NATIONAL TECHNICAL UNIVERSITY COLLEGE OF MALAYSIA

2-AXIS ROBOTIC ARM MANIPULATOR FOR EDUCATION

Thesis submitted in accordance with the requirements of the National Technical University College of Malaysia for the Degree of Bachelor of Engineering (Honours) Manufacturing (Process)

By

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APPROVAL

This thesis summitted to the senate of KUTKM and has been accepted as fulfillment of the requirement for the degree of Bachelor of Engineering (Honours) Manufacturing (Process). The members of the supervisory committee are as follows:

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ABSTRACT

Many principles in robotics field based on the human arm geometry. There are a lot of robot arms that have been created by human to make this life easier and all these arms not only for industrial using only but also for home entertainment or home appliances. In this project robot arm design have been attempted but most of them involve simulations. The goal for this project is to design and construct a two degree of freedom robot arm with two axis robot arm. This robot arm consists of joints at the base. The robot arm, which has been successfully designed, is able to perform a movement for educational purpose. The kinematics analysis of the robot arm is part of the design. The controller for a robot arm is the microcontroller system using Parallax board controller and computer software using Basic Stamp. The moving mechanism for this robot is using two servo motor. Hopefully this thesis will provide sufficient information for those who are interested in understanding the derivation of kinematics equations for two degree of freedom

ABSTRAK

Kebanyakan prinsip dalam bidang robotik adalah berdasarkan pada geometri lengan manusia. Terdapat pelbagai jenis lengan robot telah dicipta oleh manusia bagi tujuan memudahkan cara hidup dan lengan-lengan robot ini bukan sahaja untuk diaplikasikan dalam bidang industri malahan untuk tujuan hiburan dan penggunaan di rumah kediaman. Di dalam projek ini rekabentuk lengan robot yang telah dicipta hanyalah melibatkan simulasi. Tujuan projek ini adalah untuk merekabentuk dua darjah kebebasan pada dua axis lengan robot. Penyambung pada lengan robot ini terdiri daripada bahagian tapak. Robot ini pada akhirnya berjaya disiapkan, di mana ia berupaya melakukan pergerakan bebas untuk tujuan pengajaran dan pendidikan. Analisis kinematik juga diambil kira dalam rekabentuk lengan rorbot ini. Kawalan utama untuk lengan robot ini adalah pengawal mikro dengan menggunakan papan litar kawalan Parallax.dan perisian komputer dengan menggunakan Basic Stamp. Mekanisme pergerakan robot ini adalah menggunakan dua motor servo. Saya berharap agar tesis ini dapat memberikan maklumat yang mencukupi kepada sesiapa yang berminat dalam memahami persamaan kinematik dapat diperolehi daripada dua darjah kebebasan bagi lengan robot.

DEDICATION

I humbly dedicate this to :

My beloved family,

For their relentless prayers and believing in me when nobody else would

My Lecturers,

Thank You for guiding me in my journey to success

My friends,

Thank You for everything you'll did for me

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CHAPTER 1
INTRODUCTION

1.0 Introduction

Science and technology play a major role in Malaysia's dynamic industrialization. In the spirit of 'Malaysia incorporated' promulgated by the Prime Minister Dr. Mahathir Mohammad since 1983, the public and private sectors have been very supportive of science and technology developments in Malaysia. National awareness and interest in science and technology must be enhanced, as this constitutes a prerequisite for an inventive society. Inventing is a suitable approach to help make science and technology more interesting and relevant to the industries and economy. The spirit of inventiveness should be inculcated among Malaysians.

Robot, computer-controlled machine that is programmed to move, manipulates objects, and accomplishes work while interacting with its environment. Robots are able to perform repetitive tasks more quickly, cheaply, and accurately than humans. The term robot' originates from the Czech word *robota,* meaning "compulsory labor." It was first introduced in January 1921 play *R.U.R.* (Rossum's Universal Robots) in Prague by the Czech novelist and playwright Karel Capek pronounced chop'ek). The word robot has been used since to refer to a machine that performs work to assist people or work that humans find difficult or undesirable.

The term 'robotics' refers to the study and use of robots. The term was coined and first used by the Russian-bom American scientist and writer Isaac Asimov[3].

