



**TECHNICAL UNIVERSITY *of* MALAYSIA  
MALACCA**

**Design and Development of Computer Program  
to Determine 2D Robot Workspace and Safe  
Working Area**

**Thesis submitted in accordance with the requirements of the Technical  
University of Malaysia, Melaka for the Bachelor Degree of Manufacturing  
Engineering in Robotic and Automation**

**By**

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**Faculty *of* Manufacturing Engineering**

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**UNIVERSITI TEKNIKAL MALAYSIA MELAKA**

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JUDUL: DESIGN AND DEVELOPMENT OF COMPUTER PROGRAM TO DETERMINE 2D ROBOT WORKSPACE AND SAFE WORKING AREA

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DESIGN AND DEVELOPMENT OF COMPUTER PROGRAM  
TO DETERMINE 2D ROBOT WORKSPACE AND SAFE  
WORKING AREA

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## **APPROVAL**

This thesis submitted to the senate of UTeM and has been accepted as partial fulfillment of the requirement for the degree of Bachelor of Manufacturing Engineering (Robotic and Automation). The members of the supervisory committee are as follows:

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## DECLARATION

I hereby, declare this thesis entitled “ Design and Development of Computer Program to Determine 2D Robot Workspace and Safe Working Area" and submitted to Universiti Teknikal Malaysia, Melaka as fulfillment of the requirement for the degree of Bachelor of Manufacturing Engineering .

Signature : .....

Author's Name : Nor Ismawati binti Natilan

Date : .....

## **ABSTRACT**

Nowadays, industrial robots are widely used in manufacturing industries that is brought in a new challenge of safety aspects for workers and robots. Injury rates may increase without a proper safety system for industrial robot workspace. In addition, this project is design and develops with the purpose of decreasing the injury rates happened in the industries. The main objective of this project is to design and develop a computer program to determine 2D robot workspace and safe working area. In this project, the emphasis is safety and several aspects need to be considered during installation the industrial robot for ensure the safety in the future. The specific variables and dimensions are needed to be considered during installation the industrial robot and determine the robot work envelope.

In order to design and develop a computer program to determine 2D robot workspace and safe working area, a research and study on industrial robot and its specification are carried out and described in this report briefly. Either than that, a study on a computer program and drawing software is done to enhance a knowledge and information used in this project. The results of research and study are chose and will be use as a reference in designing and developing a computer program to determine 2D robot workspace and safe working area. AutoCAD is chose to create 2D robot workspace while Microsoft Visual Basic.NET is choose to program a computer program to determine 2D robot workspace and safe working area. User interface is a result of this project where user can interact with it to get their need.

## **ABSTRAK**

Pada masa ini, robot industri telah digunakan secara meluas dalam industri pembuatan di mana ianya telah membawa cabaran atau impak baru dari segi aspek keselamatan untuk pekerja dan robot itu sendiri. Kadar kemalangan akan meningkat tanpa sistem keselamatan yang cukup untuk ruang kerja robot industri. Oleh itu, projek ini direka bertujuan untuk mengurangkan kadar kemalangan yang berlaku di dalam industri. Objektif utama projek ini adalah untuk merekabentuk dan memperkembangkan program komputer dalam menentukan ruang kerja robot dalam bentuk 2D dan kawasan kerja yang selamat. Dalam projek ini, keselamatan dan beberapa aspek yang perlu dipertimbangkan semasa memasang robot industri adalah amat dititikberatkan dalam menjamin keselamatan pada masa akan datang. Beberapa pembolehubah dan nilai-nilai ukuran yang tertentu adalah perlu dititikberatkan semasa memasang robot industri dan dalam menentukan ruang kerja robot industri itu sendiri.

