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Smart Hexapod

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Abstract - *The main motivation behind this research paper is to show a Smart or automatic Hexapod. It is a robot with six legs for movement and very high degree of freedom (DOF) [1]. Different type of parameters and studies were considered while making this robot. Robots or you can also say automatic/smart robots have been in significant Spotlight for a long time now, almost every year new types of robots come and change the view of everyone. Planned and assembled to fulfill the imagination, and change the view that we have with robots, and some robots are so easy to use that they have become a part of life. Special consideration and a good amount of time is given for issues related to design and materials that has an impact on the operation of hexapod. Some designs were plotted with the main goal of making the hexapod stable, strong and look good. Because of six legs the degree of freedom is very good, so the design we selected gives enough space between each legs and does not limit the degree of freedom of each leg, i.e. 270 degrees of freedom. Multiple designs were made and used to compare and finalize the design. The design structure takes account the important points that are basic structure, mechanical Structure, electronics Configuration, legs movement and movement gait. Physical parameters are calculated. Movement Gait and body structure is shown. Materials list and structure of Hexapod was made. Implementation of all the sensors and LIDAR was done after checking the structure and working of hexapod. Lidar was applied to make the hexapod smart and to avoid obstacles. Hexapod will be controlled with the help Bluetooth or with Wi-Fi. Future Upgrade and possibilities have been discussed.*

Key Words: **DOF (Degree of freedom), LIDAR (Light detection and ranging), Li-Po batter (Lithium polymer), DC (Direct Current), Wi-Fi (Wireless Fidelity)**

1.INTRODUCTION

Six legged creatures [2] uses their legs for more stability and because of six legs they have more degree of freedom that helps to move faster in uneven terrain. Hence the concept and reason of making hexapod. Hexapod can have a lot of uses like exploring different planets, or in rescue mission in case of a natural disaster, and it even has military uses. The intense research in this field is speeding up, this gives me and my team the motivation to make this project and create something different and more creative than others. This is where the concept of a smart hexapod comes. Smart hexapod is controlled via Wi-Fi or can also be automatic with the help of Lidar (terrestrial Lidar).

1.1 Objective of the project

Main objective of this paper is the design and fabrication of smart Hexapod. Sub-divisions are as follows –

1. Literature review of structure
2. Literature review of control system
3. Block diagram for robot movement
4. Calculating all the parameters of Hexapod
5. Discussing further improvements

2.1. Literature Review (Structure and design)

The design and working method of a hexapod is similar to spider. "Bio mimetic" is a combination of a Greek expressions "bios", means life, and "mimesis" implies imitation. So, biomimetic is the impersonation of living things. There have been many examples of robots that were inspired by normal animals or insects, for example, engineers are working on making a mosquito Drone similarly there are different robots that look like snakes and other animals or insects.

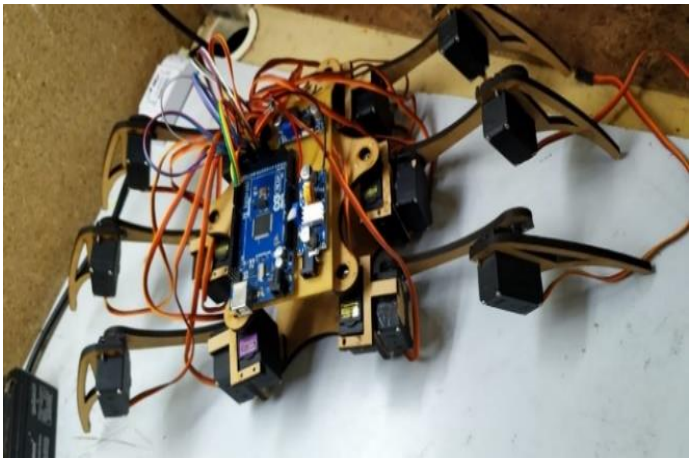
Hexapod robot has different structure and capacities. Some are simple in body and legs structure and simple in terms of complexity, whereas some are of very different and complex in structure and control. Most important point in deciding the structure of hexapod is its stability, degree of freedom of legs and its durability. The hexapod should be able to perform different tasks and there should be minimum limitations on structure.

2.2. Literature Review (Control System)

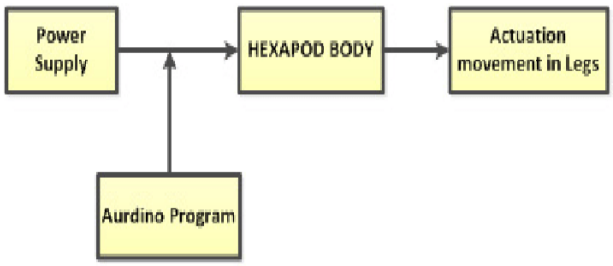
The design of hexapod in all paper have sufficient amount of unique contrasts and ideas. RHex made by [4] used Maxon sort motor. The robot legs had two Degree of freedom (DOF). The main Idea of author was to make the robot easy to construct and keep the main features of the hexapod robot and to keep no friction among those springy movements. This type of hexapod is used for stair climbing. Another, Ant Hexapod done by [5] was fabricated using carbon fiber. Ant hexapod uses SG90 [6] servo motors for its movement, and because of SG90 servo motor, ant hexapod shows less degree of freedom because of its structure. They have 1.8kg-cm of

torque, can turn 60 degrees in 3.17sec, has a small dc motor in its head used for biting or for defense purpose.

