Study and Analysis of the Gait and Legs Angle for Hexapod on the Certain Trajectory

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A report submitted in partial fulfilled of the requirements for the degree of Bachelor of Mechatronics Engineering

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"I hereby declare that I have read through this report entitles "Study and Analysis of the Gait and Legs Angle for Hexapod on the Certain Trajectory" and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Mechatronics Engineering"

Signature : .....

Supervisor's Name : .....

Date : .....

I declare that this report entitles "Study and Analysis of the Gait and Legs Angle for Hexapod on the Certain Trajectory" is the results of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : .....
Name : PAULINE NGOI
Date : .....

To my beloved family

ACKNOWLEDGEMENT

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ABSTRACT

One of the features of hexapod is the ability of walking in different types of terrains. This project is concerned on the angle analysis for each movement when the hexapod walks on certain trajectory using tripod gait movement. In this project, a hexapod with two degree of freedom on each leg is designed and built for the purpose of legs angle research. The movement of the hexapod is guided by four Infrared Sensors installed which used to track the black line. Fuzzy Logic Controller is applied to create better response of robot behavior than conventional controllers. The controller will be based on the signal input from Infrared Sensors to control the turning angle of the robot. Leg angle in 10°, 15°, 20° and 25° are tested and analyzed whether it can maneuver the given path successfully or not. In order to get accurate and reliable results, collection of data is programmed in Arduino. The data is then collected from Serial Monitor in Arduino IDE. The hexapod robot able to walk, follow and turn at any types of trajectories given.

ABSTRAK

Salah satu ciri-ciri hexapod adalah keupayaan berjalan dalam pelbagai jenis rupa bumi. Projek ini adalah fokus pada sudut analisis bagi setiap pergerakan hexapod apabila berjalan di trajektori tertentu menggunakan pergerakan tripod gaya berjalan. Dalam projek ini, hexapod dengan dua darjah kebebasan pada setiap kaki direka dan dibina untuk tujuan penyelidikan sudut kaki. Pergerakan hexapod itu berpandukan kepada empat Sensor Infrared dipasang yang digunakan untuk mengesan garisan hitam. Pengawal Logik Fuzzy digunakan untuk memberi respons yang lebih baik kepada robot berbanding dengan pengawal konvensional. Pengawal ini akan berdasarkan input isyarat dari Sensor Infrared untuk mengawal pertukaran sudut robot. Sudut kaki dalam sudut 10°, 15°, 20° dan 25° telah diuji dan dianalisis sama ada ia boleh bergerak mengikut jalan yang telah diberikan atau tidak. Untuk mendapatkan keputusan yang tepat dan boleh dipercayai, pengumpulan data telah diprogramkan dalam Arduino. Data ini kemudian dikumpul daripada Monitor Siri dalam Arduino IDE. Robot hexapod boleh berjalan kaki, mengikut dan bertukar di mana-mana jenis trajektori yang diberikan.

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DoF	-	Degree of Freedom

CHAPTER 1

INTRODUCTION

1.1 Introduction

Robot is getting attention from the world. The image of the robot that appears in people image is like human-shaped machine that appeared in comics or movies such as Transformers, RoboCop, Star Wars, and Terminator. According to the oxford dictionaries[1], robot is designed as a programmable machine that carry out a series of complex system automatically. The robot system exist either in the human shape or another shape and it is equipped with sensors, control systems, programming, electronic circuitry to perform a task intelligently. Robots are designed to replace human and perform some specific tasks that human is difficult to achieve. Robot used to perform in the dangerous task or extreme environment that hard to survive such as bottom of the sea or outer space[2]. The robot also can be found in the Auto, Military, Manufacturing, Medical and Space Industries.

Hexapod is the robot that belongs to the robot family that has six-legged and can move flexibly and stably on various terrains. The advantages of this robot is due to its high stability because it can stand stable in the static position with three or more legs[3]. This robot can be applied on many applications in real life such as search and rescue operations or environment exploration.

