END EFFECTOR AND TRAJECTORY WORKING AREA OF ROBOT SYSTEM

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END EFFECTOR AND TRAJECTORY WORKING AREA OF ROBOT SYSTEM

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A dissertation submitted
in partial fulfillment of the requirements for the degree
of Bachelor of Engineering (Hons) in Mechanical
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1999

To my beloved parents and relatives

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ABSTRACT

Robot has and will always be an important asset in the industrial operation worldwide. Besides reducing the production cost, robot also reduce the workload and working hours of workers. Therefore, the main objective of this thesis is to provide an introduction on position and orientation of the robot arm and working area, for PUMA 560 robot. Mathematical formulas and program are formulated in order to ease the calculation. It needs to be emphasized here that this analysis is important as it gives accurate movement of the robot.

ABSTRAK

Robot merupakan aset penting di dalam operasi perindustrian dunia pada masa kini. Selain dapat mengurangkan kos pengeluaran, robot juga dapat meringankan beban kerja dan masa bekerja. Di atas kesedaran ini, matlamat utama penulisan kertas kerja ini adalah untuk memberi kita pengenalan tentang kedudukan akhir lengan robot yang hendak digunakan, dan kawasan kerja robot tersebut, untuk robot PUMA 560. Formula-formula metamatik dan program dirangkakan bagi memudahkan pengiraan. Kajian ini adalah penting untuk memastikan ketepatan pergerakan sesebuah robot.

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NOTATIONS

The following notations are employed:

α	:	angle made by the absolute velocity vector V with the positive direction of the peripheral velocity u. (^{0})
β	:	angle made by the relative velocity vector V_r with the negative direction of the peripheral velocity u; known as blade angle. (^{0})
ω	:	angular velocity (rad/s)
P	:	End effector of arm (mm)
π	:	dimensionless parameter, pi
η	:	efficiency
r	:	radius
a	:	distance between the joint link measured along X axis (mm)
Υ	:	matrices of the end effector of link transformation
θ	:	angle between the joint link
T	:	matrix system

Chapter 1

Introduction

1.1 Definition

Robot are easily defined as an automatic humanoid creature. For these purposes, there are several definitions can be followed:

(i) " A robot device is an instrumented mechanism used in science or industry to take the place of a human being. It may or may not physically resemble a human or perform its tasks in a human way, and the line separating robot devices from merely automated machinery is not always easy to define. In general, the more sophisticated and individualised the machine, the more likely it is to be classed as a robot device". *Encyclopaedia Britannica.*

(ii) " A mechanical device which can be programmed to perform some task of manipulation or locomotion under automatic control." *Airforce Material Laboratory-Patterson AFB, by the (U.S.) National Bureau of Standards.*

From these definitions, robot must possess intelligence, which are normally in the form of computer program, for controlling the robot movement. This computer program is programmed first before it is been imposed to the robot movement.

1.2 Introduction To Robotics

In 1968, R.S Mosher at General Electric built **Mosher's walking truck**. It was the new generation of robots. This walking truck was over 3m long, 1400kg and using 68k/watt power from hydraulic servo. The truck stills needed a human as the drive. This machine performed well but driving it required skill and stamina. Then in 1969, a more sophisticated mobile robot, **Shanky** was built. The name **Shanky** is derived from the mechanical construction. **Shanky** was set to do simple tasks such as solving, recognizing an object using vision, finding its way to the object and performing some action on the object such as pushing the object over. It was the first mobile robot controlled by a programming system. The size of robot was large and used high electrical power [1].

Around 1970, the improvement was made by introducing the degree of freedom (D.O.F.) to six D.O.F. This type of robot was used in manufacturing industry for picking and placing task. In the 1990's, a new type of robot was introduced. It is called **PUMA** arm robot. **PUMA** is an anthropomorphic (arm of human motion) and it is powered by electric DC servo drive [1].

In 1980, The American Association Artificial Intelligent (AAAI), which specializing in turn-key robot installations combined sensor, software and robots. They also introduced CAM (computer aided manufacturing) to the robot. Automation Company **CYBOTECH**, joint ventured with Ransburg and Renault to produce all families of robot including the cylindrical coordinate system, X, Y, Z and anthropomorphic robot [4].

In 1981, Italian manufacture produced sensory manipulator that was easily converted to an industrial robot system. Then, in 1982, software called 'AML' (an assembly language) was used in the RSI (Robot System Intelligent) program for hydraulic Cartesian coordinate with six D.O.F and it was called 7535 for horizontal anthropomorphic with four D.O.F [1].

