International Journal of Engineering & Technology, 7 (2.24) (2018) 387-390

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

Hexapod Performance

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Abstract

The purpose of this project is to build a six legged walking robot, which is able to perform basic tasks like walking in the forward direction, backward, moving it's body up and down and rotating. This project involves designing the hexapod on CAD software Solid Works followed by fabrication and required electronic connections and testing. Due to the stability and its wide flexibility to move in irregular surfaces, hexapod can be very useful in the zones where the natural disasters and also in the aftereffects of the war scenario. The complexity and performance of the hexapod can be widely increased by adding additional sensors and also it can be modified in such a way that it can be used in fields of defense, manufacturing automation and can widely replace the humans in hazardous environment.

Keywords: *Automation, complexity, flexibility, hexapod*

1. Introduction

Robots are one of the intelligible creations in the human history that has revolutionized the world and has created numerous opportunities and wide range of research possibilities in the field of automation. Robots are now used to replace the human tasks which are highly dangerous and can be used to operate in the places where the humans can hardly reach.

There are many types of robots that replace the humans like the robots used in the assembly line for repetitive tasks and one such robot is the multi-legged robot which has the ability to move in irregular surfaces and can be used for various purposes depending on the scenarios and the number of legs. These multi-legged robots has more static stability while moving on irregular surfaces than the wheeled or tracked robots. RHEX robot is one of the multi-legged robots [1] which has high performance which does not include more complicated mechanisms in structure [fig 1]. Lauron III was built by FZI (Forschungszentrum Informatik). Each leg of this robot has three degrees of freedom. This robot consists of 12 actuators which has a current sensor which can be used to detect forces opposing to itsw movement in fig.2 [2]. Hexapod is a multi-legged robot that has six to eight legs which is one of the most stable legged robots present. Hexapod has greater flexibility and stability to move in irregular platform by using three legs consequently. Hexapod is a omni-directional robot which has six degrees of freedom.



Fig. 1: Rhex[1]



Fig. 2: LauronIII

The main objective of this project can be stated as follows.

1) To study the movement and dynamics of the Hexapod robot.
2) Designing the model of Hexapod robot on CAD software Solid Works.
3) To design the Hexapod basing on the market needs and making it available for selling in the market.
4) For modifying the design based on requirements.
5) Analysis and simulation of the hexapod.
6) Fabrication of hexapod.
7) Automation and controlling.
8) Testing

2. Literature Review

The theories and pre-requisites regarding the motion and dynamics of the robot has been studied. The movements of different types of robots, its joints, were studied. The rotation, revolution, orthogonal twisting, linear joints, radial symmetry of different kinds of legged robots are studied. To build this project many designs of hexapod were studied like controlling of the hexapod using servo-controller and arduino. Control method used significantly reduces the workload on MCU so it can communicate efficiently with the external devices. Also hexapods with legs radially distributing around the body are studied for the efficient construction.

3. Design

The designing of the Hexapod robot was initiated with designing different parts on CAD software Solid Works like Chassis, Robot leg structure.

3.1 Body

The main body constitutes of light-weight composite materials. It makes the whole project cost effective. To keep the center of gravity at the mid-point of the body, the legs are fixed at the opposite ends so that the robot can move continuously and balance it-self. The arduino is fixed in the back portion of the body and the servo-controller is kept in the front portion of the body.

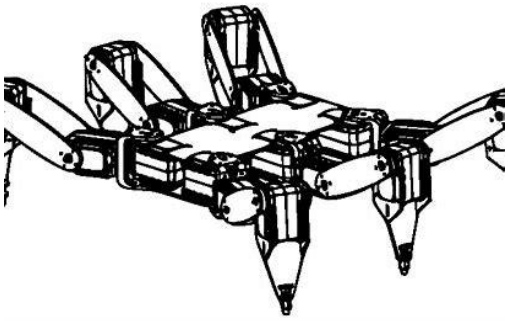


Fig. 3: Hexapod Body

3.2 Legs

Each leg of the robot has the same functions and six degrees of freedom. The only difference between the legs is the motion algorithm. The legs are designed in such a way that it can walk on irregular platforms and can climb terrains. The movement access of one of its leg is as shown in the fig 4**.**

