MECHANICAL DESIGN OF SIX LEGGED WALKING ROBOT

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Universiti Malaysia Sarawak

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This project report attached, entitled " **MECHANICAL DESIGN OF SIX LEGGED WALKING ROBOT**" prepared and submitted by Ng Wee Meng as a partial fulfillment of the requirement for the degree of bachelor of Engineering with Honours (Mechanical Engineering and manufacturing System) is hereby read and approved by:

Date : 3/11/2002

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NG WEE MENG

Thesis Submitted to the Faculty of Engineering,
University Malaysia Sarawak
as a partial fulfillment of the Degree of
Bachelor of Engineering with Honours
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Dedicated To My Beloved Family

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ABSTRACT

The mechanical design of six legged walking robot is presented in this report. The model of six legged walking robot is built for studying some of the method requirement and consideration in a walking robot design. The objective of this project is to design a six legged walking robot use the concept of robotic through literature study. The study, which include the basic mechanical design, material selection, walking gait selection and a little bit in kinematics movement. At the mechanical design, a basic robot frame and leg is built and assemble together. Material selection for each part of the walking robot also be consider so that can fulfill the requirement of the walking robot. In the walking gait, suitable walking gait for the robot is choose so that the robot can perform well in the movement. Kinematics calculation is needed in the analysis of the leg movement of the robot. By the end of the project, a better understanding of 6 legged walking robot shall be achieved.

ABSTRAK

Reka bentuk mekanikal untuk robot gerak berkaki enam telah dipersembahkan dalam laporan ini. Satu model robot gerak berkaki enam telah dihasilkan untuk mengkaji beberapa syarat dalam mereka bentuk robot gerak berkaki enam. Objektif utama project ini adalah untuk mereka satu model robot gerak berkaki lima berdasarkan konsept robotik melalui kajian literature. Antara kajian dalam mereka bentuk projek ini adalah reka bentuk robot yang sesuai, bahan pilihan, jenis pergerakan dan kajian dalam pergerakan menggunakan formula kinematik. Dalam bahagian reka bentuk robot, bahagian badan dan kaki robot telah dihasilkan dan dicantumkan. Pilihan bahan untuk setiap bahagian adalah penting bagi membolehkan menghasilkan robot gerak yang sempurna. Beberapa jenis pergerakan robot telah dicuba bagi mendapat pergerakan yang paling sesuai untuk diimplikasikan dalm projek ini. Kajian kinematik adalah perlu untuk menganalisis kan pergerakan robot. Perfahaman kajian terhadap robot gerak berkaki 6 harus dicapai di pengakhiran projek ini

LIST OF FIGURE

CHAPTER 1

INTRODUCTION

1.1 Introduction to Robot

A robot is a reprogrammable, multi-functional manipulator designed to move material parts, tools, or specialized devices through variable programmed motion for the performance of a variety of tasks. Improvements in controller power and robot design have allowed robots to be used in a number of different industries including nuclear power, forestry, defense, automotive and others. Basically there is 5 main type of robot construction. There are

1. Articulating robot (SCARA robot) - robot that have 6 degree of freedom.

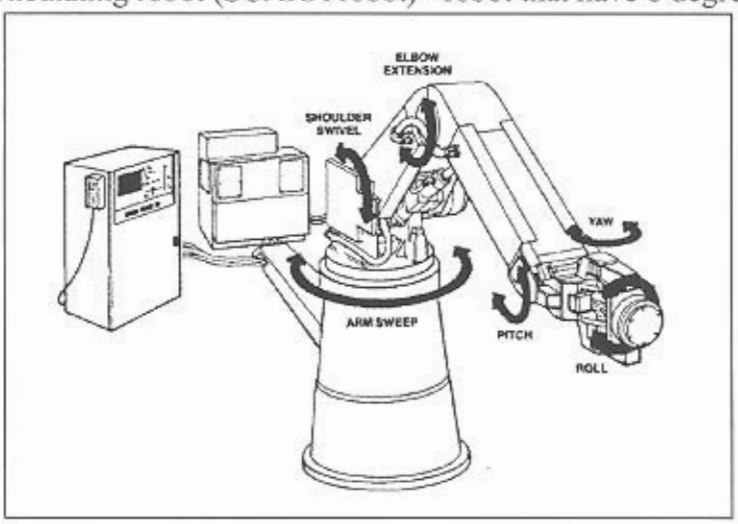

Figure 1.1 The six degree-of-freedom SCARA robot (source : Robot Geometric & Kinematics By V. Kumar)