Dalam merekabentuk dan memperkembangkan program komputer untuk menentukan ruang kerja robot dalam bentuk 2D dan kawasan kerja yang selamat, beberapa penyelidikan dan kajian tentang robot industri dan spesifikasinya telah dibuat dan diterangkan dengan lebih lanjut dalam laporan ini. Selain daripada itu, kajian tentang program komputer dan perisian lukisan juga telah dibuat untuk menambah pengetahuan dan informasi yang akan digunakan dalam melaksanakan projek ini. Hasil penyelidikan dan kajian telah dipilih dan akan digunakan sebagai rujukan dalam merekabentuk program komputer untuk menentukan ruang kerja robot dalam bentuk 2D dan kawasan kerja yang selamat. AutoCAD adalah pilihan untuk melukis ruang kerja untuk robot dalam bentuk 2D. Manakala Microsoft Visual Basic.NET dipilih untuk

memprogramkan program komputer dalam menentukan ruang kerja robot dalam bentuk 2D dan kawasan kerja yang selamat. Paparan pengguna adalah hasil projek ini di mana pengguna boleh berinteraksi dengannya untuk memenuhi kehendak atau keperluan.



## **DEDICATION**

*I dedicate this work:*

*To my caring father,*

*Tuan Natilan bin Samid*

*To my lovely mother,*

*Puan Mislinah binti Hj. Kassan*

*To my beloved brothers and sisters*

*To my supervisor,*

*En. Arfauz bin Abd Rahman*

*And the other person those are my constant sources of encouragement.....*

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# TABLE OF CONTENTS

Abstract.....	i
Dedication.....	ix
Acknowledgement.....	v
Table of Contents.....	vi
List of Figures.....	x
List of Tables.....	xi
List of Abbreviations, Symbols, Specialized Nomenclature.....	xii
<b>1.0 GENERAL INTRODUCTION.....</b>	<b>1</b>
1.1 Introduction.....	1
1.2 Objectives of the project.....	4
1.3 Scopes of the project.....	4
1.4 Layout of the thesis.....	5
<b>2.0 LITERATURE REVIEW.....</b>	<b>6</b>
2.1 Introduction.....	6
2.2 Robot and its Component.....	8
2.2.1 Robot.....	8
2.2.2 Robot Components.....	11
2.2.2.1 Mechanical Unit.....	11
2.2.2.2 Power Source.....	12
2.2.2.3 Control System.....	12
2.2.2.4 Tooling.....	13
2.3 Industrial Robot.....	13
2.3.1 Classification of Industrial Robot.....	14
2.3.1.1 Cartesian.....	14
2.3.1.2 Cylindrical.....	15

2.3.1.3	Spherical.....	16
2.3.1.4	Articulated / Jointed Arm.....	17
2.3.2	Brand of Industrial Robot.....	18
2.3.2.1	ABB.....	18
2.3.2.2	FANUC.....	21
2.3.2.3	KAWASAKI.....	23
2.3.2.4	MOTOMAN.....	24
2.3.2.5	KUKA.....	27
2.3.3	Robot Working Envelope.....	30
2.3.3.1	Example of Working Envelope for Articulated Arm Robot.....	31
2.3.4	User Interface.....	32
2.4	Computer Program Software.....	33
2.4.1	Terms in OOP (Object Oriented Programming).....	33
2.4.2	Microsoft Visual Basic.NET.....	34
2.4.2.1	Solving a Problem.....	35
2.4.2.2	Planning an OOED Application.....	36
2.4.2.3	Building a User Interface.....	39
2.4.2.4	Coding an Application.....	42
2.4.2.5	Testing, Debugging and Documenting.....	42
2.4.3	Microsoft Visual C++.NET.....	43
2.4.3.1	Structure of C++ Program.....	46
2.4.3.2	Input, Processing, Output (IPO) Chart.....	47
2.4.3.3	Coding the Algorithm into a Program.....	49
2.4.3.4	Desk-Checking the Program.....	49
2.4.3.5	Evaluating and Modifying the Program.....	50
2.5	Drawing Software.....	51
2.5.1	AutoCAD.....	51
2.5.2	Solidworks.....	52
2.6	Conclusion.....	53