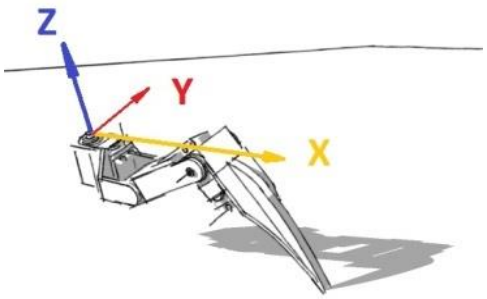


Fig. 4: Hexapod Leg Structure

3.3 Servomotor and Servo-Controller

Twelve servomotors are used in this project, two servomotors for each leg. To carry out angular displacement, a servomotor is used. The signal received by servomotor determines the angle of rotation. As this type of motors are limited to 180 degrees, they cannot perform a full rotation. A servomotor consists of four parts:

1) A DC motor
2) A speed reducing gear system (which reduces speed of rotation of output shaft and increases the torque)
3) Potentiometer (which generates a variable voltage proportional to the angle of output shaft)
4) An electronic control circuit

A servomotor has three outputs (GND, VCC, PWM), Since there are 12 servomotors used and the arduino cannot accommodate all the 12 of them, a USC 16 channel servo-controller is used for interfacing between them. The servo controller is a slave device, which can accept the commands or execute the preset commands. So the arduino is programmed to control the servo-controller.

3.4 Control of Hexapod

The remote controller of the hexapod which is used for commanding the movements and the tasks that are performed constitutes of the parts joysticks, arduino nano, axis accelerometer and a transceiver module. The accelerometer is used for detecting the magnitude and monitor the direction of propagation and also for detecting the device. It is connected to the arduino nano for controlling the movements. The transceiver module is used for the communication between hexapod and the remote controller. In this project two arduino are used, one as a transmitter and the other as a receiver.

4. Hardware Description

The Hexapod Robot is designed based on Arduino UNO R3 and Nano. The whole robot can be specifically divided into two systems one being the robot body and the other the Remote Controller, these two are connected with each other using a wireless module.

4.1 32 Channel PWM Servo Driver

The 32 channel PWM Servo Driver is used to drive the sevo motors which are used in the Hexapod legs. This generates a 32 Pulse width Modulation signals which are used to drive the servos. Though the Arduino can generate PWM signals it cannot be able to manage with a large number of signals that being the use of the servo driver in the hexapod to manage the signals generated for nearly 20 servos.

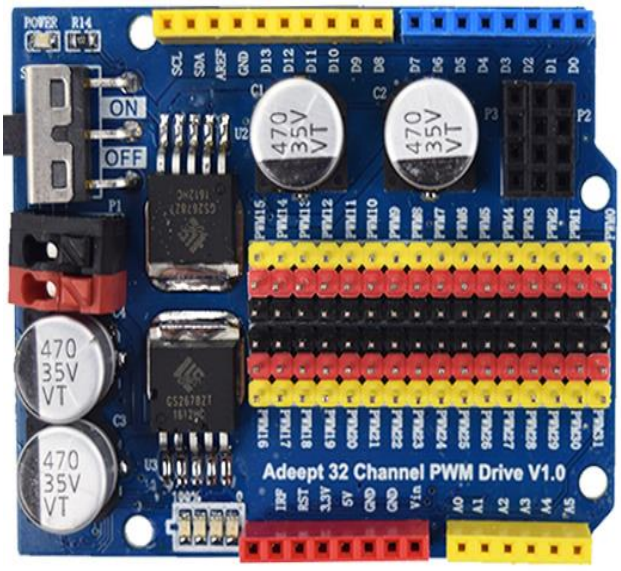


Fig. 5: Servo Driver

The width of the pulse which is the duty cycle of the signal that is generated by the servo driver determines the direction and angle of the position of the servo. The Pulse Width Modulation signals reach the servo through the microcontroller such as Arduino.

4.2 Servo Motor

A servo-motor is a rotary actuator or linear actuator that allows control of angular position or linear position, velocity and acceleration. It is the device that moves the legs of the Hexapod robot with high precision and efficiency. The servo-motor in the hexa-

pod moves with an angle till 180 degree as it cannot have a complete rotation of 360 degree. The servo motor operates in bi-directional mode that is both in clockwise and anti-clockwise direction. The rotational direction of the servo and the speed of the rotar depends on the Pulse Width Modulation commands. The servo motor consists of three pins which are GND, VCC and Pulse width modulation signal.

