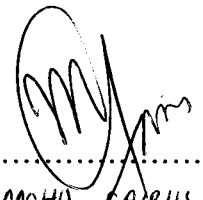
"I hereby declared that I have read through this report and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Control, Instrumentation and Automation)""



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DESIGN A DIPEDAL WALKER ROBOT

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This Report Is Submitted In Partial Fulfillment Of Requirement For Degree Of
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(Control, Instrumentation and Automation)

Faculty Of Electrical Engineering
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May 2008

"I hereby that this report is a result of my own work except for the excepts that have been cited clearly in the references"

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Thank you.

ABSTRAK

As we know, the world of technology nowadays is advancing in a faster pace each days. Now, our common use tool has entered a digital phase where everything is computerized. Same as in robotic and automation field because they have been used for industrial purpose and also popular by replacing human to do some work which is cannot do by human, for example in a chemical work, lift heavy thing and many more. One of the purposes to make a design of this bipedal robot is to create advance robot in this technology world by using microcontroller. Furthermore, the use of legged humanoid robot has been gaining popularity in hospitality industry. The technology for building legged robot can be implemented to build motorized prosthetics for the handicaps. The numerous advantages of building a legged robot especially biped robot, justified the need to built one. This will cover much different experiment with different control techniques to investigate how the robot will move. To resolve the validity of the circuit, the confirmation will be done by simulate the circuit. This robot use 16F84 microcontroller which have been programmed using microcontroller software to control every each movement. Bipedal robot is look like a human being because they have two legs to walk. The muscle for motion is to generated using HS-322 servomotor. This project is prepared when interfacings the microcontroller with two servos, but the combination of six servos can not make them move smoothly. Accordingly the parts need to upgrade and fixes for smooth motion of motors.

ABSTRAK

Seperti yang kita ketahui, teknologi dunia pada masa kini telah berkembang dengan pesat setiap hari. Sekarang, alatan asas yang sering di gunakan telah memasuki fasa digital dimana telah menggunakan system berkomputer. Sama juga dalam industri automasi dan robot yang mana penggunaannya amat meluas dalam menggantikan manusia dalam melakukan sesuatu kerja yang diluar kemampuan manusia itu sendiri seperti di kawasan yang mengandungi bahan kimia, untuk mengangkat benda berat dan sebagainya. Salah satu tujuan untuk mereka satu robot berjalan yang menggunakan dua kaki ialah untuk membuktikan robot yang yang boleh berfungsi dalam dunia yang berteknologi ini dengan menggunakan mikro pengawal (microcontroller). Penggunaan robot berkaki, terutamanya berkaki dua yang berupa manusia semakin popular di sektor hospitaliti. Teknologi pembinaan robot berkaki boleh digunakan untuk membina kaki palsu bermotor untuk kegunaan golongan kurang upaya. Memandangkan kelebihan robot berkaki yang begitu ketara berbanding robot beroda, adalah wajar usaha untuk membinanya. Projek ini juga merupakan satu eksperimen untuk mengkaji bagaimana sesuatu robot dapat bergerak. Simulasi dapat dilakukan untuk menentusahkan keberfungsian litar. Robot ini menggunakan mikro pengawal (microcontroller) jenis 16F84 yang telah diprogramkan dengan menggunakan perisian mikro pengawal untuk menentukan pergerakannya. Robot berkaki dua ini juga kelihatan seperti manusia kerana mempunyai dua kaki untuk bergerak. Pergelangan kaki robot tersebut dapat digerakkan dengan menggunakan servo motor. Robot telah dapat disediakan dan boleh di gabungkan antara mikropengawal dan dua servo, tetapi gabungan enam servomotor tidak dapat menggerakkan servo dengan lancar. Berikutan tersebut, robot ini perlu ditingkatkan dan diubah suai untuk kelancaran perjalanan motor.

