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Design Construction & Performance analysis of a Transforming Biped Robot

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Abstract- This paper emphasize on the design, construction and analysis of transforming biped robot for walking motion and the ability to transform itself into a car. This study is important since humanoid robots have been developed for a long period of time which benefits human in terms of aiding orthosis and prosthesis, understanding human body, creating human assistance and improving entertainment field. The transforming capability makes the robot to go to a place as a car where it cannot go there as a bipedal robot and also saves time.
Keywords: ASIMO, Biped , Arduino, Transforming Mechanism.

1. INTRODUCTION

Bipedalism is standing or moving for example by walking, running, or hopping, on two appendages (typically legs). An animal or machine that usually moves in a bipedal manner is known as a biped meaning "two feet" (Latin bi = two + ped = foot). Biped robots represent a very interesting research subject, with several particularities and scope topics, such as: mechanical design, gait simulation, patterns generation, kinematics, dynamics, equilibrium, stability, and kinds of control, adaptability, biomechanics, cybernetics, and rehabilitation technologies. Making the study of biped robots a very complex subject, mainly conducted usability studies in critical robotic applications such as in the area of Search, Rescue and on teleportation in nuclear environments dealing with run-time interaction with the robots. Our System can be defined as a transforming biped robot that can move forward, left, right, backward and bend to transform itself into a car. This type of biped robot can be used for Surveillance along difficult terrain, Outer space exploration, Land mine detection, Nuclear Power plant, Gas leakage detection in coal mines, can be used in rescue operations, can replace human worker in long term.

2. METHODOLOGY

The total implementation of the robot consists of three parts:
1.Observation of Human Walking Motion.
2.Mechnical Design
3.Block Diagram and Circuit Design
4.Software Development

2.1 Observation of Human Walking Motion

Human walking is accomplished with a strategy called the double pendulum. During forward motion, the leg that leaves the ground swings forward from the hip. This sweep is the first pendulum. Then the leg strikes the ground with the heel and rolls through to the toe in a motion described as an inverted pendulum. The motion of the two legs is coordinated so that one foot or the other is always in contact with the ground. Static walking assumes that the robot is statically stable. This mean that, at any time, if all motion is stopped the robot will stay indefinitely in a stable position. It is necessary that the projection of the center of gravity of the robot on the ground must be contained within the foot support area (Fig. 1).[1]

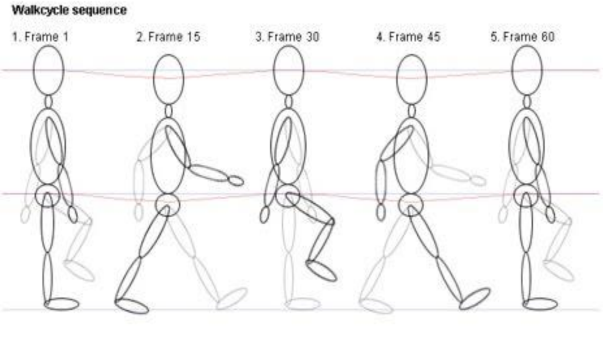

Figure 1: Walking cycle

2.2 Stability

In traditional legged robots, stability is maintained by having at least three contact points with the ground surface at all time. With biped machines, only two points are in contact with the ground surface for that reason algorithms to achieve balance must be implemented. however the mechanics design play a very important role at the robot's stability doing the correct movements. A way to reach it, is finding a correct mass distribution at the robot, thus the robot will be able to achieve the stability at walking. To achieve this, the COM should be placed in a location low enough to stabilize the robot inertially, but high enough so that it can be moved only small amounts to correct for undesired behavior.[2]

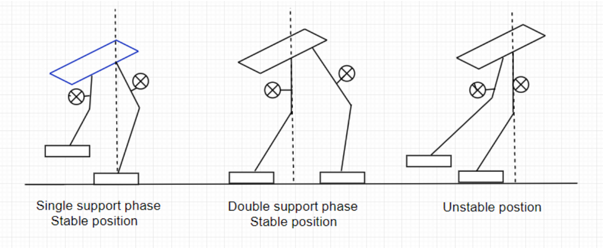

Fig 2: Stability of Robot.