To minimize or remove the limitation of degree of freedom and increase its movement speed a different servo motor was used in the hexapod that my group is building, i.e. MG 996R [7]. MSR-H01 hexapod made by Micromagic System was designed and assembled using 26 accuracy laser-cut 5053 wooden ply [8]. Hexapod made by D. Belter et.al [9] used 18 servos and all those servos were controlled by Arduino Mega microcontroller, the main reason for selecting Arduino Mega was more flash memory and more analog and digital Input/output pins [10]. So my group combined the ideas of D. Belter and Micromagic and made the hexapod with wooden ply and 18 servo motors. This robot uses Arduino mega to control the servo motors.



Microcontroller (Arduino mega) to servo connection was done by sending data parcels or data packets to servos and other sensors. Wireless communication through Bluetooth or WI-FI is used for communication between user and micro controller.



2.3. Literature Review of hexapod Movement

Hexapod's leg movement is called gait [8]. There are different walking patterns available but the most utilized gait is called Tripod stride [12]. In tripod walk, three legs of hexapod are always stay in ground. Tripod stride is one of the most stable movement gait. In Hexapod there are six legs, so for movement three legs stay in contact with ground and three legs move forward. In this way the Hexapod move forward. Initially, the walk angles are of all legs are chosen and the hexapod is in stationary position, and the final position is known as the "reference position". The research paper published by [11] is about on how the robot navigates. The important point that was focused was the initial movement. On even or smooth surface or terrain, the gait used is alternating and on uneven surface, Wave gait is used. The stride is steady and very stable since three legs are above ground at once. Reason for using wave gait is the stability for uneven surface.

2.4. Structure of Hexapod

This part of the paper is all about the structure and how the physical model or structure is created. First part in structure design is designing the outline and then simulating all the hardware parts in that design. Main parameters of a design were to keep the hexapod compact, strong, giving space to legs and to make it look good. The basic plan was divided in two different points and each design having their own unique figure and details, advantages and disadvantages.

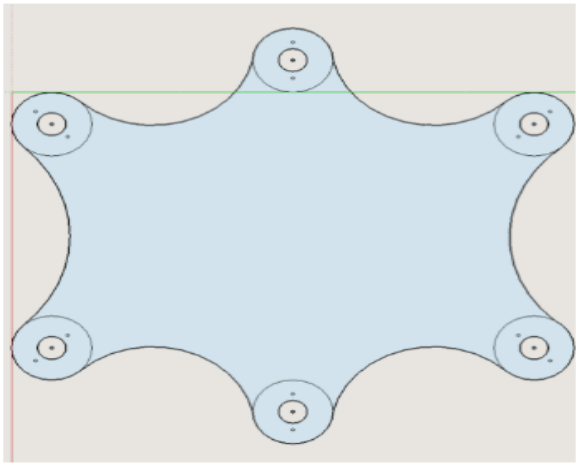
Circular (Radially symmetric)

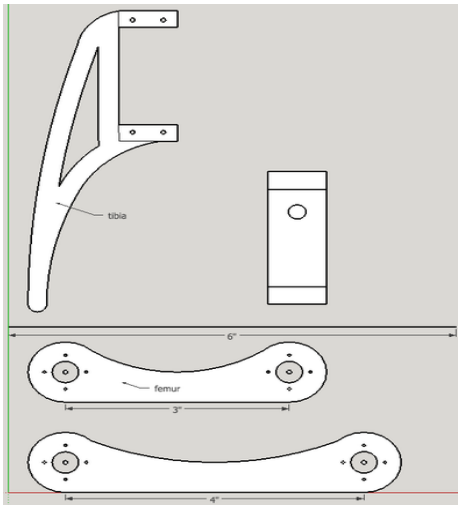
Rectangular (axis symmetric)

This is the final design of our hexapod, which uses both circular and rectangular shape.

Leg covers some different angles. Leg design was based on two major factors.

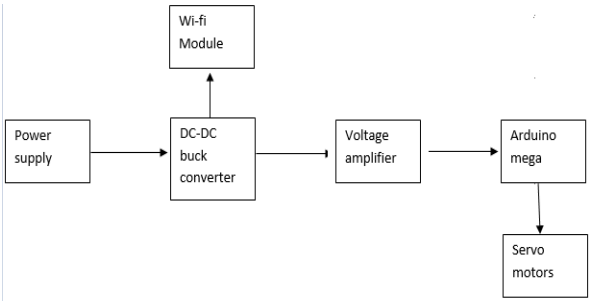
1. light weight.
2. Should support the weight of all the equipment.