In 1990's, robotic systems use artificial intelligent to perform the movement. For current robotic systems, the robots have more degree of freedom in movement.

Computers have infiltrated into all area of sciences. One of the fields, which has greatly benefited is manufacturing. It plays a major role in manufacturing industry. Computer integration or involvement has became a priority especially in the development of science and engineering.

Nowadays, robots have computer component together with electronic devices, mathematics and mechanical processes. For the purpose of operating a robot, the mathematics equations that represent the movements of the robot must be analysed and derived in order to calculate the co-ordinates of its position and orientation for every movement. It can produce the graph of working envelopes which is on of the most important part to be analyse. Now, computers software can be used to solve calculation problems more accurately compare to the manual calculation. In fact, now, robot can work with better precision, accuracy and performance.

The important movement of the robot are the translation and rotations in multi-degrees of freedom. The model needs to be improved and modified before simulation. The simulation package consists of forward kinematics equation. The PUMA 560 robot has been taken as an experimental robot in this study, since the position and orientation of the robot arm is important when justifying the work envelope.

1.3 Why It Is Important For Manufacturing?

There are several reasons that concern with the importance of automation in manufacturing processes. The reasons are as follow;

1.3.1 Quality

Automation produces parts and assemblies with greater consistency and conformity to the quality specifications compare the manual processes.

1.3.2 Production

Automation can produce higher production rate per hour.

1.3.3 Lead Time

Automation provides flexibility of changing in the production process. This could reduce the time of delivery.

1.4 Characteristic Of Motion Control System

Robot, control its drive system in order to regulate its motions. Their characteristics in motion and geometry can be divided into four basic motion categories.

1.4.1 Cartesian co-ordinates (3 linear axes)

The Cartesian coordinate system involves linear movement in each of the three or more axes. Thus, any plane within a work envelope can be specified. Figure 1.4.1 illustrates the basic structure of a robot that would move in this manner. This type of robots can be used for stacking parts in the bins or some other structures that require a lot of horizontal movement.

1.4.2 Cylindrical co-ordinates (2 linear and 1 rotary)

Cylindrical coordinates is similar to Cartesian coordinates but the y axis is changed from a linear axes to a vertical rotating axes. A lot of robots designed do primarily choose these operations for the system. In this system, the vertical axes and the arm can be extended and retracted. (refer to figure 1.4.2)

1.4.3 Spherical or polar co-ordinates (1 linear and 2 rotary)

Polar coordinates machine have the horizontal arm from a linear action to a rotating action on the cylindrical configuration create. This type of coordinateis the basic design used in the first Unimate robot. The advantages of this configuration are the simplicity of design and better lifting capabilities. This design would be used if a small amount of vertical action needed for the task. Loading and unloading punch press and some other type of machine processes are the typical machines that apply of this type of robot. (refer to figure 1.4.3)

1.4.4 Revolute or articulated co-ordinates (3 rotary axes)

By rotating the base, shoulder and elbow axes around the center create what is called a revolute coordinates system. This is the most versatile system and gives the largest working area. Programming the movement for this structure is more complicated. Therefore, this system only uses high-level computer controls. The revolute system is very flexible and perform complex applications such as spraying paint and welding. (refer to figure 1.4.4)

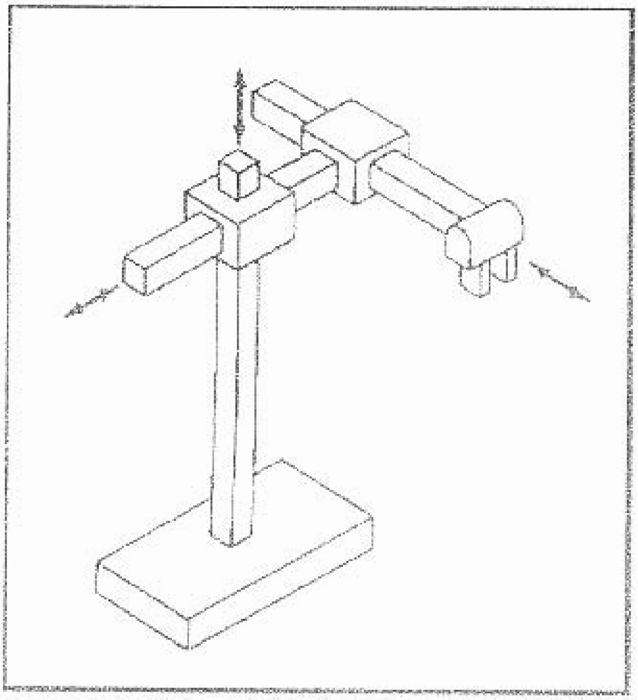

Figure 1.4.1 : Cartesian co-ordinates (3 linear axes)

