International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075, Volume-8 Issue-9, July 2019

Design and Fabrication of Hexapod Robot

Prasath C, T. Vignesh, Manikandan N

Abstract: This paper work is concentrated on the fabrication of low cost hexapod. The Hexapod having the six legs actuated by the motor. The servo motor is used for actuating the bot and the bot controlled by the controller. This bot helps for surveillance, monitoring, and agricultural works like picking the unwanted plants in the field. The camera is mounted on the bot which helps to identify the plants and other monitoring system. The precise design and smaller size which is more flexible. The recoded or streamed video sent to the respective control unit. The bot was completely fabricated by using the 3D printer PLA material.

Index Terms: Hexapod, Servo motor, PWM signal, Controller

I. INTRODUCTION

Nowadays the robotics is the developing and emerging fields. Especially the insect's kind of robot is much fabricated. This kind of robot is very useful for many purpose. At present Hexapod is the one of the recent research area. The hexapod is used in various application. The bot used in the agricultural fields and uneven surface walking area where human intervention is not possible. The mechanical design is the important parameter for controlling the bot. The bot stability is based on the mechanical design [1]. To sensing the outdoor environment the sensors are inbounded in the robot. Compass sensor is used for outdoor navigation. The bio inspired compass sensor uses only two pixel to determine the ultraviolet rays [2]. The hexapod has a six dof and compliant legs used to move the unstable terrain. The open loop controller used for small robot [3]. The dynamically stable plate form is designed in the paper. The simulation and open loop control system RHex is achieved [4]. The actuator is another important parameter for deciding the robot movement. The various actuator like pneumatic and hydraulic is compared and pneumatic actuator is suited for the best one. Using joint actuated method used for great strength[5]. In Matlab simmechanics used to analyze the model. It's a very simpler method to analysis. The model is imported using the simmechanics module in the modelling software then the model is imported into the Matlab software. From the Matlab software the various inputs is given to the system to check the stability of the model. Based on this out put the joint torque is calculated this torque compared to the theoretical torque calculation [6]. The trajectory generation and work volume of the robot is also discussed in the paper.

Revised Manuscript Received on July 05, 2019.

Prasath C, Mechatronics Department, Sri Krishna College of Engineering and Technology, Coimbatore, India

Vignesh T, Mechatronics Department, Sri Krishna College of Engineering and Technology, Coimbatore, India.

Manikandan N, Mechatronics Department, Sri Krishna College of Engineering and Technology, Coimbatore, India.

From the various literature the hexapod is designed using the Modeling software and fabricated using 3D printed components. The simple mechanism used in this bot.

II. BUILDING A HEXAPOD

A. Cad model

The modeling of the hexapod is disused in the paragraph. The modeling is done by using modeling software. The Hexapod has a six legs and one stable plate form. The six legs are connected to the plate form. The each legs has two motor for the actuation. The actuation of the motor is controlled using the controller. The figure 1 shows the cad model of the hexapod.

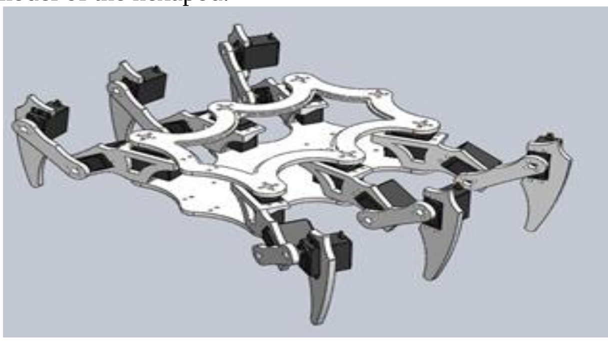

Figure 1. 3D model of the hexapod.

The bot has a 12 motors. The servomotors is used here for the controlling the leg in the particular angle.

B. Mathematical model and calculations

Mathematical modelling is used to analysis the robot. Before fabrication, the modelling is used to analysis the bot. Mathematical modelling is the simplest method to analysis the bot. The leg design has some mechanism for actuating it.

The figure 2 shows the mechanism of the hexapod. The torque calculation of the bot is shown figure 3.