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CHAPTER 1

INTRODUCTION

This chapter will discuss on the term robots. It will be discus of what is a robot, types of robots that have been built and its usage and why building a biped robot instead of a wheeled robot or a hexapod. The objectives of this thesis and a brief review on some of the robots built worldwide will also be presented in this chapter.

1.1 Introduction To The Project

Nowadays, the world has change into a global world where mostly the entire common tool has change into a digital phase where everything is computerized. Also in robotic and automation field, many robots and machines are designed in this pace of day. In the past, mobile robot were controlled by heavy, large and expensive computer system that could not carried and had to be linked via cable or wireless devices. Today, people can build robot with numerous actuator and sensor that are controlled by inexpensive, small and light embedded computer system that are carried on-board the robot. This project will develop a bipedal walker robot by using PIC as its controller. This also will prove the reliability of PIC to control all the movement of the robot by using the microcontroller software.

There are many definitions of robots according to the points of view. Some view a robot through the aspect of reprogram ability while others more concern on the manipulation of the robot, behaviors, intelligence and so on. There are two type of robot which is mobile robot and legged robot.

1.2 Robot

Basically, robots can be classified into two categories that are mobile robot and legged robot. Fixed robot is a robot mounted on fixed surface and the working materials are brought to the work space. A mobile robot moves from one place to another to do their task. The mobility of a robot is the robot's capability to move from one place to another in unstructured environments to a desired target. Mobile robots may further categorized into wheeled, tracked or legged robot.

Mobile robots are mostly used in difficult task and dangerous environment such as bomb defusing. Besides that, mobile robots are also used in manufacturing area and agriculture related activity such as in placing the seeds in the soil and fruit harvesting.

Legged robots are grouped into different categories based on the number of legs a robot had. The robots are called biped, quadruped, hexapod for robots with two legs, four legs and six legs respectively. Biped and quadruped robots are most common today. Nevertheless there are one-legged, six-legged and eight-legged robots as well. The number of legs affects the stability and weight of the robot which must be taken into considerations when designing a legged robot.

There are three actuating systems for a legged robot. They are pneumatic, hydraulic and electrical systems. Each of the systems has its advantages and disadvantages regarding to the power to weight ratio, cheapness, cleanliness, controllability and availability in the market. The degrees of freedom (DOF) of each leg and the number of legs a robot has determined the mobility and capability of the robot, and suggest whether it can move through one dimensional, two dimensional or three dimensional path.

1.3 Project Objective

The main objective of this project is to design and construct a biped robot that has the ability to walk forward on a flat plane. One of the purposes to make bipedal robot is to create advance robot in this technology world by using microcontroller. This will cover much different experiment with different control techniques to investigate how the robot will move.

There are three secondary objectives to be achieved in order to achieve the main objective stated above. The three secondary objectives are discussed in the following paragraph.

First, the objective is to design and constructs the actuators of the robot. The frame and actuators of the biped robot are to be designed and fabricated. The parts needed are to be decided, purchased, fabricate and assembled. Other than that, is to design the electronic circuit of the robot. The controller circuitry and the motor power supply circuitry are to be designed. The components needed are to be identified purchased. The circuits are to be fabricated and tested for reliability. Besides, the cause of making this bipedal walker robot is to design and create programming as controller of the robot. A program to implement the walking gait of the robot is to be written and loaded into the microcontroller.

Furthermore, the use of legged humanoid robot has been gaining popularity in hospitality industry. The technology for building legged robot can be implemented to build motorized prosthetics for the handicaps. It can help many patients in hospital to do their treatment using this kind of robot. The numerous advantages of building a legged robot especially biped robot, justified the need to built one.

1.4 Problem Statement

There are some problems to achieve the objective of developing and designing this robot because this walking robot typically has complex locomotion in control the leg in order to complete this task. The major objective of develop this robot is to study the stability of the robot by controlling the angle movement of the servomotor. According to the task, a bipedal walker robot is hard to stabilized because it only has two leg to stand and hard to control it when it start to move. So, in present invention to develop this robot, the centre of gravity and using the appropriate component were giving more attention.

