TRIBHUVAN UNIVERSITY

INSTITUTE OF ENGINEERING
IOE CENTRAL CAMPUS, PULCHOWK

Instrumentation Project Report

EX510

HEXAPOD

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Abstract

The goal of this project is to build an intelligent vision based legged robot capable of interacting with the environment and human users. Our aim is to make the robot as interactive as possible, thus we plan to integrate different gaits and dance patterns into the robot's movements, and face detection as one of its vision based intelligent ability.

Keywords: Hexapod, Legged robot, Pulse Width Modulation(PWM), Servo motor, Computer Vision, Image Processing

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1 Introduction

1.1 Background

Robotics is an interdisciplinary branch of engineering and science which consists of electronics, hydraulics, electricity, mechanical engineering, programming, communication and so on. As the research and development in Artificial Intelligence improves, robots become more and more intelligent and capable of performing tasks thought only possible for humans, in as much if not more effective manner. And as robots become more intelligent, the human-robot interaction needs to be improved for collaboration between these two different entities for outdoing each sides' achievements to that point in time. The harmony between human cognitive and perceptive abilities and machine persistence and precision will bring forth a new era of human civilization.

A hexapod is a six legged robot usually modeled off insects. The large number of

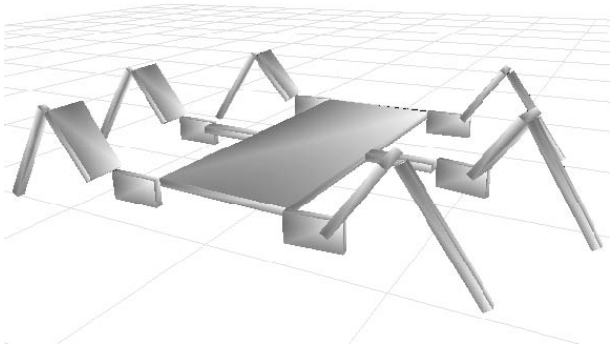


Figure 1: Simple simulated hexapod model

legs provides it with increased stability and flexibility in its movements. Simply having legs make it capable of traversing uneven terrains. Our project aims to study and develop human-robot interactions using a hexapod.

1.2 Problem Definition

This project will mainly focus on building the hexapod that can be controlled wirelessly using appropriate controller. The hexapod also needs to be able to interact with humans without the use of explicit control signals. The plan is to use a camera and make the robot act based on the visual information received.

1.3 Objectives

The basic objectives of this project are as listed below:

- To build a six legged robot with each leg capable of acting independently,
- To program appropriate walking sequences like forward, backward and turning left or right,
- To program dance sequence to make the hexapod more interactive and entertaining to use,

- To use a camera module to extract information on which the hexapod can act on to appear intelligent and human friendly.

1.4 Scope

Hexapods, by virtue of their legs are flexible, robust and attention grabbing. With increased interactive abilities and vision based intelligence, this kind of robots can be greatly useful in explorations in dangerous terrains, military applications and entertainment. One of the most promising uses for intelligent legged robots is in disaster response and rescue where a number of such robots can collaborate with human disaster response and rescue team to minimize response delay and increase survival chances of injured victims.