<b>3.0</b>	<b>METHODOLOGY</b> .....	55
3.1	Introduction.....	55
3.2	Research Methodology.....	58
3.3	Research Tool.....	58
3.3.1	Books.....	58
3.3.2	Thesis.....	58
3.3.3	Internet.....	58
3.3.4	Journal.....	59
3.4	Research Planning.....	59
3.4.1	PSM1 Gantt chart.....	60
3.4.2	PSM2 Gantt chart.....	61
<b>4.0</b>	<b>DESIGN AND DEVELOPMENT</b> .....	62
4.1	Introduction.....	62
4.2	User Interface for This Project.....	63
4.2.1	First Level User Interface.....	65
4.2.2	Second Level User Interface.....	66
4.2.3	Third Level or Result Level.....	67
4.3	Coding for This Project.....	69
4.3.1	Coding for First Level.....	69
4.3.2	Coding for Second Level.....	70
4.3.2.1	Coding for BOIR1 (No. of Robot = 1).....	70
4.3.2.2	Coding for BOIR2 (No. of Robot = 2).....	71
4.3.2.3	Coding for BOIR3 (No. of Robot = 3).....	72
4.2.3.3	Coding for BOIR4 (No. of Robot = 4).....	73
4.3.3	Coding for Third Level or Result Level.....	74
4.3.3.1	Coding for FANUC Brand (No. of Robot = 1).....	74
4.3.3.2	Coding for FANUC Brand (No. of Robot = 2).....	77
4.3.3.3	Coding for FANUC Brand (No. of Robot = 3).....	78
4.3.3.4	Coding for FANUC Brand (No. of Robot = 4).....	79

4.3.3.5	Coding for ABB Brand (No. of Robot = 1).....	80
4.3.3.6	Coding for ABB Brand (No. of Robot = 2).....	83
4.3.3.7	Coding for ABB Brand (No. of Robot = 3).....	84
4.3.3.8	Coding for ABB Brand (No. of Robot = 4).....	85
4.3.3.9	Coding for KAWASAKI Brand (No. of Robot = 1).....	86
4.3.3.10	Coding for KAWASAKI Brand (No. of Robot = 2).....	90
4.3.3.11	Coding for KAWASAKI Brand (No. of Robot = 3).....	90
4.3.3.12	Coding for KAWASAKI Brand (No. of Robot = 4).....	91
4.3.3.13	Coding for KUKA Brand (No. of Robot = 1).....	93
4.3.3.14	Coding for KUKA Brand (No. of Robot = 2).....	96
4.3.3.15	Coding for KUKA Brand (No. of Robot = 3).....	97
4.3.3.16	Coding for KUKA Brand (No. of Robot = 4).....	98
4.3.3.17	Coding for MOTOMAN Brand (No. of Robot = 1).....	99
4.3.3.18	Coding for MOTOMAN Brand (No. of Robot = 2).....	102
4.3.3.19	Coding for MOTOMAN Brand (No. of Robot = 3).....	103
4.3.3.20	Coding for MOTOMAN Brand (No. of Robot = 4).....	104
4.4	Conclusion.....	105
<b>5.0</b>	<b>DISCUSSION.....</b>	<b>106</b>
<b>6.0</b>	<b>CONCLUSION AND RECOMMENDATION.....</b>	<b>108</b>
	<b>REFERENCES.....</b>	<b>110</b>
	<b>APPENDICES.....</b>	<b>113</b>

# LIST OF FIGURES

1.1	Robotic Systems	2
2.1	The 6 Degree of Freedom (DOF) Robot	9
2.2(a)	Welding	10
2.2(b)	Spot Welding	10
2.2(c)	Spray Painting	10
2.2(d)	Assembly Operation	10
2.2(e)	Palletizing	10
2.2(f)	Material Handling in the Semiconductor Industry	10
2.3	A Major Robot Components	11
2.4	A Cartesian Configuration	15
2.5	A Cylindrical Configuration	16
2.6	A Spherical Configuration	17
2.7	An Articulated / Jointed Arm Configuration	18
2.8	A Robot Work Envelope	31
2.9	Working Envelope for IRB1410 (Arc Pack)	32
2.10	Process the C++ Compiler	44
2.11	A Typical Program Development Environment	45
2.12	A Structure of C++ Program	46
2.13	IPO Chart with a Flowchart in the Processing Column	48
3.1	Research Methodology	56
3.2	Processes in Programming	57
4.1	First Level User Interface	65
4.2	Second Level User Interface show the List of Brand of Industrial Robot	66
4.3	Third Level or Result Level	67