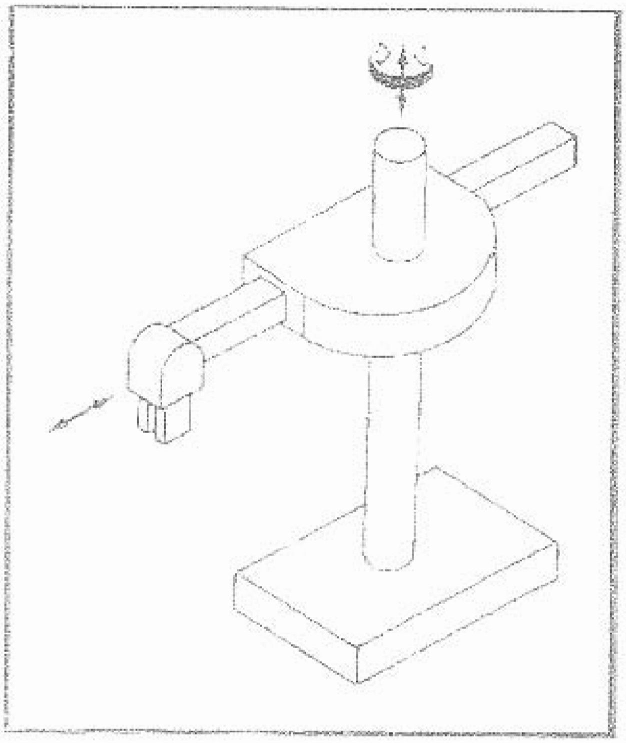

Figure 1.4.2 : Cylindrical co-ordinates (2 linear and 1 rotary)

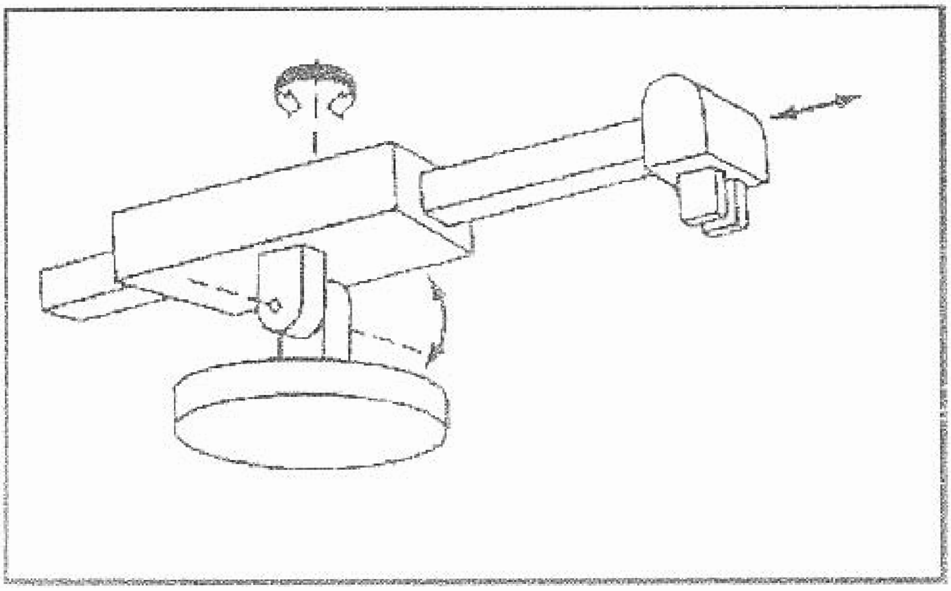

Figure 1.4.3 : Spherical or polar co-ordinates (1 linear and 2 rotary)