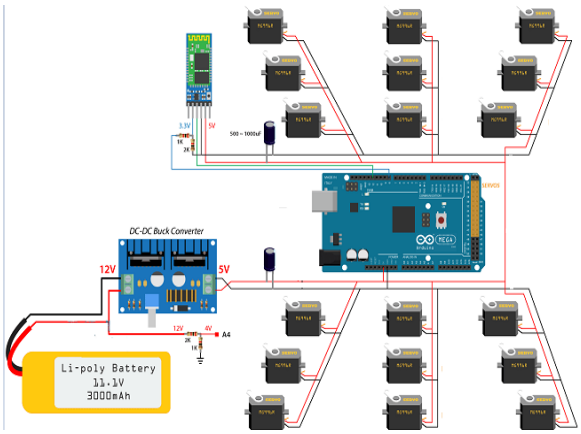




2.5. Hexapod circuit diagram

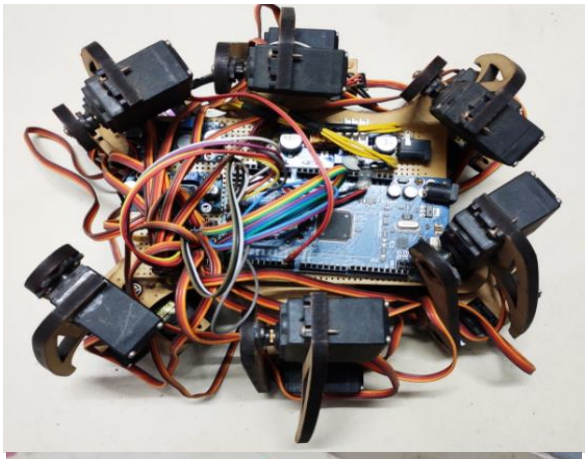
Below is the Block diagram of hexapod and a pictorial representation of how servo motors are connected to Arduino mega.

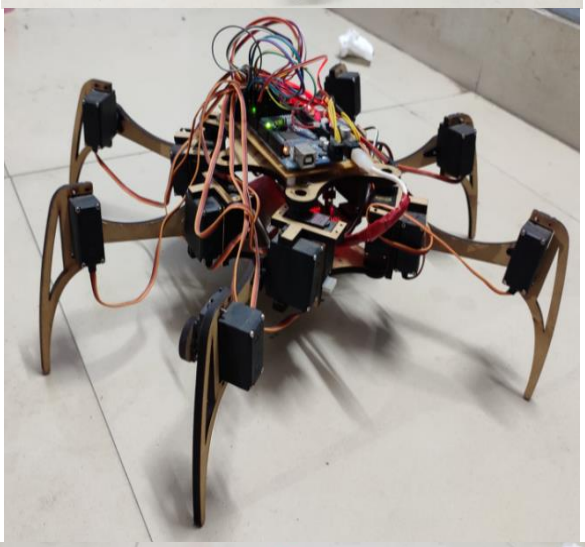


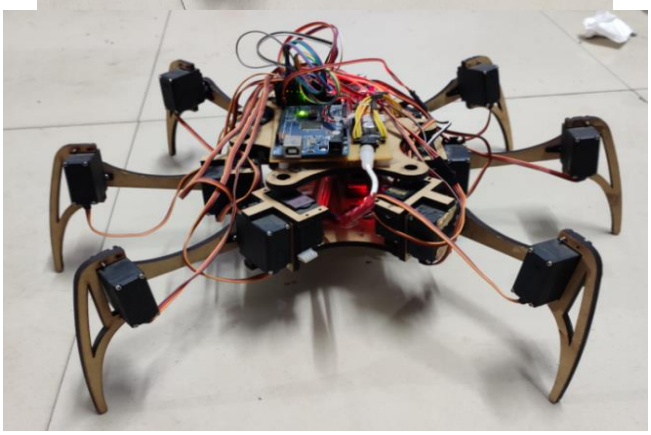


2.6. Demonstration of final Hexapod

This is the final hexapod that is made using wood ply of 5mm width, the shape of our hexapod is semi circular,18 servo motors were used, arduino mega, Wi-Fi module, etc. were used. wooden ply was laser cutted to the desired shape as shown above and MG995 motors were used, Jumper wires for basic connection. Battery used in Hexapod in 3S LI-PO Battery. DC-DC buck converter use used to convert high voltage to low voltage. This hexapod is controlled using wi-fi module which is connected to our phone.







2.7. Weight and Speed of hexapod

Weight of this hexapod is 621 gm and Speed of this hexapod is approx. 0.72 km/h.

3.1. Conclusion

This paper is made to show the future posibilities of hexapod and how it can help in disaster management. This hexapod was made while keeping it cost effective and to show a more upgraded form of hexapod. The weight of this hexapod is 721gm. And its speed is approximatly 0.72km/hr. Speed can still be increased by changing motors and by doing some changes in its code.

3.2. Limitations

1. The speed is quite slow
2. Space is limited
3. In a smooth surface, legs tend to slip.

3.3. Future Work

1. Implementation of sensors for data collection.
2. Can increase its leg measurement and movement to increase its stability, performance and speed.

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