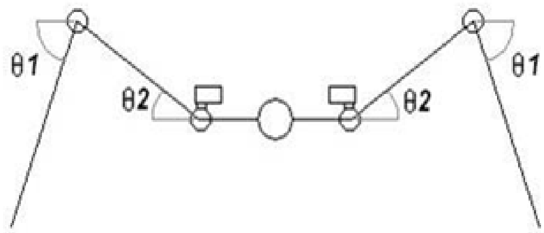

Figure 2. Front view of the hexapod mechanism

The torque is the important parameter which decides the motor. Based on the torque calculation the motor is chosen in the application.

Torque is the term force multiplied with the perpendicular distance. The force calculated using the total weight of the robot. Based on this the motor torque is calculated.

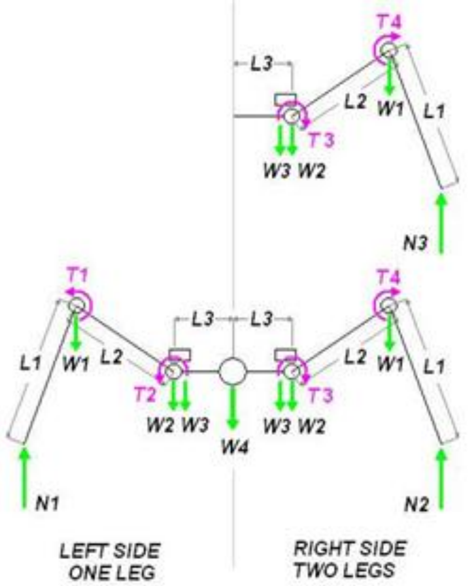

Figure 3. Torque calculation diagram

The weight and link length is shown below

W1=w2=w3=0.5886 N	L1=0.144m
θ=82.40	L2=0.095m
θ=40.47	L3=0.079m

I. Foot torque calculation

$$\sum Tfoot = -w1 * L1cos\theta1 - w2[L1cos\theta1 + L2cos\theta2] - W3[L1cos\theta + L2cos\theta2] - W4[L1cos\theta1 + L2cos\theta2 + L3] - 2w3[2L3 + C1cos\theta1 + L2cos\theta2] - 2w2[L1cos\theta1 + L2cos\theta2 + 2L3] - 2w1[L1cos\theta1 + 2L3cos\theta2 + 2L3] + 2N2[2L1cos\theta1 + 2L2 + cos\theta2 + 2L3] \quad 1$$

Apply the value and calculated the foot torque value

Σ Tfoot=0.921 Nm

II. Knee torque calculation

$$\sum Tknee = T1 - N1 * (L1cos\theta1) - w2 * (L2 * cos\theta2) - w3 * (L2 * cos\theta2) - w4 * (L2cos\theta2 + L3] - 2w3 * (L2cos\theta2 + 2L3) - 2w2 * (L2cos\theta2 + 2L3) - 2w1 * (2L2\,cos\theta2 + 2L3) + 2w2 * (2L2cos\theta2 + 2L3 + L1cos\theta1) \quad 2$$

Similarly apply the values and calculate the knee torque

Σ T knee=0.7815Nm

III. Hip torque calculation

$$\sum Thip = T2 - N1[L2cos\theta1 + L2cos\theta2] + w1[L2cos\theta2) - W4L3 - 2W2L3 - 2W3L3 - 2W1[2L3 + L2cos\theta2] + 2N2[2L3 + L2cos\theta2 + L1cos\theta1] \quad 3$$

The hip torque value is

Σ T hip=0.638Nm

IV. Dof Calculation

DOF for one leg = 3(N-1)-2p 4

Where

N – No of links
P – No of higher pairs

=3

Total DOF = 3 * 6 = 18

V. Shaft diameter calculation

M=176.25g

D= (32m/3.14) ˆ (1/3)

D= (5650.56/112.726) ^ (1/3)

D= 3.9mm

VI. Stress calculation

$$\sigma_{pla} = \frac{\sigma_y}{FOS} \quad 5$$

Where

σ_y - is the yield strength of the material
FOS – Factor of safety

σ=17.95n/mm2

Based on this calculation the bot is design and fabricated.