Then, the use of PIC microcontroller also difficult because it need to used certain language to program it. So, much time has been used in order to study the language for the programming and the part of structure of PIC. Other than that, the suitable robot's design must be created before make the real walker robot to apply controller system. This robot is designed by using microcontroller compiler and PIC programming (CCS Programming). Besides, the circuit to control the servomotor also must work properly because without this controller the robot cannot move. Finally, this project will cover up about the circuit, component chosen, use PIC software, programmed the PIC and develop the hardware.

There are also some problem in order to choose better robot either mobile or legged robot. But, there are some reasons to build a biped robot instead of a wheeled, tracked, quadruped or a hexapod robot. The most important considerations are the mobility of the robot. Although, wheeled or tracked robots are viewed to be mobile and cheap, it is only true on paved or smoothed track only. To use these vehicles, expensive paved road will have to be built thus increasing the cost. The advantages of the wheeled and tracked robot will vanish as soon as they are used on a rough, cracked or a soft surface.

The movement of each leg for legged robot will consume more energy, time and required complicated systems to achieved full locomotion. But on the other

hand, the advantages of a biped robot are the flexibility over a terrain full of breaches, holes or obstacles and require small foothold area. For the unpaved terrain, legged robot especially biped robot has many advantages comparing with other categories of mobile robot as discussed in the following paragraph.

Greater mobility is the most significant advantages of biped robot compare to wheeled robot. It is easier for a biped robot to plan through tight space compare to wheeled or tracked robots which needs big spaces to move around. With little modifications and improvements, a biped robot has access to places almost impossible to reach by wheeled robot like on creeks, soft areas or cracked areas. These places which are difficult to access, are where the service of the robot are most likely needed, like for the search and rescue operation in land slide site. A biped robot has a shorter response time because a biped robot can walk over an obstacle without having to detour to avoid the obstacle.

On the other hand, a wheeled robot needs to find an alternative route around the obstacles which is impractical in real world. The walking gait of a biped robot is much smoother, where a biped robot can walk over uneven terrain with no difficulty. The operation of a biped robot cause lesser damage to the environment compared to wheeled robots, tracked robots or robots with greater number of legs. A biped robot's foothold is much smaller compare to wheeled or tracked robot, whose wheel and track cause much damage to the ground.

The second consideration in deciding to build a biped robot is due to the fact that humanoid robot is a fast emerging trend worldwide especially in Japan compare to the dull looking robot of the past. Humanoid robots have wider application in hospitality and service field. Biped robot with the ability to move around, obstacles avoidance, stair climbing and have intelligence are suitable to be used in homes to do household chores or even to look after the elderly and disabled.

The technology in building the actuators of the biped robot can be implemented to build prosthetics for the disabled. Honda Corporation of Japan, with the knowledge they gained from building Asimo, had come out with a prototype of

motorized prosthetics for disabled. This is indeed a great breakthrough in engineering and medical field.

The quadruped and hexapod robot category is saturated with lots of quadruped and hexapod robots built around the world. The building of eight or more legged robot is almost impractical because it involves huge investment and complexity while the one legged robot has limited applications. The building of biped robot is rather new. Hence, building a biped robot is an obvious choice considering the advantages discussed above and the novelty of building it.

1.5 Scope of Work

This project is divided into software and hardware. Both of them have its own criteria and scope of the project. The hardware is more focus on the electrical controller circuit and mechanical part. However, the software more focuses on the language and using the right microcontroller compiler.

The hardware criteria are:

- Specific to leg and walker robot.
- Using 6 servomotors
- As bipedal walker stand, it can only walk forward.
- Use PIC 16F84 microcontroller to control every each of the movement.
- Have controller circuit to control the servomotors.