2.3Mechanical Design

The mechanical design process involves the creation of specifications such that the chosen walking model will succeed. This is not a trivial task, many considerations must be consider in order to ensure that the biped robot will be stable while walking. The design chosen is formed by a biped robot configured of two legs, each having 6 degrees of freedom (DOF). Three of these are rotational on the pitch axis at the hip, knee and ankle. Aluminium body is used to design the mechanical structure in order to make the robot lighter. The center of mass of the robot should not shift due to unbalanced loading to ensure stability. The foot pad were also kept moderated size so that the robot can not tip over while walking. [3]

2.4 Leg Joints Implementation

The design of the leg is oriented to the maximum achievable integration between the mechanical structure. It is need to consider three joints such as hip, knee and ankle. Plastic Perspex was used to designed the body as shown in figure1. But the body was not stable because of this. It was working but the expectation was not good. The joints was not working properly. The walking motion was not perfect. After this, the aluminium U shaped bracket were used[1] as shown in figure3.

Fig 3: Initial Leg Design with Perspex Plastic.

Fig 4: Actuator Joint with aluminium bracket .

2.5 Final Robot Design

The servo motors are attached with servo brackets and holders by using nuts and bolts. And in this way both legs are formed. Finally the legs are attached with a upper waist support maintaining a distance between them.Two dc motors are attached in the middle of each leg with aluminium plates and nuts as shown in fig 3.

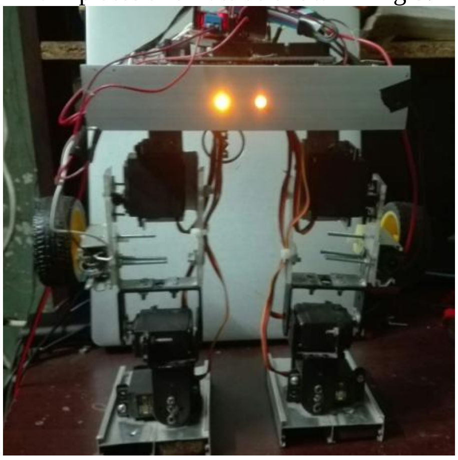

Fig 5: Final design of the Transforming Biped Robot.

2.5 Robot Dimensions

Servo bracket dimensions[2] are shown in fig 4

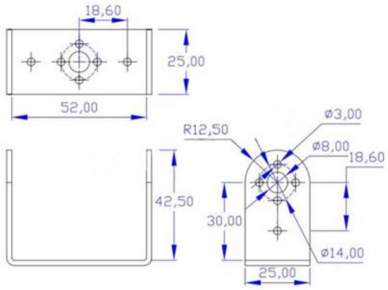

Fig 6: Dimensions of servo bracket.

Robot Height: 4oo cm
Width: 60 cm
Foot Pad Length: 15 cm
Distance between two legs: 20cm
Total Weight of the Robot: 1.85kg
Wheel Dimension: Diameter: 65mm
Width: 28 mm

3. Block Diagram and Circuit Design

3.1 Block Diagram

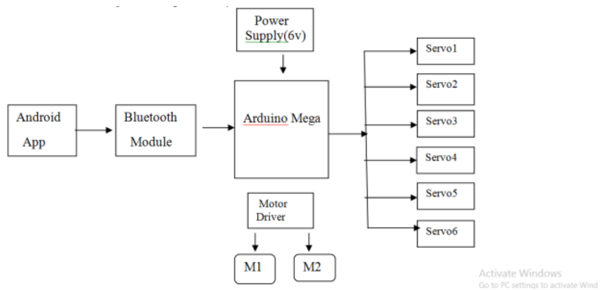

Fig. 7: Block diagram of the system.

3.2 List of Equipment

Here is a short list of Apparatus needed for the robot:

Table 1: List of Equipment

Sl. No	Name of the equipment	Number
1	Servo Motor (MG996 metal gear)	6
2	Bluetooth Module(HC-05)	1
3	Arduino Atmega	1
4	Dc Motor	2
5	Power Supply (6V,5A)	1
6	L298N motor driver	1

3.3 CIRCUIT DIAGRAM

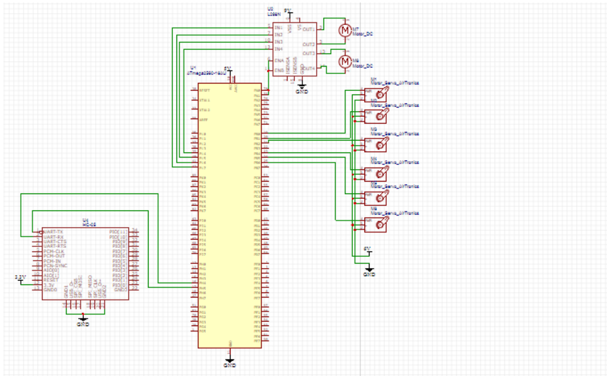

Fig. 8: Circuit Diagram

Fig.6 shows the entire circuit diagram of the transforming biped robot. Six servo motors are conncected to six pwm pin of the arduino microcontroller and are powered by six volt supply. The H-bridge motor driver is used to drive the dc motors when the robot acts as a car. The HC-05 bluetooth module is used to send command signal to the robot.