III. HARDWARE IMPLEMENTATION

A. Arduino mega controller.

The Arduino controller is used in the robot. Arduino Mega is having more pins to connect the motors. Because the servo motors has three pin total in the bot twelve motors is used. So 36 pins is required. The mega board operating voltage is 5V its not affect the any other components. The voltage drawn from the controller board is not enough to run the twelve motor so extra power supply is connected to the bot. The controller bot has it 256 flash memory so its capable of editing and erasing many programs. The clock speed of the controller is 16 MHz so the working speed of the controller is high comparative other controller. The figure 4 shows the Arduino mega controller.

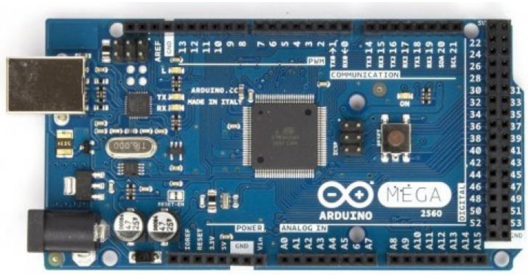

Figure 4. Arduino mega

B. Servo motor

Normal DC motor controlling is difficult comparing the other motor. So servo motor is chosen for actuation. The servo motor have positive and negative pin used for power up the motor. The third pin is the PWM signal pin, Which uses to control the motor. The signal is sent from the controller. Then based on the controller input the motor shaft is rotated. Based on that rotation the robot is moved from one place to another place. MG996 servo motor is used for prototyping purpose. The motor having the stall torque of 9.4 Kgf.Cm so it can with stand the body weight of the robot. The
Figure 5 shows the servo motor.

Figure 5. MG996 servo motor

C. Voltage regulator

The step down voltage regulator is used in this application. The 230V DC power supply used in the robot. The 230V is converted to the respective voltage depending upon the requirement. The power supply varies for the various components. For the sensors it used only the 5V,and for the other motors it require 12V. So the voltage regulator has been used in the robot. The figure 6 shows the step down regulator.

Figure 6. Step down voltage regulator

D. Battery

The battery is one of the components used in the robot. The power supply is given from the rechargeable battery. The 12V lead acid battery is used in this bot.
The figure 7 shows the battery image.

Figure 7. Lead acid Battery

These are all the components used in the robot. The connecting components and other body frames are fabricated using the PLA material in 3D printing technology. The weight of the total bot is very less compared to the other material fabrication. The basic Arduino programming used in this robot. Based on the application and the robot movement the robot is programmed. The basic Arduino programming is like a Basic English commands.

IV. METHODOLOGY

A. Block diagram

The working of the robot is described in the below figure 8.

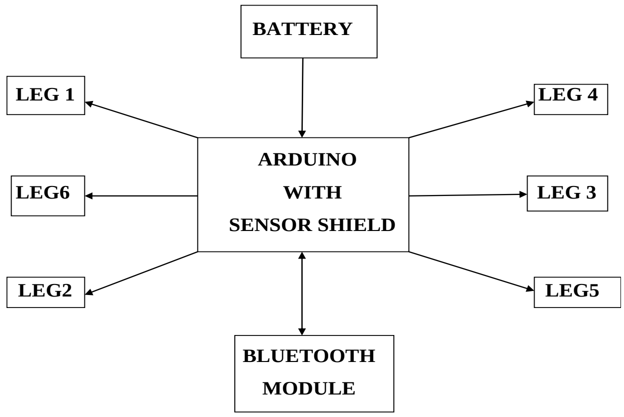

Figure 8. Block diagram of the hexapod

The Arduino controller is connected to the motor shield. The shield is connected with the power supply and the motor. The motor need more power so the shield is used to transfer the power. The Bluetooth module is connected to the controller board. Using the Bluetooth controller the bot is controlled by using the mobile app or the computer system by remotely. The twelve motor is connected to the motor shield. The battery module is used for the power supply. The motor and other module get power up using the battery.