## LIST OF TABLES

1.1	Causes of Accidents in Robot Work Cells	3
2.1	Type of ABB Robot	19
2.2	Type of FANUC Robot	21
2.3	Type of KAWASAKI Robot	23
2.4	Type of YASKAWA Robot	26
2.5	Type of KUKA Robot	28
2.6	A Programmer Processes	37
2.7	An IPO Chart	47
4.1	Types of Industrial Robots	64



# LIST OF ABBREVIATIONS, SYMBOLS, SPECIALIZED NOMENCLATURE

2D	-	2 Dimensional
3D	-	3 Dimensional
PSM1	-	Projek Sarjana Muda 1
PSM2	-	Projek Sarjana Muda 2
R.U.R	-	Rossum's Universal Robots
DOF	-	Degree of Freedom
AC	-	Analog Current
DC	-	Digital Current
ABB	-	Asian Brown Boveri
ME	-	MOTOMAN Robotics Europe AB
YEC	-	YASKAWA Electric Corporation
OOP	-	Object-Oriented Programming
IDE	-	Integrated Development Environment
OOED	-	Object-Oriented/Event-Driven
TOE	-	Task, Object, Event
IPO	-	Input, Processing, Output
CAD	-	Computer Aided Design
OLE	-	Object Linking and Embedding
API	-	Application Programming Interface
VBA	-	Visual Basic Application
cpp	-	c plus plus
obj	-	object
exe	-	executable
kg	-	kilogram
mm	-	millimeter

# CHAPTER 1

## GENERAL INTRODUCTION

### 1.1 Introduction

There were about 750,000 robots working in industry worldwide. Modern industrial robot arms have increased in capability and performance through controller and language development, improved mechanisms, sensing and drive systems. In the early to mid 80's the robot industry grew very fast primarily due to large investments by the automotive industry. The robot industry has only recently recovered to mid-80's revenue levels [1].

Robotic systems have involved installing robots in controlled access locations within a manufacturing environment. Safety principles used in manufacturing safety standards for robot installations include making sure that the operator is never in the work envelope of the robot when it is powered up and capable of moving and limiting maximum velocities during maintenance and programming tasks. The robotic systems with the safety devices and safe workplace are shown in Figure 1.1.