2 Literature Review

2.1 Pulse Width Modulation(PWM) and Duty Cycle

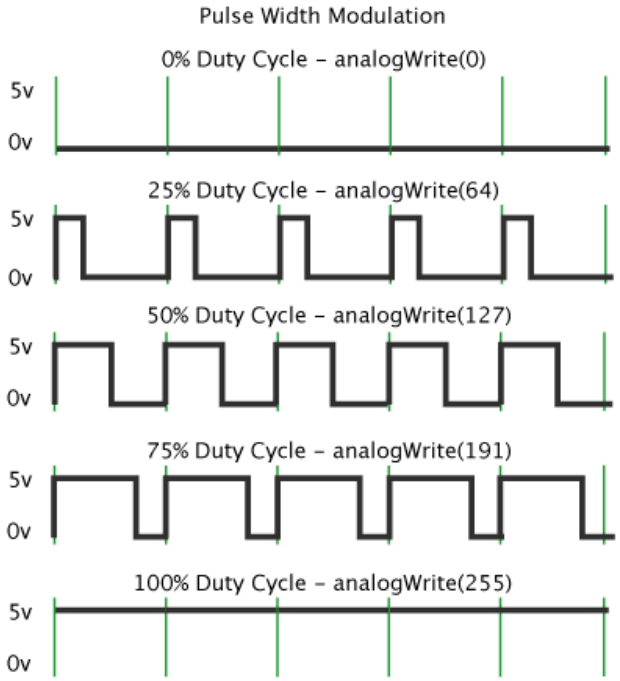


Figure 2: PWM and Duty cycle

Pulse width modulation (PWM), or pulse-duration modulation (PDM), is a method of reducing the average power delivered by an electrical signal, by effectively chopping it up into discrete parts. The average value of voltage (and current) fed to the load is controlled by turning the switch between supply and load on and off at a fast rate. The rate (or frequency) at which the power supply must switch can vary greatly depending on load and application. For example, switching has to be done several times a minute in an electric stove; 120 Hz in a lamp dimmer; between a few kilohertz (kHz) and tens of kHz for a motor drive

Duty cycle is the measure of proportion of 'on' time to a 'period' time, i.e the the

proportion of how long the signal remains high compared to total duration the signal becomes high, then low until it switches to high again. Duty cycle is expressed in terms of percentage.

A servo is a special type of DC motor that can rotate to a particular degree based on input control signal. It consists of a suitable motor coupled to a sensor for position feedback and thus can perform rotations with high accuracy and precision. Servos are extensively used in Robotics, CNC machinery and automated manufacturing. Servo control is achieved by sending a servo a PWM (pulse-width modulation) signal, where either the width of the pulse (most common modern hobby servos) or the duty cycle of a pulse train determines the position to be achieved by the servo. The PWM signal might come from a radio control receiver to the servo or from common microcontrollers such as the Arduino.

2.2 Face Detection

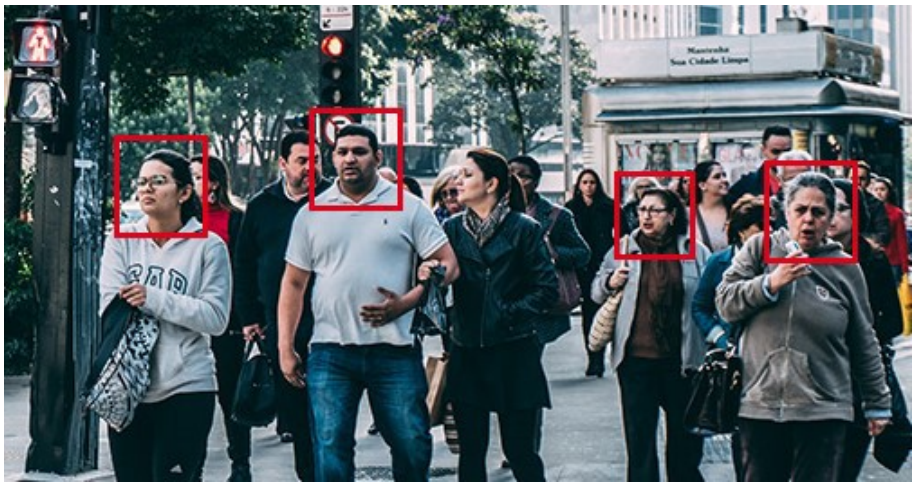


Figure 3: Face detection in action

Face detection refers to an important part of computer vision, where machines can be made capable to detect human faces in an image. Face recognition, another extensively researched field in computer vision and image processing is mostly just face detection. A number of algorithms have been developed to make machines capable of face detection. The most common is Haar Cascade Classifier from [1], which is a machine learning based classifier trained on a large number of positive and negative images, positive being images that contain faces and negative being those that do not.