2. Polar robot- robot without third axis (elbow extension).

3. Cylindrical robot- robot which has a vertical reciprocating axis for its second degree of freedom (base extension)

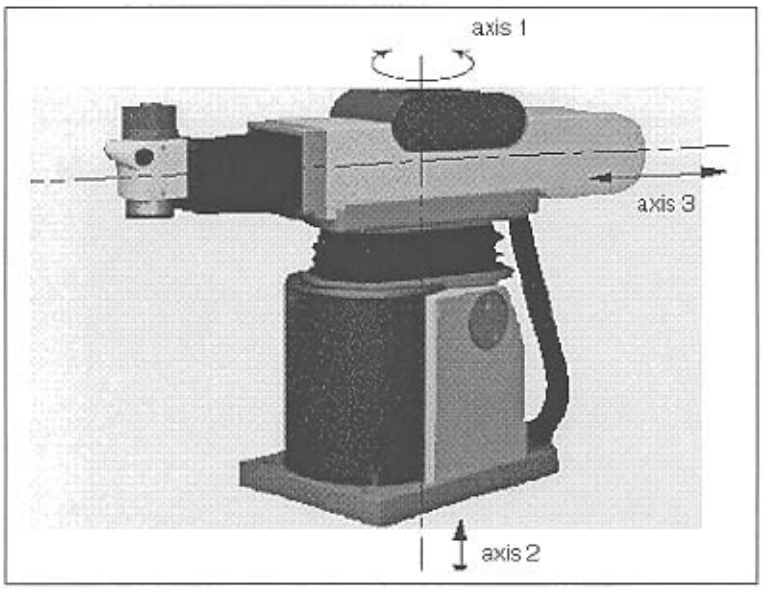

Figure 1.2 cylindrical robot (source : Robot Geometric & Kinematics By V. Kumar)

4. Cartesian Robot – robot which have 6 degree of freedom with capability to move at 3 dimension (x, y ,z) position.

5. Mobile Robot – robot that can walk on legs or move by wheel. (Refer to 1.2 for introduction to mobile robot)

In today's world, the main uses of robots are in ;

a. Exploration

People will built robot to do some exploration job. Example like doing exploration at outer space and deep ocean. People sometime have the flexibility to access these dangerous areas.. The robots are able to carry cameras and other instruments so that they can collect information and data.

b. **Industry**

A number of manufacturing industry today use robot. Comparison with human labor, robot can do repetitive work with high accuracy and it will also not feel bored like human. Industries like automobile assembly plant and electronic firm use variant type of robot in do daily job operation in the production floor.

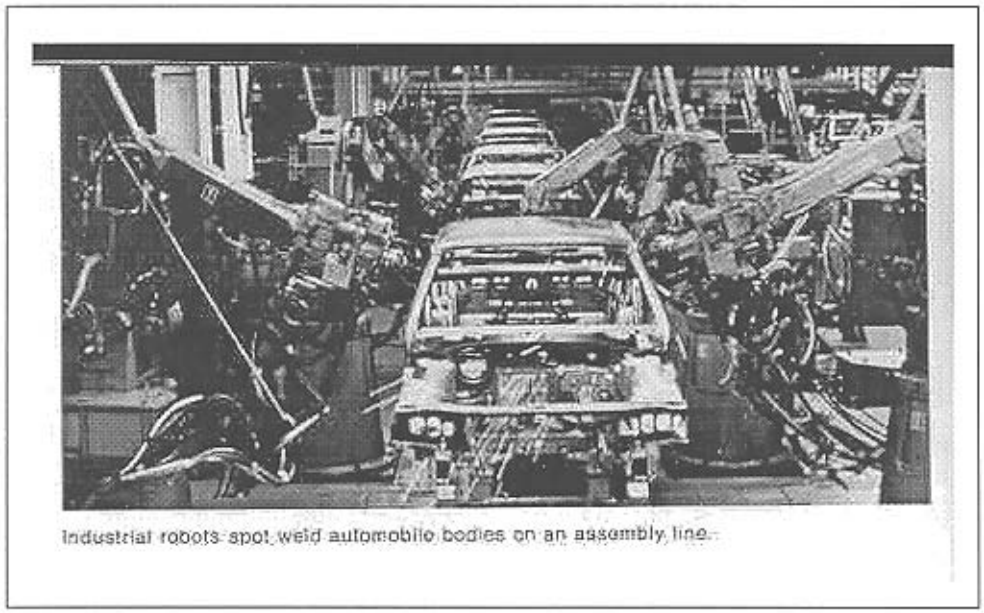

Figure 1.3 Industrial robots spot weld in automobile assembly line (source : Toyota Industry plant, Japan)

c. **Medicine**

In the medical field, robot are carry out used to operations that human doctors cannot do. For example like, operation in the human body which require a very critical task. When making medicines distribution, robots can do the job much faster and more accurately.