Asimov wrote prodigiously on a wide variety of subjects. He was best known for his many works of science fiction. The most include *I Robot* (1950), *The Foundation Trilogy* (1951-52), *Foundation's Edge* (1982), and *The Gods Themselves* (1972), which won both the Hugo and Nebula awards. One definition of robotics by Brady (1985) is:

"Robotics is the intelligent connection of perception to action."

From a different perspective, robotics is the discipline, which involves:

a) the design, manufacturing, control, and programming of robots;

b) the use of robots to solve problems;

c) the study of the control processes, sensors, and algorithms used in humans, animal, and machines; and

d) the application of these control processes and algorithms to the design of robots

A clear distinction must be made between robotics engineering and the science of robotics. Robotics engineering is concerned with the design, construction, and application of robots. While robots are built during the course of scientific research, the goal of robotics science is not the development of machines, but to understand the physical and information processes underlying perception and action. Once basic principles are established, they can be used in the designed of robots.

The word 'robotics' was first used in Runaround, a short story published in 1942. I Robot, a collection of several of these stories, was published in 1950. Asimov also proposed his three "Laws of Robotics", and he later added a 'zeroth law'.

Law Zero

A robot may not injure humanity, or, through inaction, allow humanity to become to harm.

Law One

A robot may not injure a human being, or, through inaction, allow a human being to come to harm. unless this would violate a higher order law.

Law Two

A robot must obey orders given it by human beings, except where such orders would conflict with higher order law.

Law Three

A robot must protect its own existence as long as such protection does not conflict with a higher order law.

This definition was previously the German definition. It provides a clear distinction between pick-and-place robots which race from point to point at full speed and those robots where path control between points is provided.

Obviously, this was a committee-written definition. It's rather dry and uninspiring. Better ones for robotics might include:

i. Force through intelligence.

ii. Where AI (Artificial Intelligence) meet the real world

"An automatic apparatus or device that performs functions ordinarily ascribed to human beings, or operates with what appears to be almost human intelligence"

Industrial robots have been under serious development since the early 1960s, but in the last few years, the larger industrial of the world have invested heavily in robots and automated manufacturing system. The entrance of the large companies into the robot business indicates that robotics will be fully implemented in factories of the future.

1.1 Why design a Robot Arm

Robots without arms are limited to rolling or walking about, perhaps noting things than occur around them, but little else. The robot can't, as the slogan goes, 'reach out and touch someone," and it certainly can't manipulate its world.

The more sophisticated robots in science, industry, and research/development have at least one arm for the purpose of grasping, reorienting, or moving objects. Arms extend the reach of robots and make them more human -like. For all the extra capabilities they provide a robot, it's interesting that arms aren't at all difficult to build. This arm designs can be used as factory-style stationary "pick and place" robots, or they can be attached to a mobile robot as an appendage.

1.2 Objectives of the Project

The main objective of this project is to design and develop 2-axis robotic arm in the robotic system. The designing part involves the kinematics analysis of the structure in order to count the required torque. The proposed robotic system was designed specifically for performing educational process and learning in the higher education. To achieve this objective, the following works were carried out during the research period.

The second objective is to design and program a microcontroller system to control the movement of the arm. This objective will conclude the designing of microcontroller system circuit and programming the microcontroller using its assembly language to drive the motors of the robot arm for moving the arm.

The third objective is to design mechanism of each joint and how to put them together to form a perfect arm before integrate this physical structure of the arm with microcontroller system.

1.3 Scope of Project

Few scopes and guidelines are listed to ensure the project is conducted within its intended boundary. This is to ensure the project is heading to the right direction to achieve its intended objectives.

The first scope of this project is to create a mechanical design of the links and joints. The mechanism design for each joints and a arm movement will be analyzed by forward and inverse kinematics solutions.

Secondly, the scope of this project is to design a controller for robot arms which was powered by servo motor. This servo motor can be positioned to specific angular positions by sending the servo a coded signal and it is called Pulse Width Modulation (PWM)

Another scope for this project is to create the programming of the movement. It will be determined the best sequence of movement for robot arm by using the assembly language. The programming also will considered the interfacing between computer and the robot arm.

CHAPTER 2
LITERATURE REVIEW

2.0 Classifications of Robots

There are various ways of classifying robots, such as structural configurations, power sources, and motion systems and so on. The following subsections will describe some of the common classification methods of robots.