In this project, hexapod robot will be built and analyzed on its legs angle on certain trajectory using tripod gait movement. The structure of hexapod is drawn and simulated using SolidWorks software. Since the hexapod robot in this project is travel on flat surface, the robot is built with two degree of freedom on each of its legs is sufficient to use in this project.

This report consisted of five chapters where Chapter 1 provides an overview of the whole project. The Chapter 2 reviews the previous design which highlight the past studies and theories that related to hexapod robot. In another chapter, Chapter 3 is project

methodology which describes the techniques that are used in this project. The Chapter 4 elucidates results of this project and discussion will be given. Lastly, Chapter 5 summarized the whole of the project and provides some recommendation for the future works which are related to this project.

1.2 Motivation

Every year, the news of reporting natural disaster is drastically increases. Most of the natural disasters result in severe property damages or loss of life. The first things need to be done is to start searching and rescuing operations after the disaster. During search-and-rescue mission, every second are crucial for the victims to survive. However, the rescue mission becomes extremely hard as the land covered with debris. The following figure shows the rescue workers searching for the survivors and bodies after the tsunami and earthquake in Japan.

Figure 1.1: Japanese Rescue Workers Carry A Body of Victim[4]

There are different types of technique have been introduced and applied in the search and rescue mission such as search-and-rescue dogs or modern equipment. However, some of these techniques are not efficient. Wheel vehicle can no longer be operated unless the debris are been cleared off and cause Golden Hour of rescue time is wasted. Different with wheel mobile robot, legged mobile robot can travel through these complex terrains with ease. Besides, legged robot can function just like cockroaches that can maneuver through holes between the debris. Thus, using legged robot can highly increase the efficiency of the rescue operations as it can help to maximize the rescue number of victim in shortest period. Hexapod is an ideal robot in search and rescue mission as it has the highest stability among all legged mobile robot.

1.3 Problem Statement

Currently, legged robot design has become one of the popular topics in the field of robotics research. There are various hexapod designs available either for research work or for the commercial purpose. Compared with the wheeled robots, the legged robots such as hexapod have higher adaptability and stability to the surroundings especially to maneuver through uneven terrain.

Legs are used to support body. Hexapod is a six-legged robot. In other words, it has complex coordination between legs during walking. In order to control the hexapod to move stably, different types of researches have been done to increase the overall performance of hexapod. However, the current research is more focus on design and locomotion of the hexapod. For the research on the angle analysis on hexapod legs has not widely been done in current research. In this project, the angle analysis using tripod gait movement is mainly focuses. The leg angle is an important part as it is closely related to the overall performance of the robot. Therefore, it is crucial to select the right angle for the motion.

The legs of the hexapod in this project are controlled by using Fuzzy Logic Controller. Fuzzy Logic is simple and fast to implement and able to handle the uncertain data that received from infrared sensors. Different angle of the leg are analyzed during it maneuver on certain trajectory to get the right angle that suits for each movement in this project.

1.4 Objectives

The main objectives of this project are listed as follow:

1. To design and identify parameters of the hexapod using SolidWorks software.
2. To develop a hexapod robot that can maneuver along a specified path.
3. To analyze the legs angle of hexapod robot when moves on certain trajectory.

1.5 Scope

The scopes of works in this project are:

1. This hexapod is a line following robot that utilizes Fuzzy Logic Controller (FLC).
2. The study and analysis focus on the legs movement of the hexapod during forward and turning movement.
3. The tripod gait is chosen as gait movement of this hexapod project.
4. Angle of 10°, 15°, 20° and 25° are only tested in this project.

Assumptions in this project:

1. This hexapod only moves in forward movement.
2. Turning movement is done based on the fuzzy rules set.

Limitations of this project:

1. This hexapod can maneuver only on the flat surface.
2. Each leg of the robot is considered as two degree of freedom mechanism.
3. The speed of hexapod is not considered due to it is only use for research purpose.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The previous chapter focused on a general view of the entire project. In this chapter, past studies related to hexapod are highlighted. The mechanism of hexapod robot which is a six-legged robot is thoroughly studied. The advantages of this type of robot are it can provide higher flexibility and stability in an uneven environment which wheeled robot cannot be compared with. A lot of researches have been done on legged robot in order to get the best locomotion for an autonomous robot[5]. Hexapod is the most efficient statically stable in walking among the legged robot as the speed will not increase with legs more than six[3].