d. Military & Police

Police need certain types of robots for bomb-disposal and for bringing video cameras and microphones into dangerous areas, where a human policeman might get hurt or killed. The military also uses robots for (1) locating and destroying mines on land and in water, (2) entering enemy bases to gather information, and (3) spying on enemy troops

e. Entertainment & Toys

The robot also available in the entertainment and toys. At first, robots where just for entertainment, but as better technology became available, real robots were created. Many robots are still seen on television for entertainment. The new robot technology is making interesting types of toys that children will like to play with. High technology has enable not only the making of static robot but also robot that can imitate animal action such as cat & dog. These type of robot can perform certain activities and used as pet in some countries like Japan.

Figure 1.4 Sony robot dogs (source: Sony Robotic, Japan)

1.2 Introduction to Mobile Robot

Mobile robot is the type of robot that move with legs or wheel. Mobile robot can be seen in industries such as,

a. Underground mining

b. Space exploration

c. Nuclear accident cleanup

d. Demolition

e. Fire damage inspection

f. Sea floor exploration

g. Sentry duty.

There is 2 types of mobile Robot, (1) legged model and (2) wheeled model. The legged model has the advantage to travel on uneven surface better then wheeled model. The wheeled models normally used as automatic material handling system and as interoffice mail delivery system. The wheel models are easy to control and direct. It provides a stable base on which a robot can maneuver and is easy to build. Wheeled models only suitable for operation in controlled environments like in flat surface. The legged model mobile robot is suitable in all type of working environment include rocky or hilly terrain, which might be found in such applications as forestry, waste clean-up and planetary exploration

Figure 1.5 & 1.6 show the wheeled and legged mobile robot.

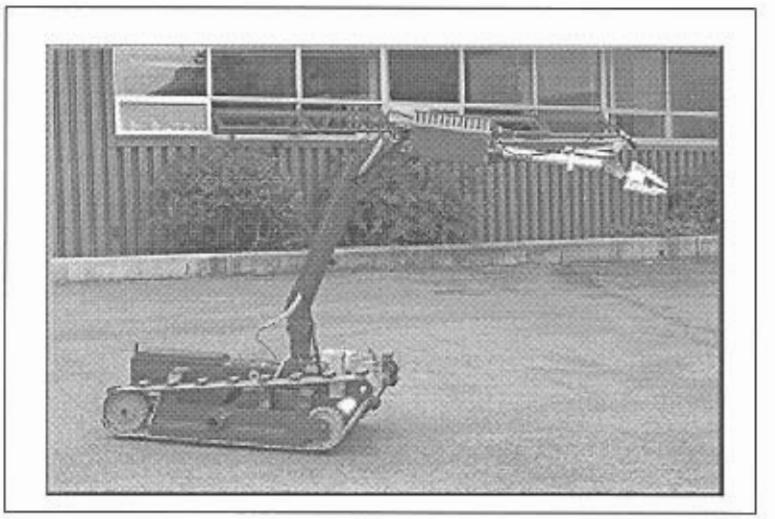

Figure 1.5 A wheel type mobile robot which use in military action.(source : US military)

