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Designing a Microcontroller Based Voice Controlled Humanoid Walking Robot (Biped)

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Abstract: ***This research is on building an efficient humanoid walking robot (biped) using four servo motors. Servo motors are used in every joint of its humanoid legs to move the biped. An Arduino microcontroller is used to command the biped using voice given by user. The shafts of servo motors rotate sequentially in such a way that the biped can walk like a human in actual confidence.***

Keywords: Biped robot, Servo Motor,Biped Structure, Voice controlling, Bluetooth module, Principle of Operation, Weight Lifting

1. Introduction

A biped is a robot whose movement almost resembles with human walking.

While making a biped robot, consumption of excessive power becomes a great issue to make the biped walking exactly like a man [1-3]. It is so desired that, the walking biped should consume less amount of power as it can. When it walks carrying with some load on its back, it is observed, more weight will make the motors to draw more current, hence consume more power [3].

Recently, numbers of works and researches are performed on robotic sector. Among them, Bluetooth controlled robots is popular as they can perform tasks by getting command wirelessly [1]. Several mathematical modeling based works are performed as well to determine the actual walking concept of a biped [2]. Furthermore, many researches are done to understand the balancing of a biped while it is walking [3-9].

This research is on building a humanoid biped which is microcontroller based and can perform assigned tasks using voice command of the user. The research uses four servo motors to make the biped walk.

Servo motor usually rotates by pulse width modulation (PWM) technique [4-6] which will be described sequentially in this paper.

The exclusivity of this research is to building a biped robot, which is voice controlled and has considerable amount of weight lifting capability. It is more economical than traditional robots as it draws less amount of current due to its unique construction.

A Bluetooth module is used which utilizes an android app named "AMR_Voice" to command the biped to walk.

All necessary simulations are performed using Proteus simulation tool.

2. Proposed Biped Walking Concept

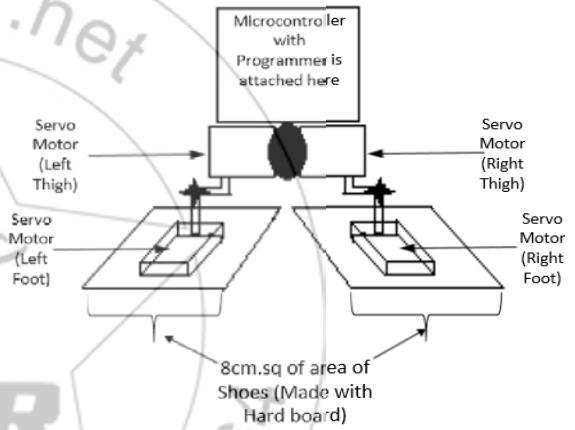

Figure 1: Geometric model of Biped

Figure 1 represents the geometric model of Biped. Total height of the biped from the ground to head is 13cm. the trunk, where load can be placed is 8cm from the ground. An Arduino based microcontroller is used to program all the servo motors after doing all physical setup of the Biped.

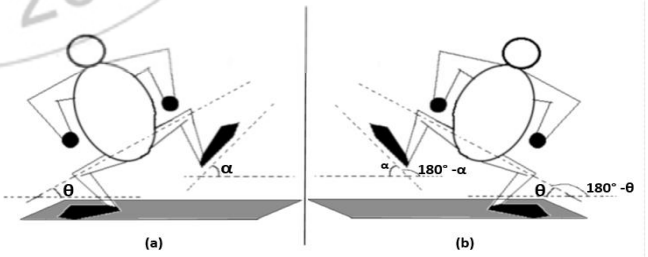

Figure 2: Biped walking Concept

Figure 2 shows a perception of biped walking. Since, the biped is constructed with four servos to decrease power consumption, the shortcoming is, it has to walk swingingly. The foot angle αshould always greater than or equal to knee angle θ, to provide the biped a good balance walk [10-11].

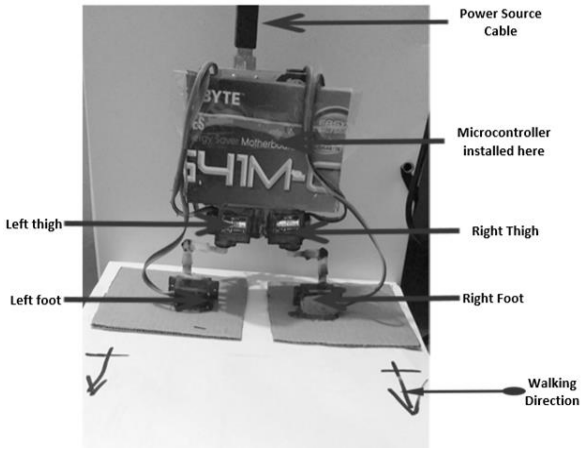

Figure 3: Biped (front view)

Figure 3 shows the practical model of the biped. The biped is Bluetooth voice controlled. It starts to walk according to command of the user. When user commands START, biped starts to walk forward. In this research, four servos (model: MG995) are used which will rotate sequentially to make the biped walk. The biped is constructed with thin, hard card-board. Thus, it has less amount of weight from its self-structure although having a robust build. This is the finest advantage of the biped. A special kind of 8cm squared shoes are used in leg. Therefore, when one side is off the ground, other side can take the total weights of biped and can stand flawlessly with one leg only. Microcontroller IC is put on a thin pcb board and this pcb board including all the connections is attached at the chest of the biped.