The software is about:

- Make use of Microcontroller software as microcontroller compiler to program the PIC 16F84.
- Apply right language to the programming
- Make the bipedal programming and compiled.
- Program it into the PIC

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Recently, numerous people are interested to study the bipedal walker robot and also the demand to build biped robots have increased. However, there is little information about the bipedal robot design process when search through the internet. There also have some researches that have analysis to make some comparison for the system that already use for this robotic and automation field. This literature review is done to give more information according to this project. The journals will give much reason, theory and how to solve some of the problem in order to develop this robot. The research should be done to make sure all the requirements aspect will be covered to make the design of the robot success.

This bipedal robot is hard to find ways to stabilize itself when it started to walk. So, this research can help ways to solve it.

Further, the researches also help to find the suitable component to be used. For example in choosing the motor for the robot, it better used servomotor compared to stepper motor. Both of them have it own advantages and disadvantages.

Subsequently, there are many of PIC microcontrollers that have been use to send the data programming to the IC such as PIC16F84 and PIC16F877. From the research, the Peripheral Interface Controller has been used because it has more advantages.

2.2 History of Biped Robotics

The first recorded design of a humanoid robot was made by Leonardo da Vinci in 1495. The robot is a knight, clad in German-Italian medieval armor, which is apparently able to make several human-like motions. These motions include standing up, moving its arms, neck and an anatomically correct jaw. It is partially the fruit of Leonardo's anatomical research in the Canon of Proportions as described in the Vitruvian man 1. This fact was rediscovered from Leonardo's notebooks in the 1950s.

In the 20th century the first computer controlled humanoid robot was designed and built at the Waseda University in 1967, which was called Wabot-1. At that time the technology of the robot was very impressive and the robot is able to make step in only 45 second as well as gripping hands with tactile sensors, and a vision system and a communication system. The realization of this first humanoid robot influenced lots of engineers and scientists around the world to orient their research to this subject.

There are many humanoid projects that continue around the globe, although the eastern countries, like Korea or Japan.There are some of the past bipedal projects:

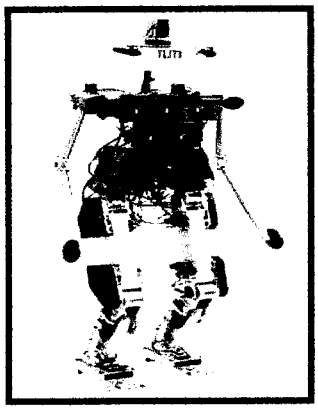

Figure 2.1: Humanoid robot Johnnie of the University of Munich

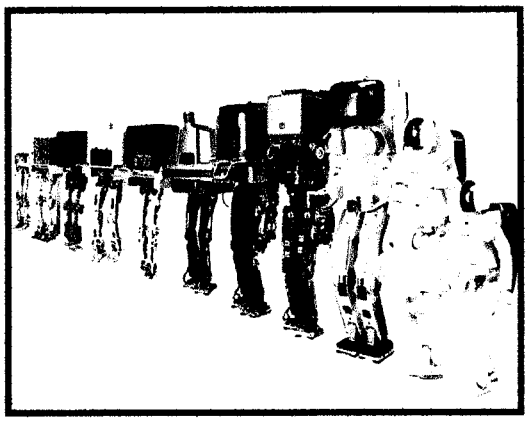

Figure 2.2: Honda's humanoid project since 1986.

The robot's hardware design has a huge influence in order to obtain a reliable bipedal walker robot. According to Steven H. Collins, Martijn Wisse and Andy Ruina there is four things need to focus in order to stabilize the walker robot. It is:

1. Foot bottoms shaped to guide lateral motion;
2. Soft heels to reduce instability at heel strike;
3. Counter-swinging arms to negate yaw induced by leg swinging.
4. Lateral-swinging arms to stabilize side-to-side lean.

The journal from the writers also focus on the mechanical structure design must always attempt an adequate robot's proportions. For that reason, mass distributions, CM (Center of mass) location and the actuators selection are important stage on the mechanical structure design and have a direct impact on the robot's performance. The key of the mechanical stability of a biped robot is an adequate CM (Center of mass) location. The CM (also called centroid) is the point in a system of bodies or an extended body at which the mass of the system may be considered to be concentrated and at which external forces may be considered to be applied. The CM is determined during the mass distribution process.

