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DESIGN AND DEVELOPMENT OF WALKING BIPEDAL ROBOT WITH THE HELP OF ARDUINO CONTROLLER

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ABSTRACT

A biped is a two legged walking robot which imitates human gait. It is used in places where wheels cannot go easily for example stairs, terrains, etc. It is easier for bipedal robots to exist in a human oriented environment than for other types of robots. With advances in science and technology, the interest to study the human walking has developed the demand for building the Bipedal robots. In this paper we describe the design, fabrication and analysis of Bipedal walking robot. The main objective of the project is to study about the theories and the practical challenges involved in making the bipedal ant to design the walking pattern for this. The Bipedal walking robot is designed with minimum number of actuators (servomotor) and it is controlled by the arduino based easily operated micro controller. The robot is designed by aluminum strip and simple servomotor. It walks like a human by balancing the centre of mass.

KEYWORDS: Bipedal robot, Arduino, gait and actuators.

INTRODUCTION

This paper describes the design, fabrication and analysis of Bipedal walking robot. The main objective of the project is to study about the theories and the practical challenges involved in making it. The Bipedal walking robot is designed with minimal number of actuators (RC Servomotor). Two french laboratories, LMS and INRIA Rhône- Alpes, have designed and constructed an anthropomorphic biped robot, Bip. The goals and initial results of the project are reported in [1] and [2] and the implementation of the postural motions and static walks achieved until now are described in [3]. When we look at terrestrial animals, we notice that most of them move around using legs - be it two, four or more legs. If we compare legged animals and non-legged ones, we often find that the legged ones are typically more agile than their non-legged counterparts - they can traverse more types of terrains. This fact has inspired many researchers to look into building legged systems as an alternative to the wheeled systems that currently dominate mobile robotics and even land transportation systems. Besides, the legged robots will be able to work in human environments better than wheeled robots can [4]. Currently, many institutions around the world are conducting research on legged systems [5, 6, 7, 8, 9, 10]. The common legged systems being researched are the two legged (biped), four legged (quadruped) and six legged (hexapod) ones. Arguably, between these, bipedal walking is the most interesting and most difficult to achieve. Though there are many researches on bipedal walking, sadly, only a handful had succeeded in producing a stable dynamic walk. This only underscores the difficulty in developing a bipedal walking system. The development of a bipedal walking system actually consist of a variety of research areas -robotics, mechanics, electronics, control and biomechanics all contribute to various aspects of this research. System integration is therefore very crucial to the successful development of a bipedal robot. Attempts at building walking machines can be traced back at least to the 1960s. In addition to research concerning bipedal robots, efforts were also made to develop monopedal (Raibert, 1986) and quadrupedal robots (Furusho et al. 1995). One of the first functioning bipedal robots was developed in the 1970s by Kato (Kato and Tsuiki, 1972). Today, there are many bipedal robot projects in the world, and the number of active projects is growing rapidly. Here, we will briefly review some of the work in bipedal robotics to date. We will mainly focus on motor skills for walking robots. [11]

METHODOLOGY

In this methodology the following steps have been performed. In this synthesis of dimensions was done followed by selection of material, actuator and modeling in design software. Analysis of bipedal robot is done with the help of Arduino.

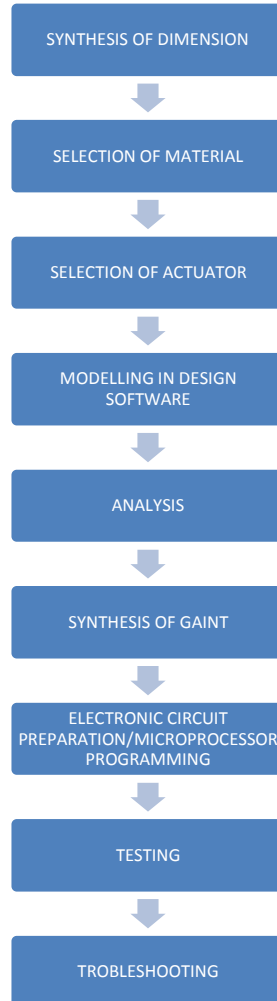


Figure 2.1

DESIGN

The design process involves the creation of a specification for the building of a robot upon which the chosen model of dynamic walking will be implemented. The aim is to derive the specifications such that the chosen walking model will succeed. This is not a trivial task—there are many considerations to take account of in order to ensure that the biped robot will be stable while walking. The most important of these are balance, forces, moments, torque, proportions, mass and strength.

The Mechanical design forms the basis for developing this type of walking robots.