Since vision is one of the most important source of information for a human, a machine able to interpret some of the visual information is able to perform intelligent actions. Computer vision is the basis on which most of the intelligent systems like serving robots in restaurants, manufacturing robots in industries and autonomous cars are developed.

2.3 Object Tracking

In object tracking we aim to track an object across images. By employing object tracking along with face detection we are able to track a face across frames of a video feed from a

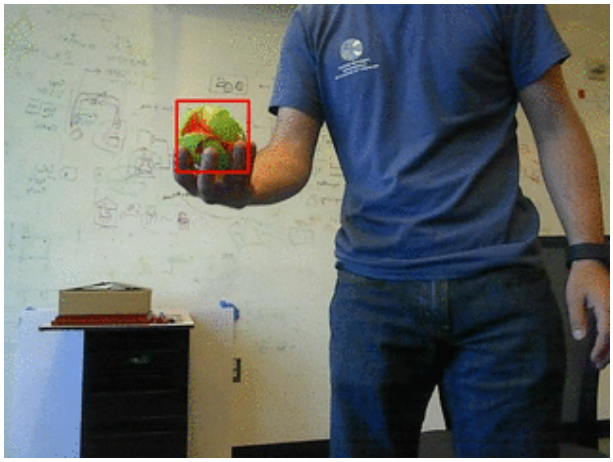


Figure 4: Object Tracking

webcam. This allows us to implement interesting intelligent behaviour into our hexapod such as turning towards the tracked face or any generic object. It is even possible to make the robot capable of following a person or an object by comparing the size of tracked object across frames and determining if the object has moved closer or further. In our project we employed re-3 a regressional neural network tracker described in [2] to track a detected face or an object. The face or object to be tracked if the number detected is more than one can be determined by choosing the largest one, if we assume the largest one to be closer to the hexapod and thus more important to the hexapod.

3 Project Requirements

3.1 Hardware Requirements

3.1.1 MG90s Servo Motors

Figure 5: MG90s servo motor

The MG90s micro servo motor is tiny and lightweight with torque rating 1.2 kgf·cm

(4.8V) and metal gears. This servo is used for our hexapod legs. 12 such servos was required to drive all the legs with 2 servos per leg.

3.1.2 Arduino Mega

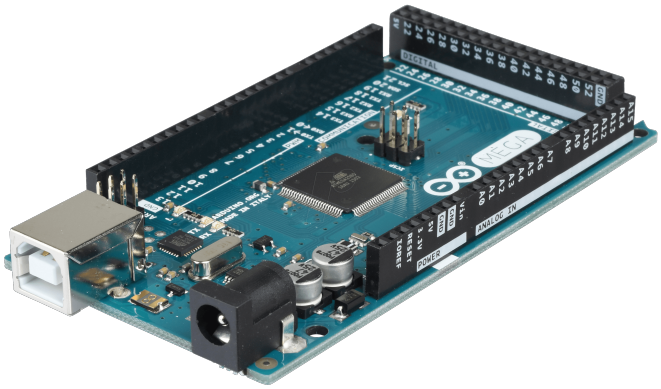


Figure 6: Arduino Mega 2560

The Arduino mega has exactly 12 PWM pins and fairly good computational power and is our choice for driving the servos.

3.1.3 Camera Module

Figure 7: Gionee P5 mini(android smartphone used for video feed)

The camera module used is an android smartphone with 8 MP primary webcam.

3.1.4 Bluetooth Module

The bluetooth module used is HC-05. It recieves control inputs for movement wirelessly from a computer and sends it to the Arduino for further processing.