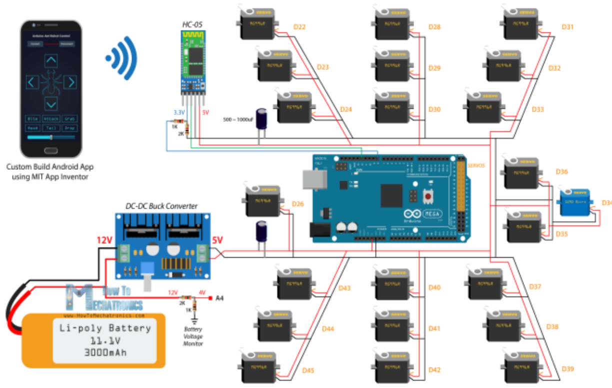

Figure 9. Circuit of the hexapod

The figure 9 show the circuit diagram used in the robot. The motor connection and the shield is connected to the controller. The power supply is connected to the shield. The Bluetooth device will gets powered up using the shield.
The figure 10 show the 3D printed component used on the bot.

Figure 10. 3D printed components

V. RESULT AND DISCUSSION

The proposed design is more stable and simpler compare to the other models. The robots are used for many purposes. The work trajectory of the link one and two is show in below figure 11 and 12. It shows the reachability of the model link one and two. Here one is simulated using the modelling software. The similarly the other links is simulated with same conditions.

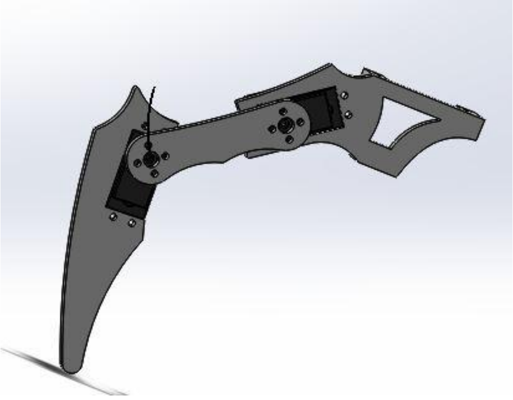

Figure 11. Link 1 trajectory

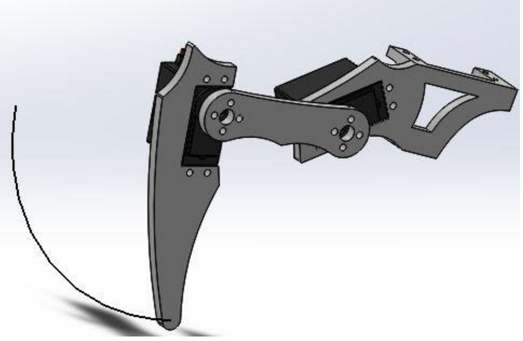

Figure 12. Link 2 trajectory

The linear velocity of the links is simulated using the modelling software. The figure 13 shows the linear velocity, acceleration and displacement of the links.

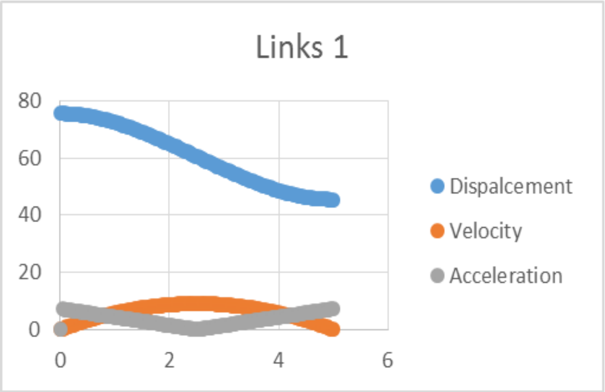

Figure 13. Linear displacement, velocity and acceleration of the links.

The fabricated model is shown in the figure 14. The prototype models is fabricated using acrylic sheet with 3D printer. It is very less in weight and has more accuracy in moving.

