

The Hexapod Walking Robot

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Abstract

Now a- days, robots are made for just walking on flat surface and are unable to walk on sand, hills & rough surfaces but this type of problem can be solved by using new technology of robots called Hexapods. A hexapod is capable of fulfilling all these needs & also has high accuracy in its motion because of the use of servo motors rather than DC motors. A hexapod has multiple legs which makes it an ideal choice not only for climbing purpose but also as dancing robot. This paper proposes the concept of mechanical/structural design for a hexapod walking robot. The hexapod walking robot design is inspired by the insects around us. The main feature of the insects is their stability and their style of movement. Taking these factors into consideration, a novel design is proposed in the form of "Hexapod" that walks on 6 legs & move in at least 3 directions. The hexapod prototype can thus be utilized in applications such as defence sector as a spy bot, for health monitoring of patients in remote areas, etc.

Keywords: Hexapod, Servomotor, Servo Driver, Development Board, Hip Legs, Torso Motors

Introduction

The engineers of today always strive to build new gadgets that can address the different problems faced by humans in their day to day life. Keeping this perspective in mind, the need of advanced robots, capable of reaching places that humans cannot, has emerged. The bio-mimetic [3] bots serve the same purpose. Insects are often used for inspiration while designing walking robots because of their ability to easily navigate through all type of surfaces. The insects have a symmetric structure, low weight, small size and most important: their joint legs which are at least 6 in number. Due to such a body structure, they are able not only to move freely around but also survive in the changing environment conditions [1] There are many types of robots like industrial, agricultural, tele-robots, service robots, mobile robots, Hexapods etc. The Hexapod robots, have the ability to move in an environment unlike stationary industrial robots. And they can be classified by their travel environment; Water, air, ground, ice or space according to the application and control by the device they use to move; Legs, wheels or tracks. Thus, through an extensive and exhaustive research keeping all these characteristics of the insects at hand, it then became possible to come up with the Hexapod Walking robot. The hexapod which is an insect inspired design, is highly stable in its movements because its body is supported by 6 legs with as many as up to 12 servomotors fitted in the joints and

the interconnects between the main body & legs. The robot thus designed showcases more flexible movements on all kinds of surfaces & does not require any other additional balance mechanism. It however requires a positive feedback to ensure more precise movements. This type of robot finds applications in real life, such as search and rescue applications, environment exploration, and also as a CNC machine. [4] "A major goal in this field is in developing capabilities for robots to autonomously decide how, when and where to move."

Methodology

Mechanical Design

The hexapod robot presented in this paper has been developed bearing in mind several abilities such as, moving on irregular paths, climbing and going down stairs and keeping a low overall weight. It is also used to overcome obstacles without compromising with its stability. [2] After several iterations, a geometric model was achieved, as it is shown in the figure1.



Fig.1 Mechanical Structure of Hexapod

The body of the hexapod is rigid. The structure has six legs which are exactly similar in dimension and are equi-spaced around the main body of the bot. Each leg is attached to the main body by means of 2 revolute joints. The Auto-Cad software is used for mechanical design.

Design of Body Framework

The body has been designed using AutoCAD and then shifted to Corel draw through pdf for fabrication. For flexible movements, a very light material like acrylic is used to decrease the load on the motors. The length, width and height of body chassis is 25cm, 20cm and 8cm respectively.



Fig.2 Body Chassis of Hexapod

Design of Leg

The main leg design has been inspired by spider's legs. The legs were designed per size of motor. The length, width and height of leg is 7cm, 5mm and 15cm respectively.

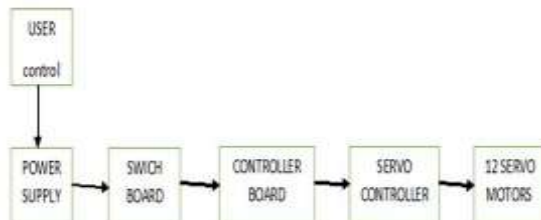


Fig.3 Leg of Hexapod

Design of Attachment between Leg and Body Chassis

The attachment has been designed using AutoCAD and then shifted to Corel draw through pdf for fabrication. The length, width and height of Attachment between leg and body chassis is 10cm, 2cm and 5mm

Block Diagram



Power supply: - 5V power supply is used for ATMEGA-16 controller board to turn on. Also, a power supply of about 6V with drop of 0.7V gives the supply to servo motors

Controller Board: - As soon as the power supply is given to the controller board, it gets reset to 90 degrees. This indicates standing position of the Hexapod. Controller board is connected to the servo controller which decides the movement of servomotors.

Servo controller: -servo controller is used for the controlling the all motors at the same time

Switch board:

- The switch board is connected to the controller board through serial communication standards. This in turn commands the servo controller so that the bot walks or moves. There are 4 switches on the switch board for forward, backward, left, right movement of the hexapod. A tripod gait technique is being used to decide the walking style of the Hexapod. According to this

technique, an algorithm for 12 servomotors is constructed and programmed in controller board IC.

Servo Principle

Servo motors are used in hexapod for better performance and accuracy. For implementation of 12 servo motors in hardware we need to design in such that the power supply given to the motor should provide a sufficient current to each motor (i.e. minimum 1 Ampere).

When power supply is provided to the circuit i.e. actually PWM pulse is given to each motor. After the power supply given to the motors (each motor) it takes about 0.5msec to set the motors at 0 degree. After 0.5msec it takes 1msec to reset at 90 degree. And again for 180-degree rotation it takes 1msec. i.e. total time taken by the motor for one complete pulse is about 2msec i.e. from 0-180-degree rotation.

