DESIGN, FABRICATION AND ANALYSIS OF BIPEDAL WALKING ROBOT

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Abstract: This paper describes the design, fabrication and analysis of a bipedal robot and development of a strategy of balance control of bipedal robot during its walk. By using cascading logic algorithm and control signal by the microcontroller for the servomotors placed in the links. Instead of taking 6 degree of freedom for each leg of the robot will have 3 degree of freedom (hip-1 D.O.F, knee-1D.O.F, and ankle-1D.O.F) to overcome the cost of the project and complexity of controlling of the actuators? With these six degrees of freedom (both legs) the robot is capable of walking. To describe this link orientation and angular displacements are defined using kinematic parameters mathematical calculations. Then the walking of the robot will be achieved by balancing center of mass, which calculated form the design of robot. The basic challenges involved in making bipedal robot will be studied and its uses are explained.

Keywords: - degrees of freedom (DOF), cascading, Centre of mass, microcontroller.

I. INTRODUCTION

A bipedal robot can be generally described as the types of autonomous system this can imitate human walking motion with maintaining postural stability during the motion. To obtain human-like robotic walking has been a long standing, if not always explicitly stated, goal of robotic locomotion. Achieving this goal promises to result in robots able to navigate the myriad of terrains that humans can handle with ease for example, important applications to space exploration, walking up on a stair etc. Moreover, if one can understand how to make robots walk like humans, this understanding can be used to build robotic assistive and prosthetic devices to aid people with walking impairments and lower extremity amputations walk more efficiently and naturally. The main idea behind this paper is to explain the practical challenges takes place in making bipedal walking robot. Design of bipedal robot involves both mechanical and electronics considerations equally. The robot has six degrees of freedom, with three degrees of freedom per leg. Each leg has Hip, Knee and Ankle. The hip and knee Joints are actuated in vertical plane (Pitch) and the ankle joints are actuated in horizontal plane (Roll). With advances in science and technology, the interest to study the human walking has developed the demand for building the Bipedal robots. This robot is capable in demonstrating the human walking by its complicated link design controlled with microcontroller. This can be helpful in heterogeneous areas were human cannot enter as autonomous robot.

II. WORK FLOW OF PROJECT

As per the reference undergone the following will give the basic steps in designing the bipedal walking robot.

III. EXPERIMENTAL SETUP

Design, analyzing and making of bipedal walking robot will be carried out through following steps. The model diagram and devices of bipedal robot are explained below.

a) Conceptual designing
b) Mathematical analysis
c) Components using in bipedal robot

3.1 Conceptual Designing

Design of link for bipedal robot is main task because servomotor to be include in every link. In this link will in rectangular shape which contain upper bracket and lower bracket. Servomotor will be arranged in upper bracket. Link design will be as following diagrams drawn in solid works software.
Two brackets are connected each other in order to create a link of the bipedal walking robot. Servomotor will be fixed in the upper bracket and the lower bracket is used to transmit the output of the servomotor. Lower bracket and servomotor are coupled using servomotor horn. By using the brackets there is a greater flexibility and individual joint can be actuated without disturbing the other joints. The Servomotor brackets are designed in accordance with the motor size as shown in the following figure.

And the centroid will be \((X_t,Y_t,Z_t)\) which is defined from the product of centroid in respective axis and area of total elements in the model. The values of the COM and areas of the links will be in the above table accordingly. Hence the centroid of the total model is \((X_t,Y_t,Z_t)\)

3.2 Mathematical Analysys

For achieving walking mechanism of bipedal robot balancing is important. Centre of mass of the model will be employed to gain stability of the bipedal robot. Hence Centre of mass is mathematically calculated from the following model diagram.

3.3. Components in Bipedal Robot

After all mechanical designing of robot is done (i.e., link design, mathematical calibrations) signal must be send to servomotors which are placed in servo brackets. This signal will be send by microcontroller through high level languages. When command signal reached to servo motor it activate and particular motion will be obtained. Following experimental setup will show the components present in bipedal robot.
1. Microcontroller
Both motors and sensors are present in robot, which are controlled by microcontroller. In this project robot will have six DOF, each DOF has one servomotor. They are controlled by any low cost microcontroller having the following features. At least eight actuators has to be controlled by controlling board, it should have receiving unit to control the sensor inputs. It should have a capacity of working in a closed loop by the help of sensor input. 16K bytes of in-system programmable flash program memory with read while write capabilities, 512 bytes EPROM, 1K byte SRAM, 32 general purpose I/O lines, 32 general purpose working registers, an interface for boundary scan, on chip debugging support and programming, three flexible timer/counters with compare modes, internal and external interrupts.

### Specification Table for servomotor

<table>
<thead>
<tr>
<th>S.NO</th>
<th>SPECIFICATIONS</th>
<th>RANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Control System</td>
<td>+Pulse Width Control 1500usec Neutral</td>
</tr>
<tr>
<td>2</td>
<td>Operating Voltage</td>
<td>4.8-6.0 Volts</td>
</tr>
<tr>
<td>3</td>
<td>Operating Speed</td>
<td>(4.8V):0.19sec/60° at no load</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(6.0V):0.15sec/60° at no load</td>
</tr>
<tr>
<td>4</td>
<td>Stall Torque</td>
<td>(4.8V):4.2 oz/in (3.0 kg/cm)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(6.0V):4.9 oz/in</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(4.5 kg/cm)</td>
</tr>
<tr>
<td>5</td>
<td>Motor Type</td>
<td>Cored Metal Brush Potentiometer Drive: 4 Slider/Direct drive.</td>
</tr>
<tr>
<td>6</td>
<td>Weight</td>
<td>1.52oz (43g)</td>
</tr>
</tbody>
</table>

IV. CONNECTORS

In this project rotational joints are used, which can connect the links and free movement of the links are provided. So threaded bolts and nuts will be employed to assemble the robot. There is a possibility of implanting the cam mechanism in joint leads to the free motion of the robot links achieved. Through this the complexity in walking of the bipedal robot can be reduced. So, when the walking complexity is reduced there is a great possibility in increasing the robot accuracy in work and time will be saved. While coming into electronic part input and output cables are needed to connect the servomotor and microcontroller. There is a possibility of implementing Bluetooth signaling system to make the robot wireless.

V. ALGORITHM

In this project algorithm using is related to cascading algorithm nothing but activating the second cylinder in the off–time period of first cylinder. Similar to that in this also six servomotors are activated one after other in off–time period of previous motor. There is no particular algorithm for this, there is a possibility of simulating the robot by using fuzzy logic control, ADMS software and c-language coding also.

![Basic working diagram of servomotor](image)

ON OFF

Motor 1

Motor 2

Motor 3

Motor 4

Motor 5

Motor 6

Fig. work flow of servomotors using Algorithm
CONCLUSION

Through this project steps to design, fabrication and analysis of bipedal walking robot can be observed. Simple walking mechanism of robot will be achieved through servomotors placed in servo brackets, which are controlled by microcontroller. While walking of robot small vibrations are occurs to avoid this degree of freedom have to increase. If degree of freedom is more there will be increase in cost of manufacturing. So in order to minimal the cost of the project six degrees of freedom is considered. This robot having the capability to enter into the places were human cannot enter and works as autonomous robot. From this project coding and control of microcontroller can be learned.

SCOPE OF PROJECT

There is a scope of implementing the robot vision system to observe the object and obstacles. By making the robot wireless it will work as an autonomous robot in heterogeneous areas. On implementing the robot in ANSYS software failures of the bipedal robot is observed when particular loads are applied on the robot.

REFERENCES


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