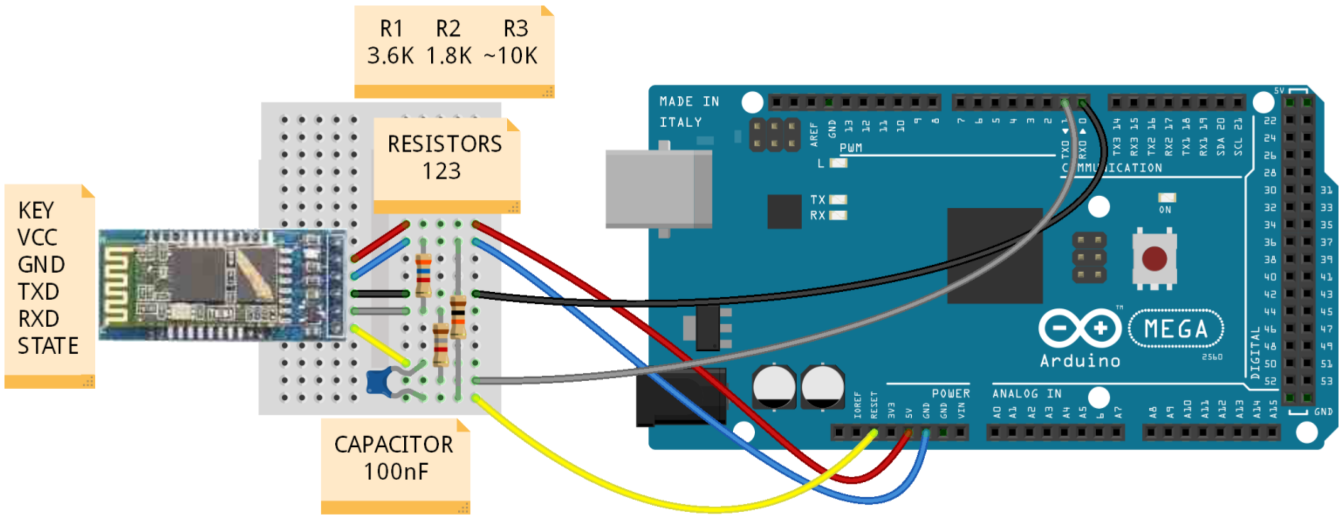

Figure 3.2: Circuit diagram of Humanoid robot (Wireless control)

The android application controlled robot communicates via the Bluetooth to the Bluetooth module present on robot. While pressing each button on application, corresponding commands are sent via the Bluetooth to the robot. The commands sent are in the form of ASCII. The Arduino on the robot then checks command signals received with its previously defined commands and controls servo motors.