2.2 Mechanism of Hexapods

2.2.1 Literature Review on the Hexapod Design

Generally, hexapod can be grouped into two types which are rectangular and hexagonal. Rectangular hexapod has a rectangular body with three pairs of legs installed symmetrically on sides. Hexagonal hexapod has a round or hexagonal shape with legs distributed equally[5].

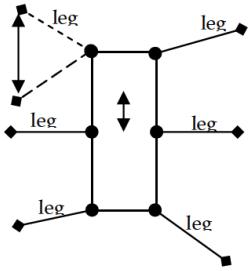


Figure 2.1(a): Rectangular Hexapod[5]

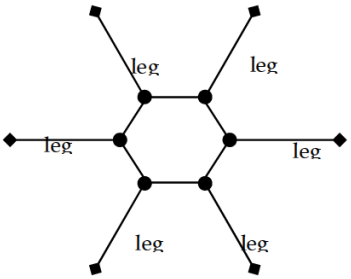


Figure 2.1(b): Hexagonal Hexapod[5]

2.2.2 Literature Review on the Structure of Hexapod's Legs

There are a lot of hexapod designs based on biomimicry concept. Biomimicry imitates the nature of living organism with the purpose of solving complex problems[6]. According to [7], natural structure has better function and higher adaptability to environment changes than the man-made mechanical equipment. In order to design a bionic hexapod, the model of insect can be referred to get the ideal mechanical structures[6]. The model of cockroaches is taken as an example. As shown in Figure 2.2(a), the cockroach's body has three primary regions - (i) the head, (ii) the thorax, (iii) the abdomen. All of its legs are attached at thorax region. The structure of legs can be divided into five main segments which are Coxa, Trochanter, Femur, Tibia and Tarsus[8].

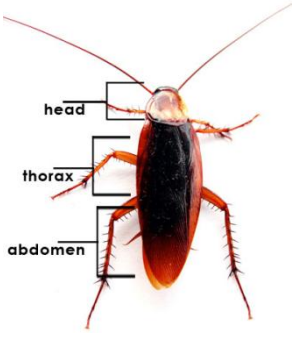


Figure 2.2(a): Primary Region of Cockroach Body[8]

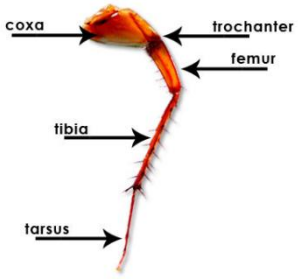


Figure 2.2(b): Structure of Cockroach Leg[8]

2.3 Gait Movement of Hexapod

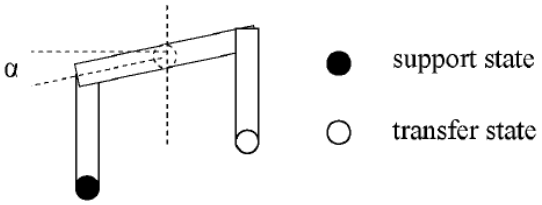
Gait analysis is the study of the moving pattern that depends on the body's mobility, stability, flexibility and strength[9]. A hexapod has different types of gaits which help it to stabilize it statically during moving. The regular gaits can be classified into (X + Y) gait (X = 3, 4, 5; Y = 3, 2, 1). X stands for the number of supporting legs on ground whereas Y stands for transferring state of legs. Tripod gait gives high speeds as it forms a tripod support for body whereas quadruped gait gives lower speeds[5].