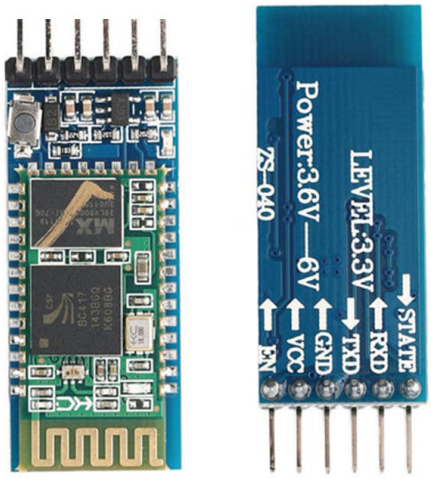


Figure 8: HC-05 Bluetooth module

3.1.5 Gamepad

Figure 9: Gamepad

A gamepad(also called joystick) was used to generate control instructions for the hexapod.

3.1.6 Buck converter

A 5v 3A buck converter was used to regulate input voltage to the servos. The buck converter can step down high voltages to a specified lower voltage without much power loss. The buck converter can be used with a DC adapter and thus the hexapod can be operated with AC supply using the adapter instead of a battery.

Figure 10: 5V 3A Buck converter

3.2 Software Requirements

3.2.1 Proteus

Proteus is very useful to prototype and simulate electronic circuits with motors and Arduino before building it and thus provides a preliminary confirmation that the circuit works as desired.

3.2.2 Kicad

Kicad is a software used to design PCBs and was used in the project to build PCB to house all electronic Components

3.2.3 IP Webcam

IP webcam is an android application that can be used as a wireless webcam feed accessible through WiFi.