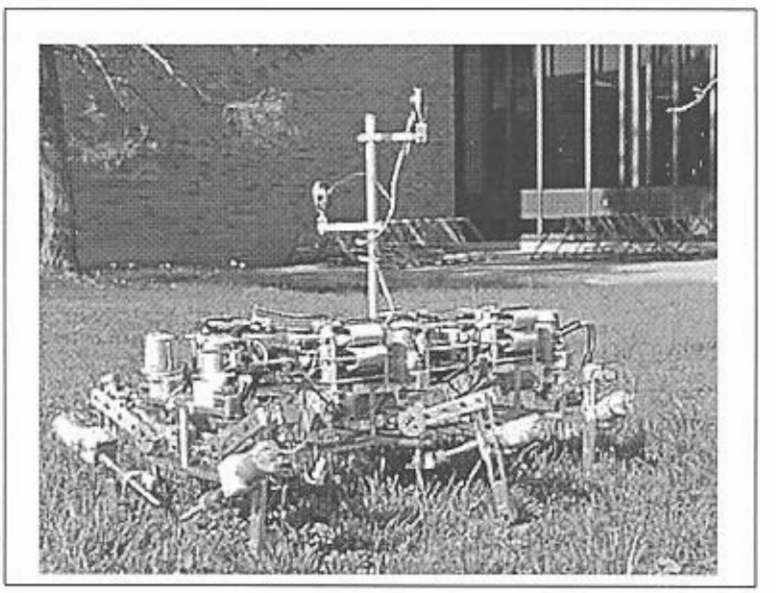

Figure 1.6 A leg type mobile robot (source : Hexotica walking robot, University of waterloo, Canada)

1.3 Introduction to the Project

The project is to build a walking robot with six legs. The structure that designed will mainly consist of body and robot legs. It will be designed such that it could support its own weight and tolerate stress while it walks. The movement mechanism must allow the robot to walk in straight.

Kinematics path study control method will be used for guidance to find the best robot legs movement. A good mechanical design will facilitate all future work and will minimize the need for redesign. A good leg design will allow for simple and adaptive control of the robot's motion.

The mechanical structure of the robot consists of one main body frame to carry load and six similar legs symmetrically located on the body composed of 2 links, interconnected by 2 revolute joints and attached to the main body. Servo motors will be used as movement mechanized of the system

6 bilateral symmetric legs is chosen because the 6 legs will give more stability when it move in a straight line compare to 4 or 2 legs robot (Adam Currier ,1986). Another advantage of six legs is it capable to make a stable turning motion. The legs will be using 2 degrees of freedom to make a movement. The motion are forward, backward, up and down

The main body dimensions is approximately 300mm length, 200 width and 120mm height. The total weight estimated as 1.45 Kg.

Figure 1.7 & 1.8 show the basic mechanical design of the project

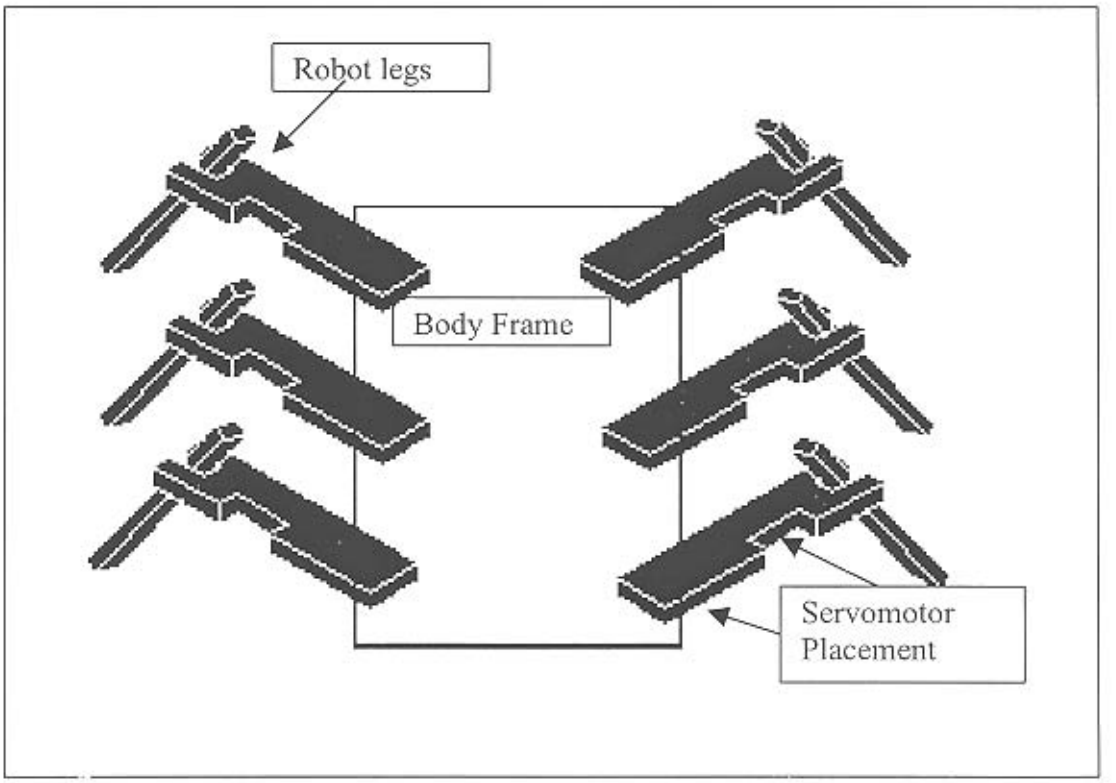

Figure 1.7 Basic Mechanical design of the walking robot.