Table 2.1: Comparison of Gaits[5]

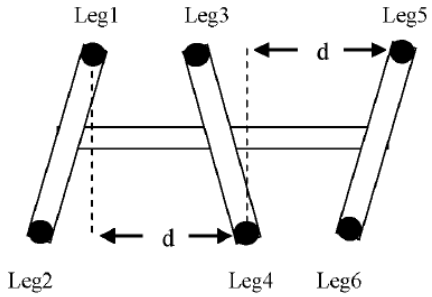
Gait	Moving Pattern	Duty Factor β	Advantages
3+3	Three legs lifting off, three legs supporting	1/2	Quick and Stable
4+2	Two legs (one leg from left side, one leg from right side) lifting off, four legs supporting	2/3	Fault Tolerant Ability
5+1	One leg lifting off one by one, five legs supporting forming clockwise or counterclockwise order	2/3	-
Free	Non-fixed pattern	-	High flexible and adaptive than periodic and regular gaits

2.3.1 3+3 Tripod Gait

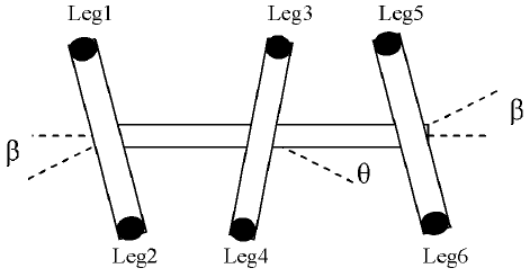
In order for a robot to move forward using this type of gait, three out of six legs need to be lifted off from the ground and another three legs applied a backward force to achieve a forward movement[10].



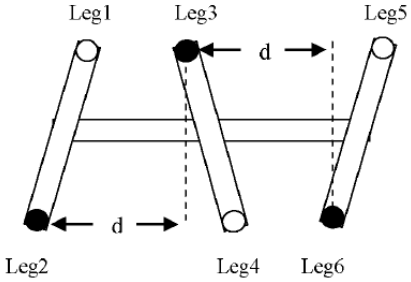
Front View of A Pair of Robot Legs



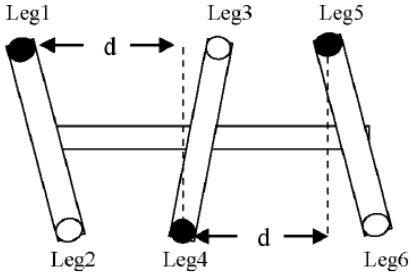
Leg2, Leg3 and Leg 6 Support on Ground



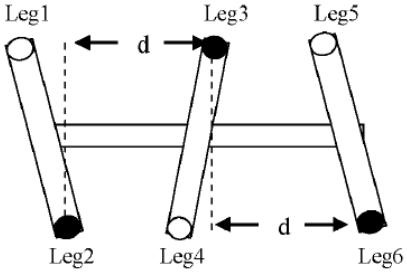
Top View of the Hexapod Robot



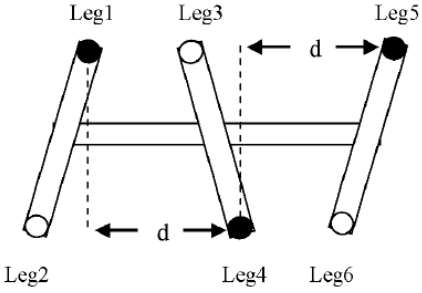
Lift Leg1, Leg4 and Leg5



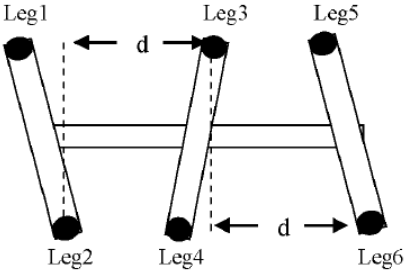
Lift Leg2, Leg3 and Leg6



Body Move Forward



Body Move Forward



Leg1, Leg4 and Leg5 Support on Ground

Figure 2.3: 3+3 Tripod Gait Movement[10]