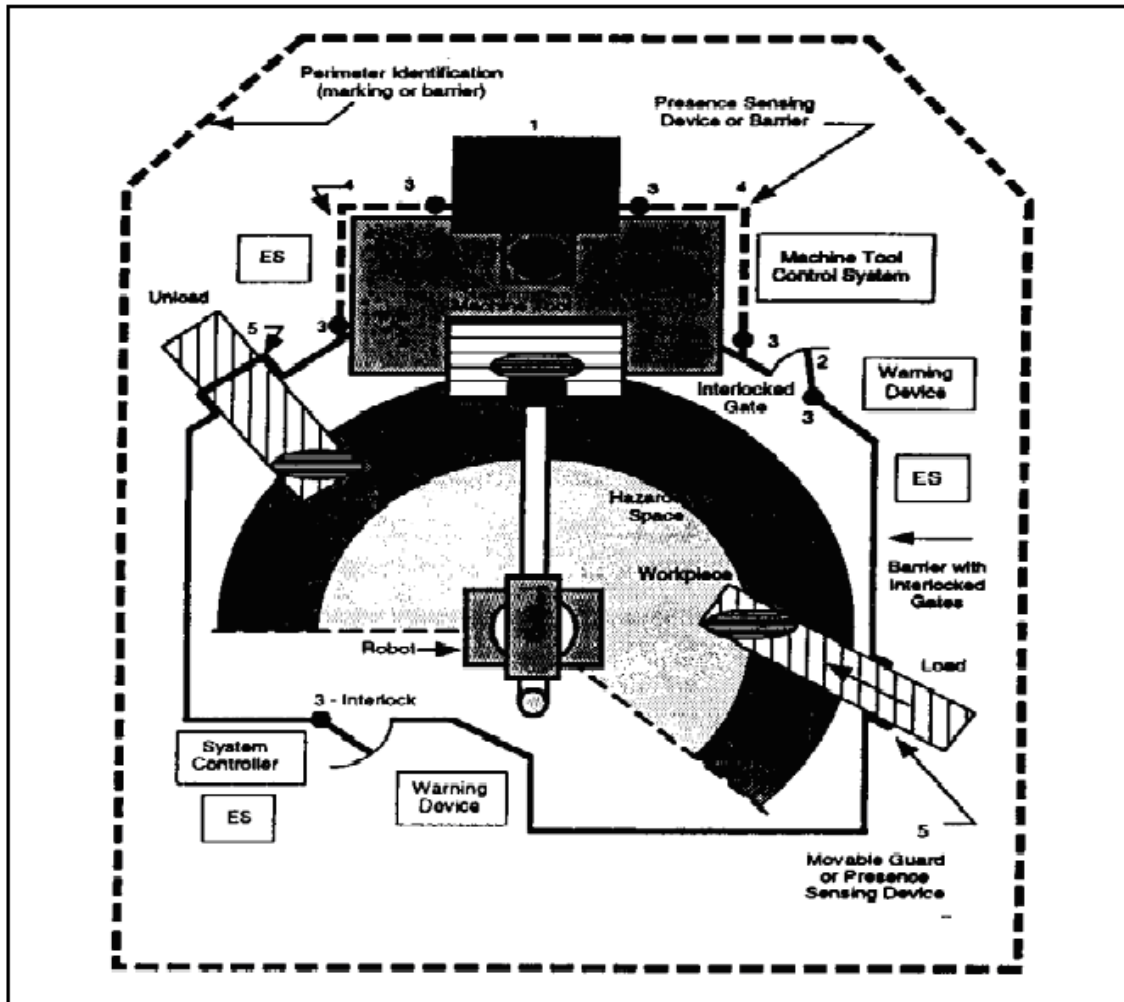


Figure 1.1: Robotic Systems.

The extensively industrial robot use in the manufacturing industries make a new challenge of safety systems and robot installations for all people in the industry especially workers in the working envelope. Injury rates for workers may be increase without proper safety systems and robot installations software for safety workspace and safe working area. Therefore, the need of safety systems and robot installations software are important and necessary. All of these things are to ensure the hazard can be minimized and eliminated to an acceptable limit.

The statistics on occupational injuries compiled by Labor Department of Hong Kong in 1999, there were nearly 7000 injuries and 40 fatalities in manufacturing. These statistics also indicated that there were more than 1300 workers injured due to striking against or being struck by dynamic moving objects in the workplace [2]. In Sweden and Japan, some industrial accidents were related to robot operation including failure to stop, expected and unexpected pauses and starts of robot motion, high speed motion of the robot arm, entering the work envelope for troubleshooting repair and maintenance, unauthorized entry into general robot work envelope, intentional disabling of safety devices and robot work functions unknown to the operator [3]. There are eight causes for accidents in robot work cells identified in Japan as listed in Table 1.11[4, 5].