Servo coupler plays an important role for the biped to walk. The stronger the coupler, the more confidently biped can move. For each side, two servo motors shafts are paired with each other by strong plastic joint. Each shoe is 100cm.sq in size so that the biped gets a better balance by not falling in any side. Physical model of the biped is such that, it can balance in every situation.

3. Simulation, Measurements, and Hardware Realization

3.1 Simulation

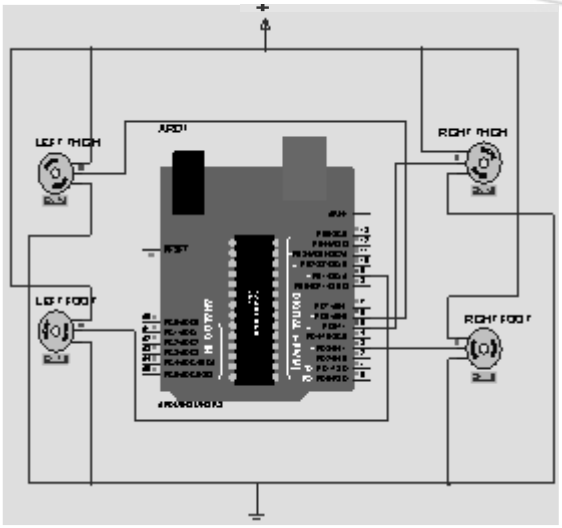

Figure 4: Simulation Circuit in Proteus

The whole connection is simulated in Proteus simulation tool which is given while running the simulation process.

Following Tabulation is given to understand the motors rotating sequence for walking forward.

Table 1: For walking forward

Sequence No.	Left Foot (°)	Right Foot (°)	Left Thigh (°)	Right Thigh (°)
1	90	90	90	90
2	55	90	90	90
3	55	115	90	90
4	120	115	120	90
5	120	115	120	120
6	90	90	120	120
7	65	120	120	120
8	120	60	120	60
9	120	60	60	60
10	90	90	60	60
11	90	90	90	90

From Table 1, It is noted that, 90° positon is the standstill state for all the servos. Every after four steps, all the servos are forced to 90° to be stable in that position.

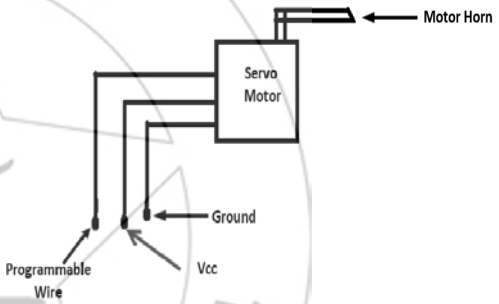

Figure 5: Wire connection of Servo Motor (MG-995)

Figure 5 represents wire connection of MG-995 servo motor. All the programmable wires of servos are connected to the PWM pins of Microcontroller pin 3,5,9,6 respectively for right foot, right thigh, left foot and left thigh.

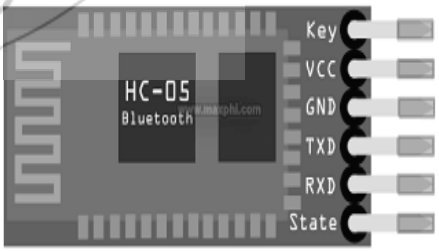

Figure 6: Pinout of HC-05 Bluetooth to UART converter

Figure 6 shows the pin configuration of a six pin HC-05 Bluetooth to UART converter which is used to control the biped using voice command [10]. The RXD pin is connected to the TX pin of Arduino where the TXD pin of the module is connected to the RX pin of Arduino.

After getting command from user, the biped will walk forward.

The necessary code for microcontroller can be burned using Table 1. The code will determine the direction and sequence of movement of the servo motors after getting voice command from the user.

3.2 Hardware Realization

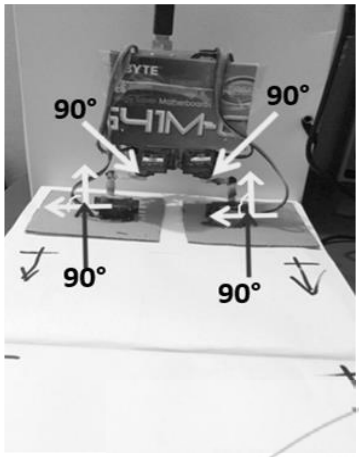

Figure 7: Biped at standstill position

Figure 7 shows standstill position, all motors are positioned at 90° by following sequence-1 (Table 1). After delaying 500ms, left foot gets upward and biped starts to walk to the direction of arrows in the picture.