- A. Determining the Mechanical constraints.
- B. Conceptual Design
- C. Building the Prototype model
- D. Specification and Fabrication of the model

Determining the Mechanical Constraints

There are various design considerations when designing a Bipedal robot. Among them, the major factors that have to be considered are:-

- **Robot Size Selection:**

Robot size plays a major role. Based on this the cost of the model, materials required for fabrication and the no of actuators required can be determined. In this project miniature size of the robot is preferred so a height of 246mm is decided which includes mounting of the control circuits, but the actual size of the robot is 170mm without controlling circuits.

- **Degrees of Freedom (D.O.F):**

Human leg has got Six Degrees of freedom (Hip – 3 D.O.F, Knee – 1 D.O.F, Ankle – 2 D.O.F), but implementing all the Six D.O.F is difficult due to increase in cost of the project and controlling of the actuators which become complex, so in this project reduced degrees of freedom is aimed so 3 D.O.F per leg has been finalized (Hip – 1 D.O.F, Knee – 1 D.O.F, Ankle – 1 D.O.F).

- **Link Design:**

In this project we design the link by using a low cost and lightweight aluminum material called aluminum strip which is joining the servos to the leg parts wherever needed. Aluminum strip is used of various lengths according to the various lengths of the different parts of the leg and it also join the servo motors to the different joints.

- **Stability:**

With Biped mechanism, only two points will be in contact with the ground surface. In order to achieve effective balance, actuator will be made to rotate in sequence and the robot structure will try to balance. If the balancing is not proper, in order to maintain the Centre of Mass, dead weight would be placed in inverted pendulum configuration with 1 D.O.F. This dead weight will be shifted from one side to the other according to the balance requirement. But in this project no such configuration is used.

- **Foot Pad Design:**

The stability of the robot is determined by the foot pad. Generally there is a concept that oversized and heavy foot pad will have more stability due to more contact area. But there is a disadvantage in using the oversized and heavy foot pad, because more material will be required leading to increased costs and no significant contribution to the stability of the system. This will also force the servo motors to apply more torque for lifting the various leg parts. By considering this disadvantage an optimal sized foot pad was used. Dimensions of the foot pad are 90X80mm.

Conceptual Design

Initially the Bipedal robot was conceived with ten degrees of freedom. Due to constraints faced in controlling greater number degrees of freedom we, a new design was arrived with the knowledge gathered from developing previous Bipedal models. The new design has got Six degrees of freedom with three degrees of freedom per leg. Optimal distance was maintained between the legs to ensure that legs don't hit each other while walking.

The 3D models are developed using AutoCAD.

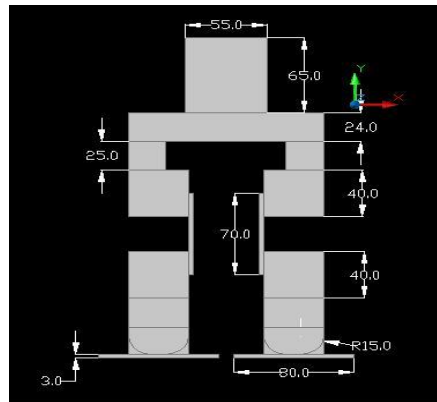


Figure 3.1

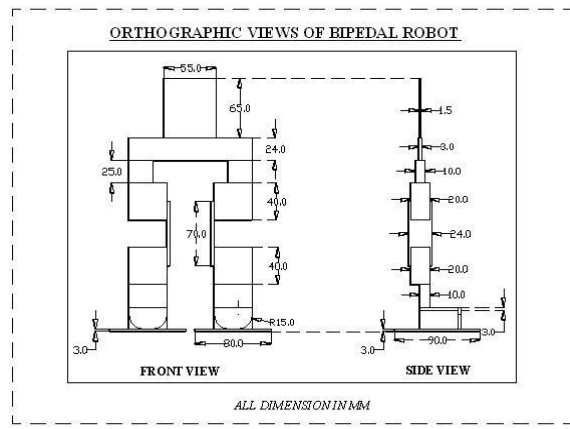


Figure 3.2

Proto type

Firstly we make a prototype modal which is made by only aluminum strip after that we made a single leg and done programming to walk it.