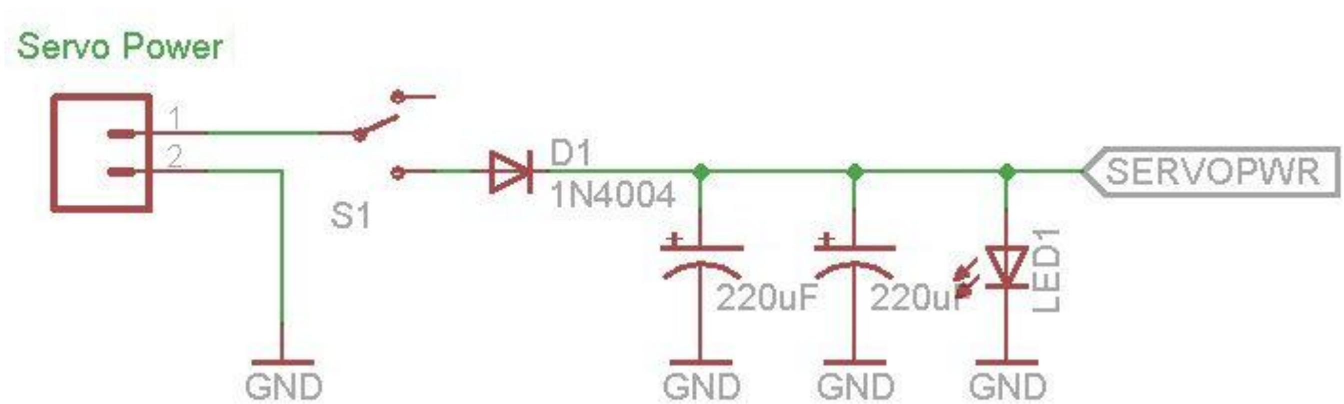

Figure 3.3: Servo power supply

The servo power supply is a simplified circuit. We created it to provide a simple and safe way to power 18 servo motors. The supply consists of couple of capacitors to help the supply extra current during high current demands on battery, a diode to prevent the reverse polarization, convenient switch for the power, and a small LED for simple power indicator.

The obstacle avoiding robotic humanoid uses an ultrasonic sensor for its movements. The Arduino is used to achieve the desired operation. The ultrasonic sensor is attached in front of robot.

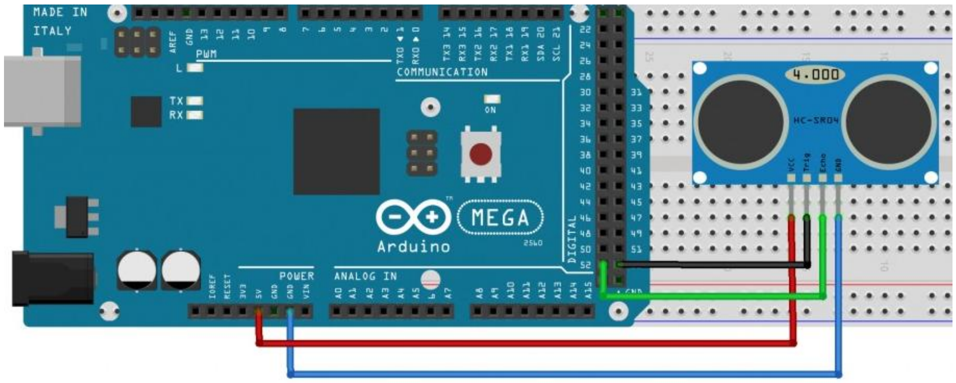

Figure 3.4:Circuit diagram of obstacle avoiding robot.

Whenever the robot is going on a desired path, the ultrasonic sensor transmits ultrasonic waves continuously from its sensor head. Whenever an obstacle comes ahead of it, ultrasonic waves are reflected back from the object and that information is passed on to the Arduino. Arduino controls the motors left, right, back, front, based on the ultrasonic signals.

Self-balancing robot is based on the principle of the inverted pendulum, which is two wheel vehicle balances itself up in the vertical position with reference to ground. It consist both parts: hardware and software implementation. Mechanical model is based on the state space design of the cart, pendulum system. To find the stable inverted position, mechanical design consist of two dc gear motors with encoder, one Arduino microcontroller, an IMU (inertial mass unit) sensor and a motor driver as a basic need. IMU sensor MPU 6050 which consists of an accelerometer and a gyroscope gives the reference acceleration and an angle with respect to ground (vertical), when the encoder which is attached with motor gives the speed of motor. These parameters are taken into consideration as system parameters and determine the external force needed to balance the robot up. If the robot gets tilted by an angle, than in the frame of wheels; the center of mass of robot will experience a pseudo force which will apply a torque opposite to direction of tilt.