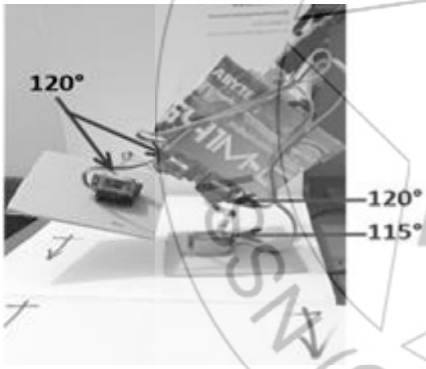

Figure 8 (a): Biped following sequence-5

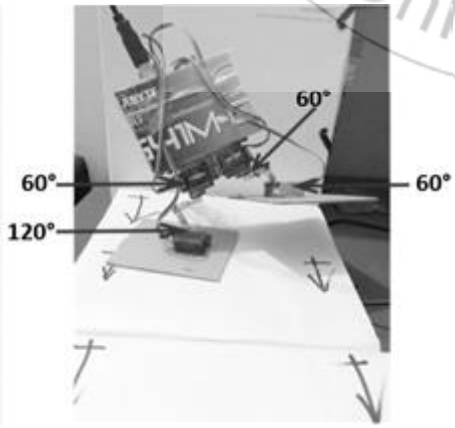

Figure 8(b): Biped following sequence-9

Figure 8(a) shows, when left side goes upward, position of both left foot and thigh are 120° where right foot and thigh are 120° and 115° respectively. When right side goes upward as shown in Fig. 8(b), position of both right foot and thigh are 60° where left foot and thigh are 120° and 60° respectively. Thus, the biped starts to walk in swinging mode.

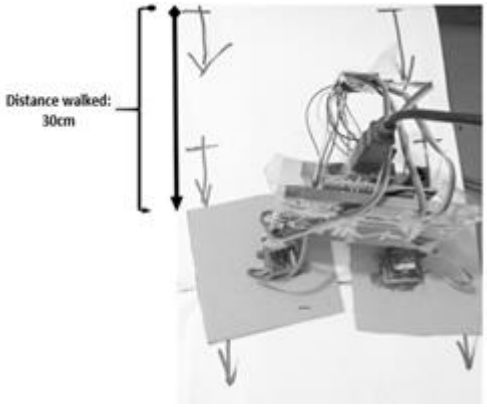

Figure 9: Distance Covered (top view)

Figure 9 shows the distance covered by Biped. For this research, distance walked is measured as 30cm. Walking like this mechanism, a biped can walk confidently.

3.3 Calculation of Maximum Lifting Weight

This research used four servo motors which had initial stall torque of 3.6kg-cm. For a balanced walk, Load torque should be less than 3.6kg-cm.

Weight of each servo itself, m=9g.

Weight of 4servos together: (9g*4) = 36g.

Total height of the biped is observed 13cm from the ground.

The weight of the biped must be calculated without any load carrying on it.

Using a small weight machine, total weight is measured at no load, found as 194g. This 194g is divided by two foots. So, one side is lifting 97gm initially.

When left, side is off the ground as shown in figure 8(a), right foot servo must take all the pressure of the biped including load carrying on its back. So, total 197g is on right foot at zero load.

The biped trunk, where load can be put is 8cm from the ground. So, right foot must move with load 9cm apart from its rotor.

So, Stall torque is changed to,

$$\frac{3.6}{8} = 450g$$

New stall torque, T' = 450g-8cm; which means, if the biped weight becomes around 450g including load carrying on it. The biped will be unable to move.

Considering, Load Torque T_L = 3kg-cm. So, one servo can lift 3kg in distance 1cm from its rotor. It can be calculated as,

$$\frac{3kg}{8} = 375g$$

We have, no load weight, W_{NL}= 197g
Thus, the weight limitation of biped is 375g-197g= 178g. So, around 178g to 188g of weight can be carried by this biped

to walk flawlessly.

4. Discussion and Conclusion

This research primarily focuses on a voice controlled biped capable of walking confidently. It can lift considerable amount of weight with low initial torque.

Its unique shape and materials used make the biped have a low amount of weight at no load. Hence, low amount of power is consumed due to its low initial torque.

Future work includes installing sensors, robotic arms, and automatic remote switch to control the biped wirelessly.

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Author Profile

Abdullah Mahmud is currently completing Bachelor of Science Degree in Electrical and Electronic Engineering at American International University-Bangladesh. He involves his studies in doing numbers of project and thesis based works on robotics, mathematical modeling, programming, and power engineering. His researcharea of interests is focused on power engineering and robotics science.

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