For one complete cycle, it takes about 18msec. After 2.5msec to 18msec i.e. about 15.5msec, the bot is at stable position. After 18msec again the cycle is repeated. For each 1 degree rotation, it takes about 11.11usec. The rotation can be performed using TIMERS which are controlled by interrupts.

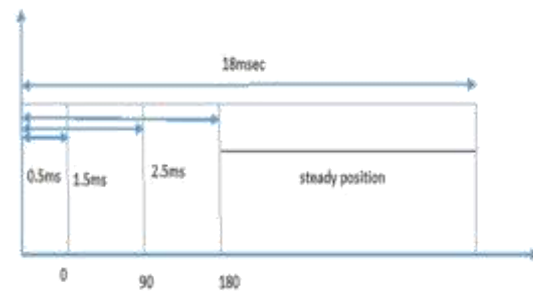
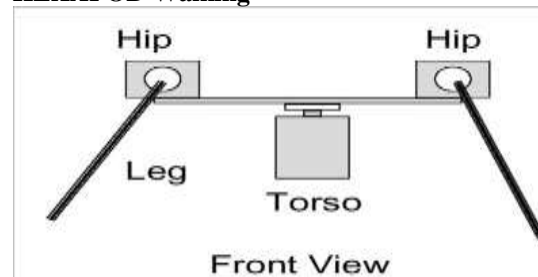


Fig.4. PWM Pulse

The hexapod robot has six legs which are used for better precision in stabilisation. For the movements of each leg, 2 servo motors as per the joints are used.

For the fabrication of legs, PVC or any other mechanical material can be used. Synchronization process can be done by programming.

HEXAPOD Walking



The front view shows that there are two main types of motors in the hips and the torso. The servo motors in the hips of the robot are supported by the servo motors in the torso. The servo motors in the hips help in lifting & dropping of legs while the servo motors in the torso help in the sideways movement of the bot.

Algorithm Used

Forward walking algorithm: -

The servomotor numbers 1, 5, 9, 4, 8 and 12 are known as hip legs because they are attached to legs. The remaining motors are attached to the body hence they are called as torso motors. An alternating tripod gait technology for walking of Hexapod was used.

Step1: -

Hip legs 4, 5 & 12 are down while hip legs 1, 8 & 9 are up

Step2:-

Rotate torso servos 2 & 10 in counter clockwise direction while rotate torso servo 7 in clockwise direction.

Step3:-

Hip legs 1, 8 & 9 are down while hip legs 4, 5 & 12 are up.

Step 4:-

Rotate torso servos 3 & 11 in clockwise direction while rotate torso servo 6 in counter clockwise direction.

After repeating the above steps, forward motion of the hexapod in the direction shown in figure e is obtained. This method is called alternating tripod gait method

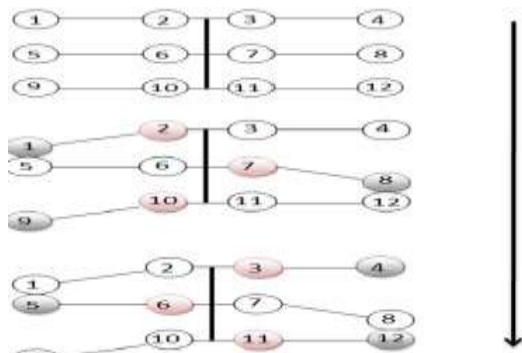


Fig. 5: Arrangement of Servomotors in Hexapod for Forward Motion

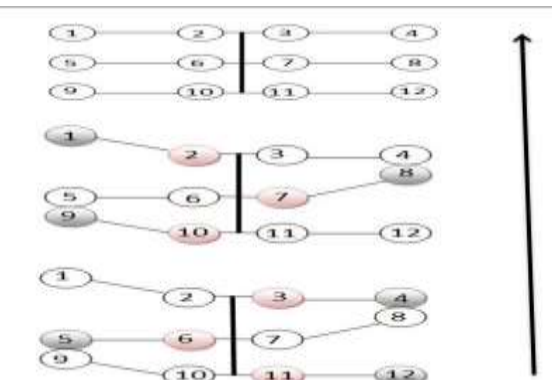


Fig. 6: Arrangement of Servomotors in Hexapod for Backward Movement

Step1:-

Hip legs 4, 5 & 12 are down while hip legs 1, 8 & 9 are up

Step2:-

Rotate torso servos 2 & 10 in clockwise direction while rotate torso servo 7 in counter clockwise direction.

Step3:-

Hip legs 1, 8 & 9 are down while hip legs 4, 5 & 12 are up.

Step 4 :-

Rotate torso servos 3 & 11 in counter clockwise direction while rotate torso servo 6 in clockwise direction.

Go to Step1.

Results and Discussion

The hexapod robot is thus constructed and it is then programmed using the above forward & backward walking algorithms so that it can be able to move on both flat & rough surfaces. While moving, the proposed bot maintains its stability & it also able to overcome any obstacles in its way. Figure 1 depicts the final model of the hexapod.

Conclusion, Future Scope & Application

The Hexapod thus developed can control the system of a typical walking robot which can run on rough terrain or any other surface. This platform can then be further used for educational purposes and in different research areas. Hexapod robot can be modified as a bot that autonomously decide how, when and where to move with the help different type of sensors.

Besides this, an advanced hexapod with 18 or 24 servomotors can also be implemented. This increment of servomotors in hexapod would in turn provide more flexible leg movements. Such a hexapod can also climb the stairs.

The main applications of the HEXAPOD are as follows:

- military application
- farming
- spy robot
- domestic use

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