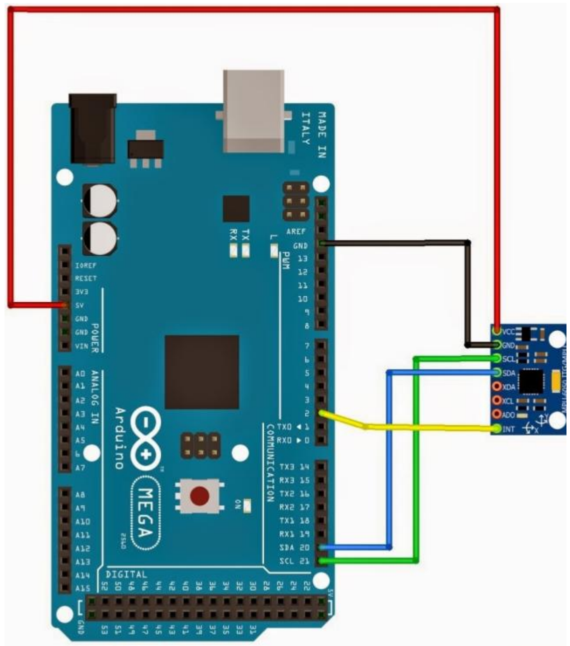

Figure 3.5:Circuit diagram of MPU 6050 connection.

3.1 Walking algorithm

Walking algorithm for biped robots often derived from classical control theory. It uses a reference trajectory for the robot to follow and reference trajectories can rarely be defined to work in the real world. Uses static balance poses to define points of tending to balance during a gait. The point that a biped robot tends to balance is called a state. The walking states are chosen as the maximum and minimum tending to balance stance equilibrium positions where little or no torque needs to be applied to maintain the state.

Walking gait example, 5 states where the robots tends to either balance or tend to topple. The center of gravity tends to shift as shown by the cube on top of the robot.

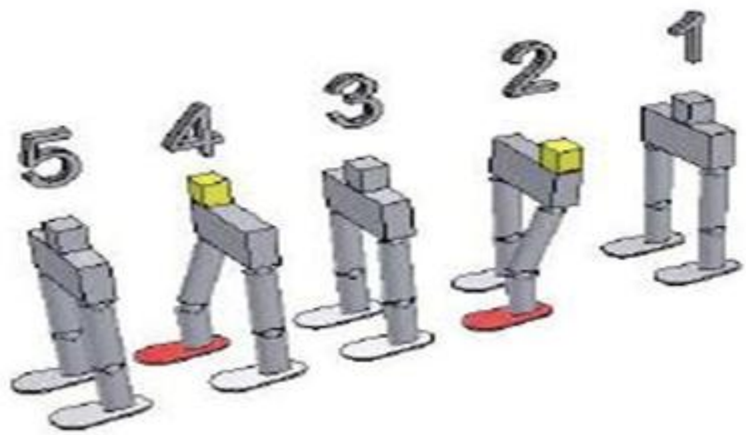

Figure 3.6:Walking gait.

In states 2 and 4, the robot is tending to move to an out of balance point. If the leg which is bent continues in same direction, then the robot will topple. The control algorithm should not counter tending to topple position by bending other knee on the other leg or shifting the original leg back to the initial position. The control algorithm should continue with balance control state, expecting it to prevent a fall, the robot should counter balance by shifting its center of gravity to either the neutral position or to next tending out of balance point on the opposite side.

Chapter 4

Results and Conclusion

This control mechanism provides an easy movement & control of legs and arms but doesn’t facilitate the teaching and learning. Thus, a cheap and easy way of control using popular Arduino mega and Bluetooth devices is implemented. The structure of arm platform as shown in figure 5.1.