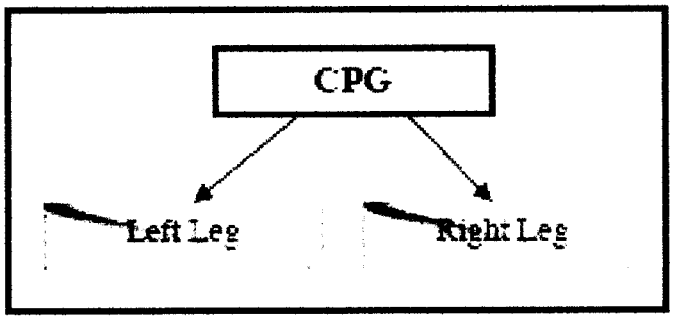

Figure 2.3: Symmetrical neural networks. The Centre Point Gravity

From journal of Seiichi Miyakoshi1, Gentaro Taga2 and Yasuo Kuniyoshi, the writers more focus on the degrees of freedom and structure of the system to make it more stable. From the picture given, there is the degree of freedom that has been obtained.

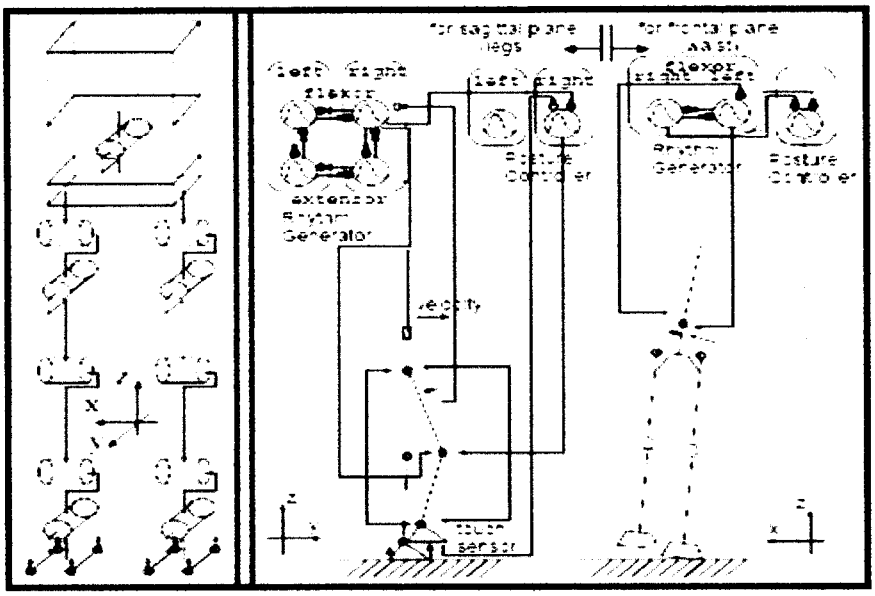

Figure 2.4: Distribution of degrees of freedom and structure of the system

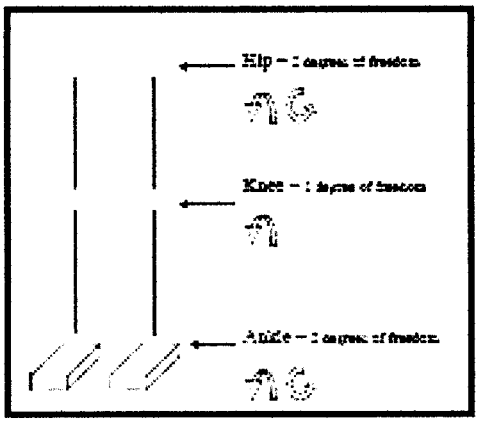

Figure 2.5: Degree of freedom