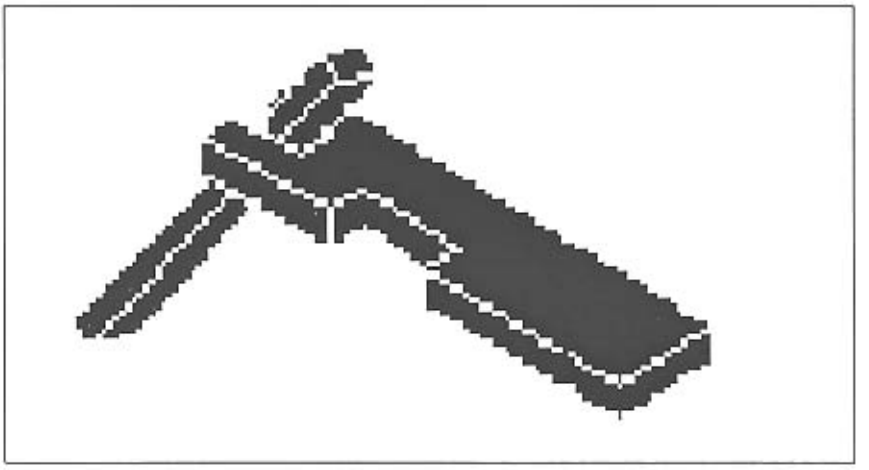

Figure 1.8 Robot legs Configuration

1.4 The Objective Of the Research

Objective of the Research

1. To design and implement a legged robot using servo motor.
2. To design robot legs which suite to the proposal design.
3. To study the movement of the robot legs using kinematics method.
4. To study the working gait of the robot legs which suite to the proposal design.

CHAPTER 2

LITERATURE REVIEW

2.1 The Previous Research of Mobile Robot

Research of the mobile robot was started on 1960 by by Nikola Tesla (Adam Currie, 1985) when he built a remote control vehicle. Tesla is the best known inventor of AC electric power, radio (before Marconi), induction motors, Tesla coils, and other electrical devices (Adam Currie, 1985)

The students from Stanford Research Institute (SRI) in Palo Alto, California in the 1960s is built a robot called "Shakey". It was a small unstable box on wheels that used memory and logical reasoning to solve problems and navigate in its environment.

The General Electric Walking Truck was a large (3,000 pounds) four legged robot that could walk up to four miles a hour. The walking truck was the first legged vehicle with a computer-brain, developed by Ralph Moser at General Electric Corp. in the 1960s. The first modern industrial robots were probably the "Unimates", created by George Devol and Joe Engleberger in the 1950's and 60's. Engleberger started the first robotics company, called "Unimation", and has been called the "father of robotics." (Issac Asimov & Joe Engleberger, 1979)

2.2 Robot legs design

The successful design of a legged robot depends to a large extent on the leg design chosen. Since all aspects of walking are ultimately governed by the physical limitations of the leg. It is important to select a leg that will allow for a maximum range of motion and that will not impose unnecessary constraints on the walking gait chosen. The first stage of the leg design process therefore consists of a search for an optimal leg design.

A survey of the literature shows that there are a number of different leg designs currently employed for walking robots. All have advantages and disadvantages and a few of the options considered are outlined here.

I Simple two-link leg

Variations on the simple two-link manipulator, shown in Figure below were considered as one potential leg design. This design consists of two links connected through a knee joint. The walking motion is accomplished by controlling the angle of the two links to position the end effector, or foot. The entire leg is mounted on a swiveling base in order to advance and retract the leg. There are a number of different ways in which the joints can be actuated, with the actuation of the knee joint being the major difference from one design to the next. Options include mounting the motor at the joint itself or using a pulley, chain or lead screw to set the angle of the knee using an actuator mounted near the base of the leg. The major drawback of this design is the necessity to actuate remote joints. Placing the actuator at the knee joint adds various dynamic effects to the leg which have to be compensated for by the controller. This adds complexity to the control algorithms needed to move the leg. It