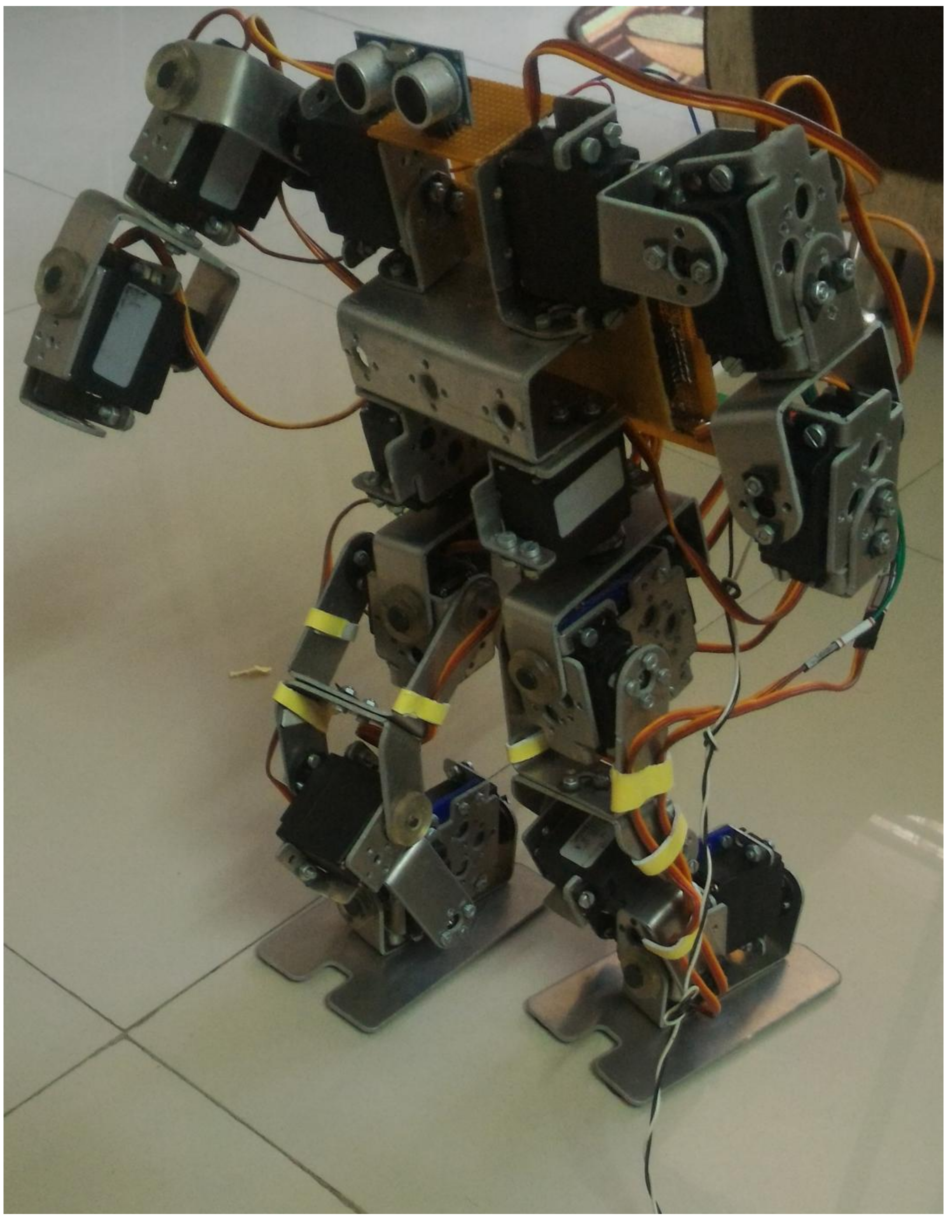

Figure 5.1: Humanoid Robot

Conclusion

- In this thesis, the procedure of building an humanoid robot using a arduino and servo motors with the help of PWM has been discussed.
- The building procedure consists of building the kinematic structure of robot, hardware design and implementation, software design and implementation and microcontroller programming.
- The motion of the robot is controlled via PWM signals which are generated with the arduino and discussed the effect of these pulses on the servo motors using both software simulation and real-time experiment.

Future Work

As the future work of the developed humanoid robot, a voice-controlled robot can be considered where the user can simply control the robot by giving voice commands such as giving directions (up, down, left, right) and actions (grasp, drop, rotate left, and rotate right) and interact with human.

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