4 Methodology/Project Workflow

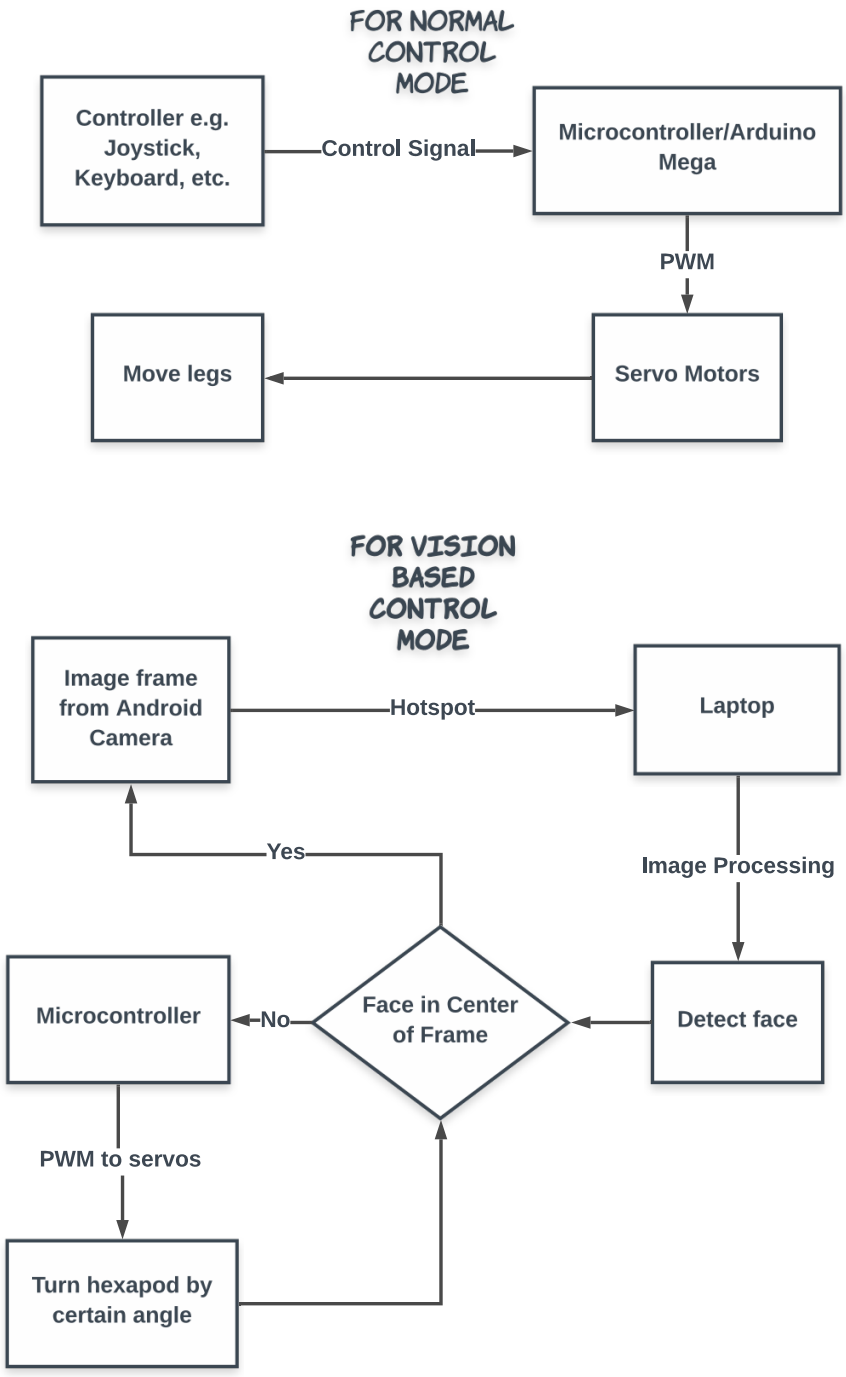


Figure 11: Flowchart of project Workflow

5 Project Cost

Device	Tentative Cost
12 MG90s servo motors	Rs.4800
1 Arduino Mega 2560	Rs.1600
Others(Material for body and legs, screws, wires, etc.)	Rs.1000
Total	Rs. 7400

Table 1: Project Cost Estimation

6 Robot Details

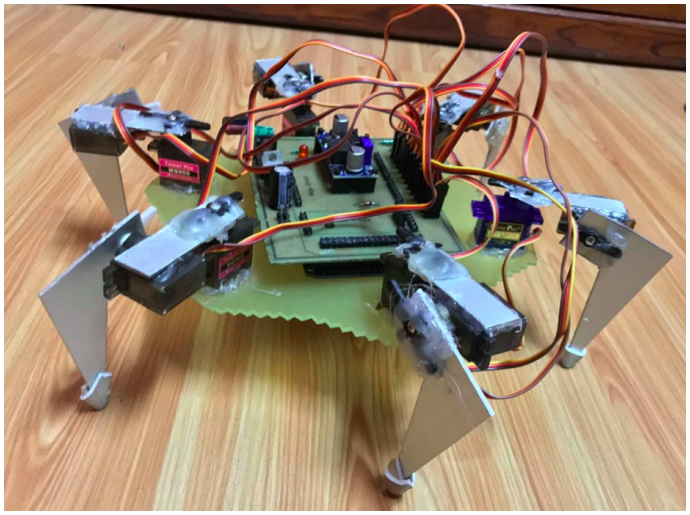
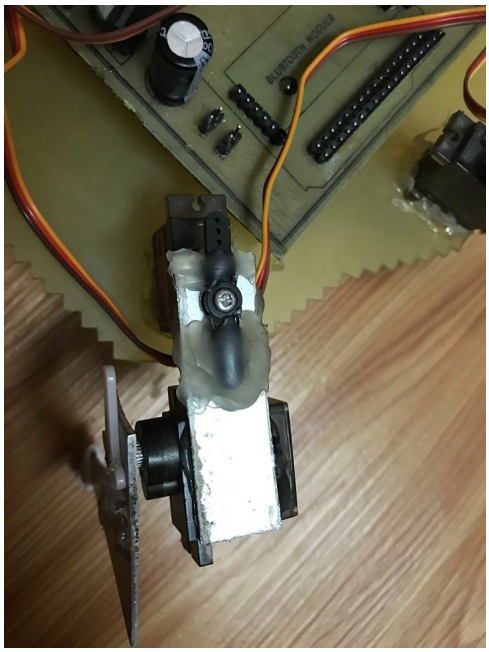
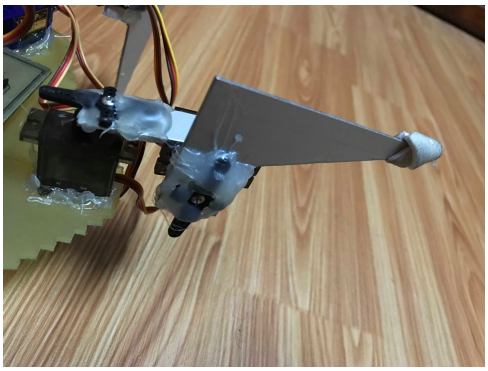