4. Development of Algorithm

The algorithm of the robot is divided into four modes:

1. **Walking :** In this mode all six joints are driven in a sequence maintaining each joint initial position. The sequence is developed by observing human walking motion as shown in fig7:

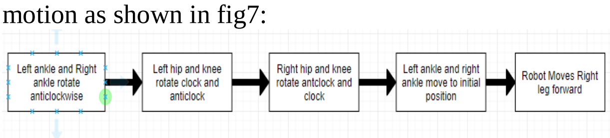

Fig 9: Walking algorithm.

2. **Turn Left :** The selection of the sequence to turn the robot to left is not influenced by the human motion. Because if the human motion was followed then the robot structure would be bulkly and 2 more servo need to be attached at the top of the robot. Figure 8 shows the algorithm that was choosen:

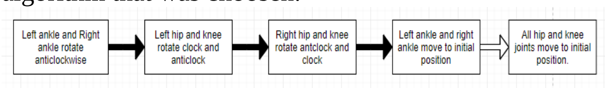

Fig10: Algorithm of turn the robot left.

3**. Turn Right:** It was found that the algorithm for tuning the robot to right is exactly opposite of the turning left algorithm as shown in fig 9:

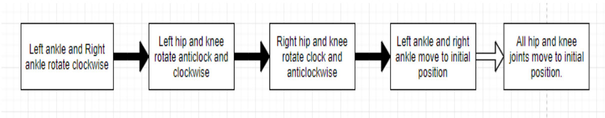

Fig 11: Algorithm of turn the robot right.

4. **Robot to car transformation algorithm:** To transform the robot into a car the knee joints have to rotated anticlockwise so that the dc motors attached on the middle can touch the ground and used as a car as shownfig12:

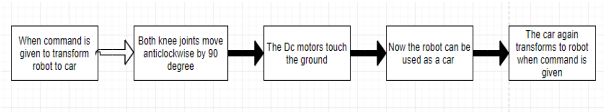

Fig 12: Transforming algorithm of Robot ⟷ Car.

5. RESULT & ANALYSIS

In this section we'll discuss the result of walking of robot.

5.1. Walking Of Robot

Name	Time	Distance/Angle
1st Step	3 s	8.4 cm
2 Steps	6 s	16.1 cm
Left	3 s	60 Degree*
Right	3 s	35 Degree*

Table no:2

The result obtained from transformer biped robot is shown in table 2. After some adjustment when the robot fixed into this angle then the walking motion was good. The robot took 3second for first step and took 6second for second step. The left angle was fixed into 60 degree and the right angle was fixed into 35 degree.

5.2. Bending Mechanism

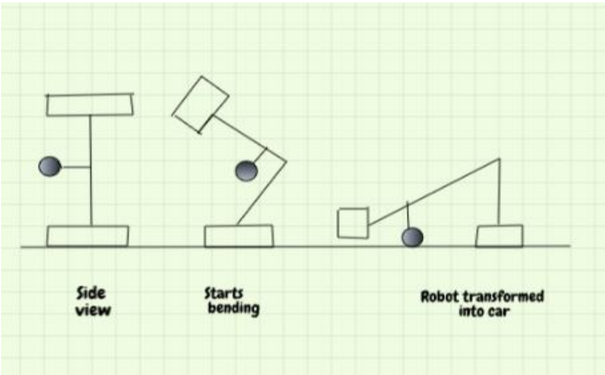

Fig 13:Bending Mechanism of Robot

This fig 13 is shown the bending mechanism of transformer robot where first picture is the side view of the robot and the second one is the starting of bending and the third one is robot transormed into car.

6. CONCLUSION

Owing to the increasing importance of humanoid robot further research is required. Especially in places where human presence can be hazardous for example in rescue missions. The use of humanoid robots for the physically disabled can be of great importance and is yet to be researched upon. Handling robot through remote control adds on to its applications in dangerous and remote locations. In this work, we focused on analysing and improving the movement of such a machine. The walking pattern was motivated from the movement of an inverted pendulum. The idea was realized by the use of Atmega 328 microcontroller and commonly available hardware for actuators, making this work highly viable in real life scenarios. The results demonstrated that our robot could perform walking action in a highly stable manner. We believe that further improvements can be done with the actions by adding voice recognition and artificial intelligence. In the future, we would be working to improve the pattern by feedback correction from sensors.

6. Acknowledgements

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7. REFERENCES

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