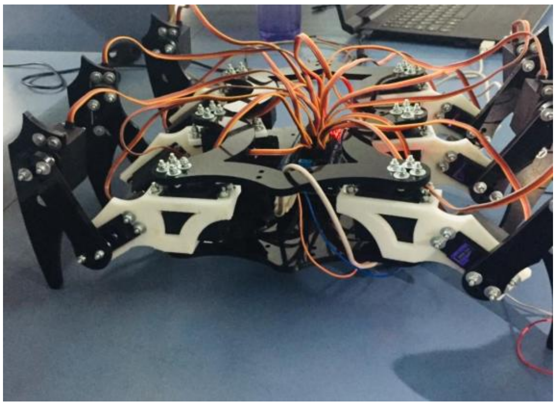

Figure 14. Fabricated model

VI. CONCLUSION & FUTURE WORK

The Arduino controller used in this robot to obtain the control of the robot and the Bluetooth device are used here to control the robot in remotely. Totally 12 motors are used in this robot. The main advantage of this robot is to monitor the environment and agricultural purpose. In the agricultural the unwanted plant is removed using the robot. This robot is used to move in the uneven terrain surfaces. The future work of this paper is to integrate the camera module and GPS to the bot. It helps to identify the location the robot and capturing the images.

REFERENCES

1. S. Rasakatla, K. M. Krishna, and B. Indurkhya, "Design, construction and a compliant gait of 'ModPod': A modular hexpod robot," *2010 IEEE Int. Conf. Robot. Biomimetics, ROBIO 2010*, pp. 1341–1345, 2010.
2. J. Dupeyroux, J. Diperi, M. Boyron, S. Viollet, and J. Serres, "A bio-inspired celestial compass applied to an ant-inspired robot for autonomous navigation," *2017 Eur. Conf. Mob. Robot. ECMR 2017*, 2017.
3. E. Z. Moore, D. Campbell, F. Grimminger, and M. Buehler, "Reliable stair climbing in the simple hexapod 'RHex,'" *Proceedings-IEEE Int. Conf. Robot. Autom.*, vol. 3, no. May, pp. 2222–2227, 2002.
4. U. Saranli, M. Buehler, and D. E. Koditschek, "Design, modeling and preliminary control of a compliant hexapod robot," *Proceedings-IEEE Int. Conf. Robot. Autom.*, vol. 3, no. April, pp. 2589–2596, 2000.
5. G. Granosik and J. Borenstein, "Integrated joint actuator for serpentine robots," *IEEE/ASME Trans. Mechatronics*, vol. 10, no. 5, pp. 473–481, 2005.
6. T. Vignesh, P. Karthikeyan, and S. Sridevi, "Modeling and Trajectory Generation of Bionic Hand for Dexterous Task," pp. 1–6, 2017.

AUTHORS PROFILE

Prof. C. Prasath is working as assistant professor in the Department of Mechatronics Engineering at Sri Krishna College of Engineering and Technology, Coimbatore, Tamilnadu, India – 641008. He has Obtained B.E, degree in Mechanical Engineering from Adhiparasakthi Engineering College, Melmaruvathur, India in 2009 and M.E., degree in Production Technology from Thiagarajar College of Engineering, Madurai, India in 2013. He has published a number of research papers in international journals and conferences and guided a number UG Scholars**.**

Prof. T. Vignesh is working as assistant professor in the Department of Mechatronics Engineering at Sri Krishna College of Engineering and Technology, Coimbatore, Tamilnadu, India – 641008. He has obtained B.E, degree in Mechanical Engineering from Jeppiaar Engineering College, Chennai, India in 2015 and M.E., degree in Mechatronics Engineering from Madras Institute of Technology, Chennai, India in 2017. His research interests include Robotics and Automation. He has published a number of research papers in international journals and conferences and guided a number of UG Scholars**.**

Prof. N. Manikandan is working as assistant professor in the Department of Mechatronics Engineering at Sri Krishna College of Engineering and Technology, Coimbatore, Tamilnadu, India – 641008. He has obtained his B.E, degree in Mechatronics Engineering from Kumaraguru College of Technology, Tamilnadu, India in 2010 and M.E, degree in Computer Integrated Manufacturing from PSG College of Technology, Tamilnadu, India in 2013. His research areas include Robotics, Additive Manufacturing and Manufacturing Systems.