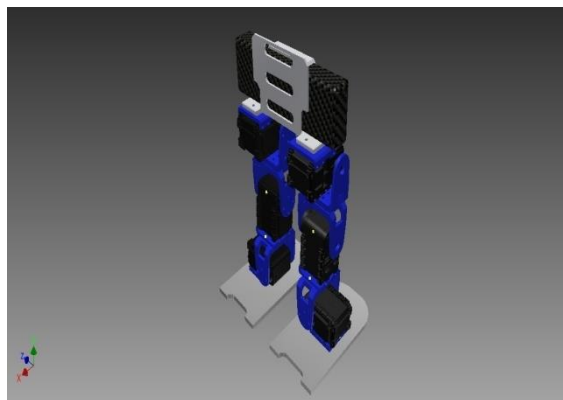


Figure 3.3

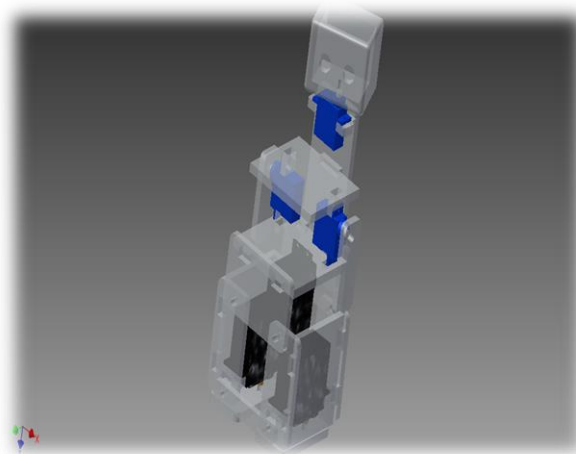


Figure 3.4

Specification and Fabrication of the model

Degrees of Freedom – 3 D.O.F/Leg so total of 6 D.O.F (Hip, Knee and Ankle)

Table 3.1

S.No.	Name of Component	Length (mm)	Width (mm)	Height (mm)
1	Length of Bipedal model	170	24	275
2	Leg length	40	43	207
3	Foot pad	80	90	3
4	Servo joint upper	40	24	40
5	Servo Clamps lower	40	3	23

Table 3.2

S.No.	Name of Component	Weight
1	Estimated servo clamp weight	60gms
2	Servo motor weight	55gms
3	Total estimated weight for a link (servomotor + servomotor bracket)	120gms
4	For 6 links (i.e. 2Legs)	720gms approx
5	Foot pad weight (2 legs)	60gms.
6	Circuits & Batteries	350gms approx

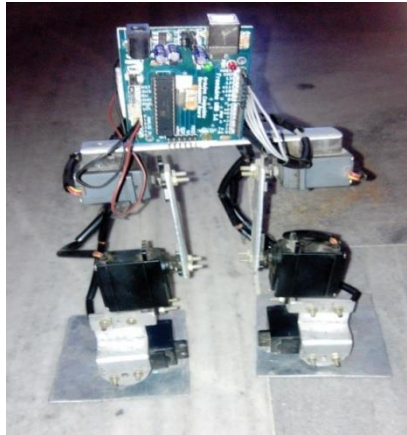


Figure 3.5



Figure 3.6

RESULT

The most important part of research and experimentation is obtaining and analyzing results to verify previous explanations and theories. During the course of this research, several experiments were completed and the results were collected. In which we move it with load and without load condition.

WALKING WITH LOAD AND WITHOUT LOAD

We saw during the load position the bipedal is moving proper but it required more power and many times when load is more it was unbalanced. We put load in box which is attached beside the robot and operate it the result is below in table.

Table 3.3

S. No.	Load / Weight (gm.)	Result
01	10	Walk smoothly
02	20	Walk smoothly
03	50	Walk but slow
04	200	Walk but unbalance
05	250	Fully unbalanced

While we run it freely without load, it run smoothly and required low power.

CONCLUSION

It is not trivial to implement dynamic walking in bipedal robot, however in this dissertation the relevant issues for designing and constructing such a machine have been discussed, and the possibilities for implementing a control system to coordinate the dynamic gait have been examined.

A useful tool for the development of gaits for our bipedal robots has been developed. A more complex control system may be required in order to stabilize the robot sufficiently. This may require an adaptive control system, such as artificial neural networks (ANN), genetic algorithms (GA) or fuzzy logic. However, it is more likely that the method of gait generation will also need improvement, in order to generate the most stable gait before control is implemented, minimizing the control problem.

The importance of gait generation has been established, as well as the significance of control system to stabilize the robot while in motion. Both must be present for dynamic bipedal walking to succeed, and both require more research. Research in this field is important for developing robots which can operate in normal human environments, and can adapt to disturbances and variations in the environment, enabling them to traverse over uneven terrain. In the future, with the convergence of many widely differing fields of research, this is becoming a reality.

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