Table 1.1: Causes of Accident in Robot Work Cells

No.	Cause	Percent (%)
1	Incorrect action of the robot during normal operation because of system fault.	5.6
2	Incorrect action or operation of peripheral equipment in the robot work cell during normal operation.	5.6
3	Careless approach of robot by operator, programmer, maintenance personnel or unauthorized employee.	11.2
4	Human error in teaching or testing.	16.6
5	Incorrect action of the robot during manual operation because of system fault.	16.6
6	Incorrect action of the robot during testing and repairing.	16.6
7	Incorrect action or operation of peripheral equipment in the robot work cell during testing and repairing.	16.6
8	Other causes	11.2

In Malaysia, a specific study on the robot installations software or computer program for robot workspace and safe working area is not yet carried out. Therefore, this project is create, design, and develop considering that subject testing will incorporate a psychophysical approach to an analysis of risk and hazard perception for risk reduction in the workplace. Before this, during installation the robot system in the industry, there is no software or program to determine 2D robot workspace and safe working area.

Virtual and real conditions can be compared. This software is expected can be used to help industry to establish realistic guidelines to improve facility design and reduce hazards in the workplace. The software could be used ultimately for risk reduction in the workplace.

## **1.2 Objectives of the project**

The objectives of this project are as follow:

1. To create and determine 2D robot workspace and safe working area.
2. To evaluate current computer program to determine 2D robot workspace and safe working area.
3. To recommend for improvement of computer program to determine 2D robot workspace and safe working area.
4. To design and develop a new model of a computer program to determine 2D robot workspace and safe working area.

## **1.3 Scopes of the project**

Scopes of this project include:

1. Collect necessary data on the current computer program to determine 2D robot workspace and safe working area.
2. Use any programming software and workspace software.
3. Create experimental documentation and user manual for Workspace software.
4. Design and develop a new model of a computer program and determine 2D robot workspace and safe working area.

## **1.4 Layout of the thesis**

The general introduction about this project is provided in Chapter 1 that discusses about the problem statement carried out for this project named “Design and Develop a computer program of 2D Robot Workspace and Safe Working Area”, objectives and scopes of this project briefly. Layout of this report is also presented in this chapter.

Chapter 2 provides a literature review or past studies in area relating to robot, industrial robot and work envelope for the robot in the industry, computer program and drawing software. This chapter is also as a reference to implement this project. List of brand and type of industrial robot is presented in this chapter that will be used and applied in this project. Computer program and drawing software will be chosen and used to create, program and execute this project become success.

All of the method and analysis of the data used to implement this project is presented and described briefly in this chapter named Methodology chapter or Chapter 3. Flow chart of research methodology from start to end of this project is presented and explained briefly. Sources of the data and information are described in research tool. Project research planning for PSM1 and PSM2 that has been fixed in Gantt chart are outlined in this chapter.

The fourth chapter is Design and Development chapter. The emphasis of this chapter is the output of this project and it also including the analysis done during implements this project and presentation of the user interface.

Chapter 5 or known as Discussion chapter provides a general discussion on the results of this project, stressing the significance and several implications of the findings of the project undertaken.

Overall of this project will be described and concluded in the last chapter (chapter 6) named Conclusion and Recommendation. Beside that, any suggestion to improve and develop this project in the future will be outlined in this chapter. All the result and finding drawn from this research will be concluded in this chapter.

## **CHAPTER 2**

### **LITERATURE REVIEW**

#### **2.1 Introduction**

Nowadays, robotics technologies are widely use in our lifestyles in determining and fulfill our need. The real application of robot in industry has been started early 1950's. General Motors installed its first industrial robot to enhance the productivity of production lines. The uses of industrial robot were replacing workers from unhealthy and hazardous environment. It also brought some new safety problems for them especially when workers are in working envelope of the robot. The accident rates will be increase if there are not proper or lack of safety integration between workers and robot [5]. Beside that, during installation and locate the industrial robot at any workspace, the working envelope of the robot should be considered and emphasized so that the accident rates can be decrease. There are many brand of industrial robot in this new era technologies such as ABB, KUKA, FANUC and any others that are use in the industries with different application and working envelope. However, industrial robot should be programmed first to perform its job or application. Then, it will perform its application according to the programming and work in its working envelope.