Figure 12: Hexapod

The hexapod body consists of a base, 6 hip(upper leg) plates and 6 knee(lower leg) plates. The base is made of thin acrylic sheet cut in a hexagon like shape while the leg plates are made up of aluminium sheets.
The circuit primarily consists of a 5V 3A buck converter for power regulation, a bluetooth module for control input and and 12 3-male-pin headers for connection to servos.
The hexapod can be used in two modes, manual and automatic. In manual control movement instructions are generated manually using a gamepad whereas in automatic mode the instructions are generated by a computer according to processed frames of video feed from robot



(a) Upper leg



(b) Lower leg

Figure 13: Legs

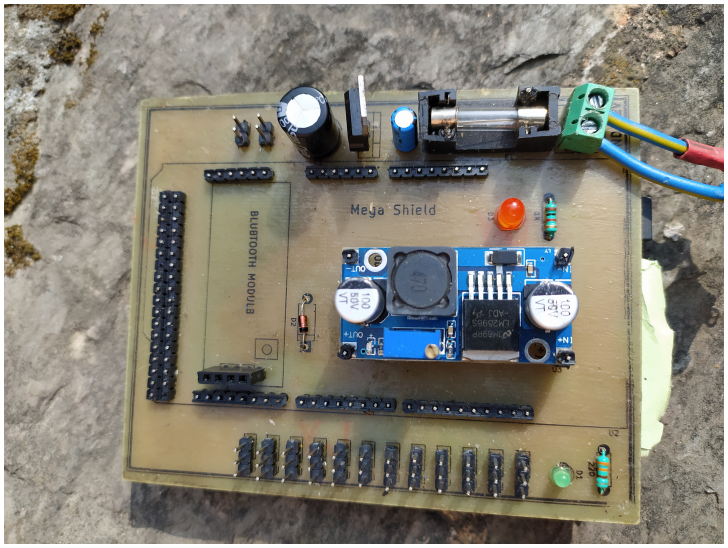


Figure 14: PCB

7 Results

We have managed to build a smart hexapod that can move around and interact with people. It is capable of tracking and following a generic object by using the object tracker and object detector employed. We believe that such systems will be useful in transportation, explorations in hazardous terrain, automation and entertainment industry.

8 Limitation Analysis

The limitations of this project are the cheap low torque servos used that are incapable of handling large weights and that all servos do not show same response for same input that might make the movement look awkward. Furthermore the camera module used is a fairly large smartphone and the servos struggle with its weight during movements.

References

[1] Michael Jones Paul Viola. Rapid object detection using a boosted cascade of simple featurese. *Accepted Conference on Computer Vision and Pattern Recognition 2001*.

[2] Daniel Gordon, Ali Farhadi, and Dieter Fox. Re3: Real-time recurrent regression networks for visual tracking of generic objects. *IEEE Robotics and Automation Letters*, 3(2):788–795, 2018.