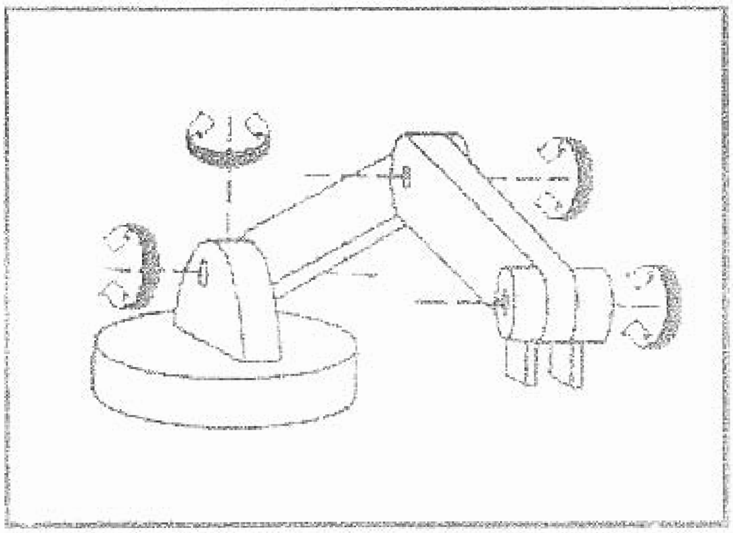

Figure 1.4.4 : Revolute or articulated co-ordinates (3 rotary

1.5 Work Envelopes

The objective of this study is to evaluate the robot trajectory working envelopes. The basic structure of a robot is similar to human operator. It has a body, arm, wrist and hand or end-effector. The robot body is the foundation on which the arm is mounted. Most industrial robots have stationary bodies, but additional mobility may be provided by mounting the bodies on a track or overhead gantry. The primary function of an arm is to move the wrist and end-effector to a desire location in the work envelope. Additional orientation of the end-effector is provided by rotation of the wrist. The end-effector consists of a hand-like device to grip parts, tools and holding devices to enable the robot to perform the desired work task.

When attempting to determine the work envelopes of the robots, it becomes obvious that there are no standards that have been accepted and utilized throughout the robot industry. Manufacturers differ on how they specify the various axes and working envelopes. It is important to specify the robot motion in order to eliminate some of the confusion over terminology and dimensions of the robot system. The axes are designated as closely as possible to those that are used in conventional machining and Numerical Control program languages. Each of the X, Y and Z axes have both minimum and a maximum dimension which clearly define the work envelop in relation to the center line of the robot base. By standardizing on these dimensions, it is possible for all engineers and analysts to have a common language when evaluating or specifying a particular robot for a given application.

1.5.1 Rectangular Robot

The axes of movements for a rectangular type robot (sometimes referred as a Cartesian co-ordinate robot) are shown in Figure 1.5.1. This type of robot moves in the vertical and horizontal axes in simple straight-line motions, forming a rectangular workspace. To extend the range of these robots, they are frequently mounted on a track or overhead gantry.

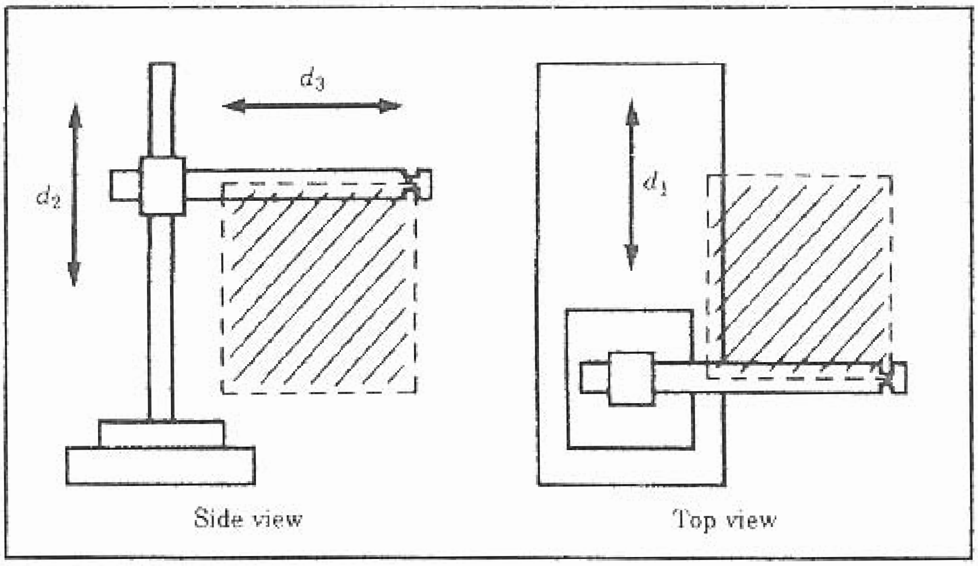

Figure 1.5.1 Rectangular Robot