2.1 Arm Geometry

The role of robot arm is to move the end effectors (grippers or tool) to a given position in a desired orientation. In order to get to any point in space, an arm needs to have six degrees of freedom; namely three translational (right or left, forward or backward, up or down) for reaching the point and three rotational (roll, yaw, pitch) to get any orientation

A common way of classifying the structural configuration of the arm is by looking at different co-ordinate systems of the three major axes (translational). The major axes will provide the vertical lift stroke, the in and out reaching stroke, and the rotational or traversing motion about the vertical lift axis of the robot. Such a classification can distinguish between five basic types commonly available in commercial industrial robot. And they are described as below

2.1.1 *Cylindrical Co-ordinate Robot.*

The robot body is a vertical column that swivels about a vertical axis. The arm consists of a few orthogonal slides that allow it to be moved up or down and in or out with reference to the robot body. This is illustrated schematically in Figure 2.1.1. In the figure, types of motions are shown by arrows; namely two translational motions and one rotational motion. This kind of robot allows good access into cavities and machining working area. Typical manufacturers are Fanuc, Prab and Seiko.

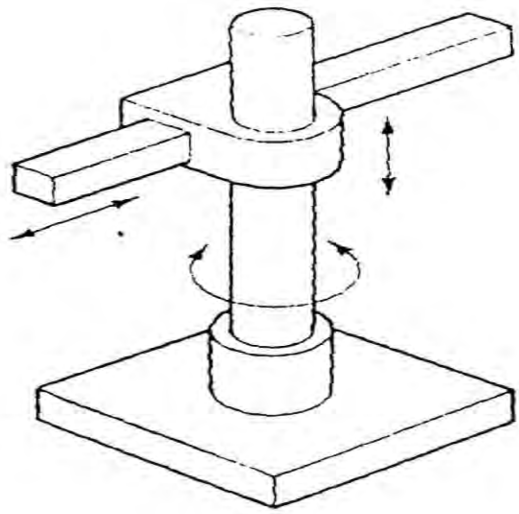

Figure: 2.1.1 (Cylindrical Co-ordinate Robot)

2.1.2 *Spherical (Polar) Co-ordinate Robot.*

As shown in Figure 2.1.2 this type of robot geometry has two rotary axes combined with a linear axis. The base axis is a rotary axis with a second rotary axis providing vertical motion. The linear axis makes the radius of the sphere. Unimation is one of the companies that produce this kind of robot. As shown by the arrows in the figure, it has two rotational motions and one translational motion. This kind of configuration can cover a large workspace from a central support. It can also pick up objects from the ground by bending down its upper part of the structure.

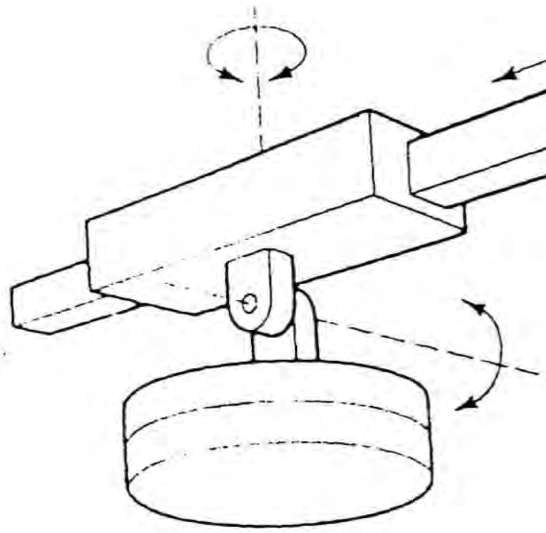

Figure: 2.1.2 (Spherical (Polar) Co-ordinate Robot)

2.1.3 *Cartesian (Rectangular) Co-ordinate Robot.*

Other names for this configuration include rectilinear robot, x-y robot and gantry cranes. "This robot has joints the move in rectangular orthogonal direction as illustrated in Figure 2.1.3. As shown by the arrows in the figure, it can have three translational motions. Examples of this kind of robot are IBM 7565 (originally RS1) assembly robot, the Olivetti Sigma and the DEA Pragma. Generally, it has a rigid structure and can use inexpensive pneumatic drives for pick and place operations.