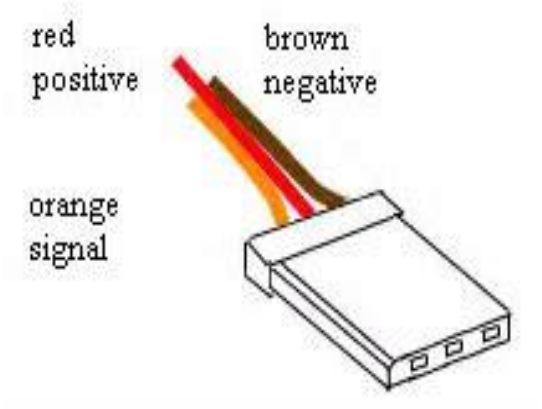


Fig. 6: Servo Motor Pin Diagram

4.3 Arduino UNO and Nano

The Arduino UNO is fixed to the hexapod body while the Arduino Nano to the controller part.
Arduino UNO is based on the microcontroller board ATMega32. It has 14 in-out digital pins of which 6 are PWM outs, 6 analogs, a 16MHz crystal oscillator, a USB Connection, power jack, ICSP header, reset button.



Fig. 7: Arduino UNO

The Arduino Nano is very small and is compatible to use it on a bread board with other components. So it is much preferred to use it on the remote controller of the hexapod due to its size. As it does not have a DC jack the power supply is given through USB port or directly connecting the Vcc and GND.

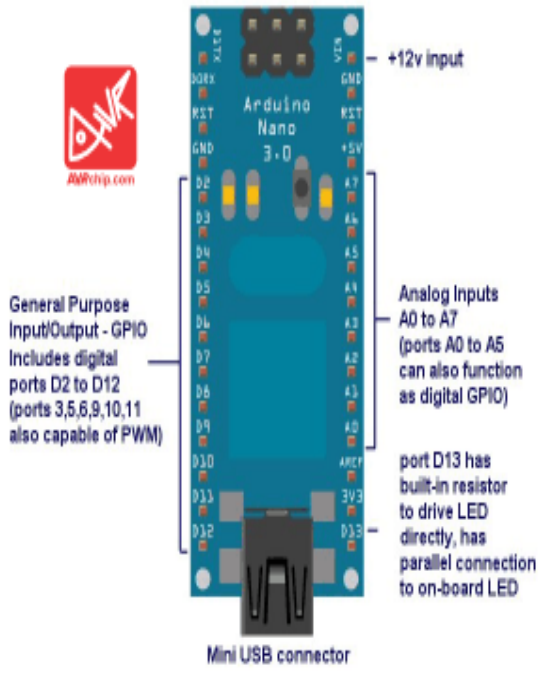


Fig. 8: Arduino Nano

4.4 2.4 Ghz Transceiver

A total of two transceiver modules are used, one in the hexapod body and the other in the remote controller. It has a range of about 200 feet to 100 meters. It is used as a medium to control the hexapod using remote controller

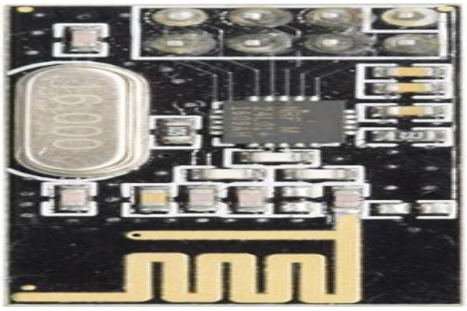


Fig. 9: 2.4 GHz Tranceiver

4.5 Ultrasonic Sensor

The ultra sonic sensor used in the hexapod robot helps to sense the obstacles and in avoiding them. It is used to measure the distance of the object by using sound waves. It measures the distance by sending the sound waves with a specific frequency and listening for it to bounce back. By observing the time taken for the signal to meet the obstacle and bounce back, the distance between the robot and the obstacle can be calculated.



Fig. 10: Ultrasonic Sensor

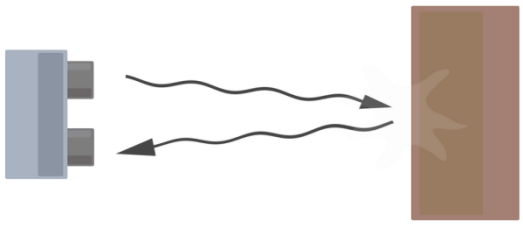


Fig. 11: Ultra sonic sensor operation

5. Conclusion

This paper emphasis the need for developing the legged robot rather than the wheeled robot. The model which is designed is basically based on the structure of six legged insects and its movements. This hexapod model is mainly designed for in places such as the after effects of the war and disaster zones which has an ability of obstacle avoidance, surveillance. It is designed in such a way that it has improved stability and performance compared to the other legged robots. Many experiments and tests are made to improve the overall performance of the robot and the future work will be concentrated on the energy consumption, movement and speed of the robot.

6. Acknowledgment

I would like to express my deepest gratitude to my guide. Her valuable guidance, consistent encouragement, personal caring, timely help and providing me with an excellent atmosphere for doing research. All through the work, in spite of her busy schedule, she has extended cheerful and cordial support for completing this research work.

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