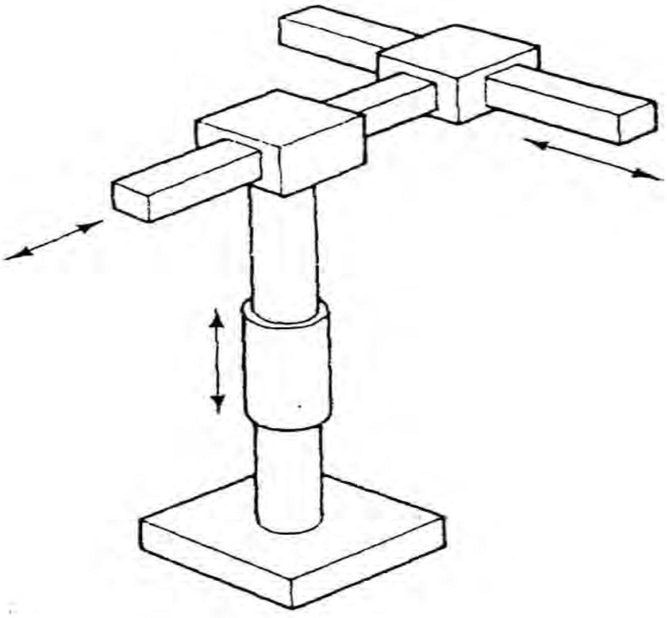

Figure: 2.1.3 (Cartesian (Rectangular) Co-ordinate Robot)

2.1.4 *Revolute Co-ordinate (Jointed Ami) Robot*

Sometimes it is known as anthropomorphic robot. It is having three rotational motions, as shown by the arrows in Figure 2.1.4. It consists of rotary joints called the 'shoulder' and the 'elbow' (corresponding to the human arm) all mounted on a 'waist' consisting of a rotating base that provides the third degree of freedom. It provides maximum flexibility. It can cover a large workspace relative to the volume of the robot and can also reach over and under an object. Electric motor is best suited for this kind of robot. The Cincinnati Milacron, Asea and Unimation are some of the typical manufacturers of this kind of robot.

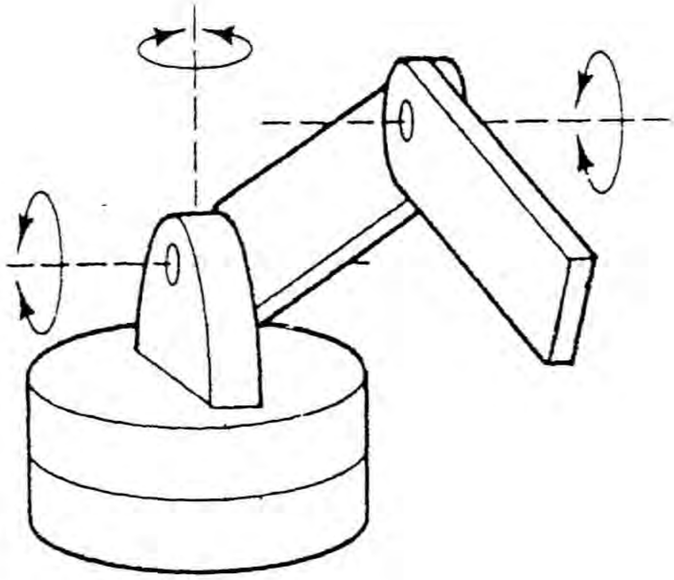

Figure: 2.1.4 (Revolute Co-ordinate (Jointed Ami) Robot)

2.1.5 *SCARA Robot.*

SCARA is an acronym for Selective Compliance Assembly Robot Arm. The robot is almost the same as the jointed arm robot except that the shoulder and elbow rotational axes are vertical. In another word, the arm can be constructed to be very rigid in the vertical direction, but compliant in the horizontal direction. Compliance is a desirable property for arms that are used in assembly processes. The robot can flex its arm to accommodate the small errors in position that occur when one object is brought into contact with another. Manufacturers of the robot are Pentel, NEC and IBM , to name a few. Figure 2.1.5 is describing the robot schematically. The arrows in the figure show the two rotational motions and one translational motion.