



UNIVERSITY TEKNIKAL MALAYSIA MELAKA

**FRAMEWORK FOR ROBOTIC WORK CELL
CONFIGURATION**

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Robotics And Automation) with Honours.

By

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ABSTRAK

Penggunaan robot yang semakin meningkat berikutan dengan era industri pembuatan telah membawa cabaran baru dalam konfigurasi sel kerja robot dalam industri pembuatan. Pembinaan perisian simulasi untuk konfigurasi sel robot merupakan skop utama dalam kajian ini. Tujuan projek ini adalah untuk membantu jurutera industri di masa hadapan untuk reka bentuk susunan atur yang optimal untuk robot di barisan pengeluaran. Rangka program ini memanipulasi reka bentuk susunan atur dengan menggunakan peraturan Masa Memproses Terpendek (Shortest Processing Time) atau SPT untuk beroperasi. Parameter seperti kelajuan robot, robot spesifikasi, liputan kerja robot dan masa proses yang digunakan untuk melengkapkan process in boleh didapati di dalam rangka perisian.

Dalam usaha untuk mereka bentuk and membina rangka perisian ini, pelbagai penyelidikan and kajian maklumat yang berkaitan dengan projek berserta dengan implikasi peraturan-peraturan kepada rangka perisian telah dilaksanakan dan langkah kerja implikasi akan dirumuskan dalam laporan berkaitan. Selain daripada melakukan penyelidikan berasaskan jurnal kajian, kajian berkaitan dengan program komputer dan lukisan perisian dilakukan untuk meningkatkan pengetahuan dan maklumat perisian berkaitan dengan kajian projek ini. Data yang diambil dari pemerhatian robot industri akan digunakan sebagai rujukan bagi mereka bentuk rangka pembinaan perisian projek. Microsoft Visual Basic.NET merupakan salah satu platform untuk mereka bentuk rangka kerja perisian. Dalam perisian tersebut mampu memberi pengguna perisian untuk melihat susun atur sel robot yang dipilih.

ABSTRACT

The widely used of industrial robots in manufacturing industries has brought in a new challenge in the configuration of the robotic work cell for manufacturing industries. Developing the simulation software for the configuration of the robotic work cell is the main scope of the study. The purpose of this project is to aid future industry engineers in designing optimal robot work cell layout for the production line. The designed framework is manipulated the layout design by the use of Shortest Processing Time or SPT rules to operate. The parameters such as the robot speed, robot specification, robot's work envelope and processing time needed to finish the process are included in the framework software.

In order to design and develop the framework, a research and study for the related information about the project and rules to implement into the framework are carried out and described briefly in the report. Other than doing the paper research, a study on the computer program and drawing software is done to enhance a knowledge and related information for the project. The data taken from the observation of industrial robots will be used as references for the designing the layout. CATIA and WORKSPACE are used to create 3D robotic work cell and simulate the robot. The data analysis are based on the simulation time and observation for the development of framework. Microsoft Visual Basic.NET is a platform for the framework development. The framework capable to gives user view the selected desire layout.

DEDICATION

For my beloved family, project supervisor, industrial supervisors, lecturers and friends that always believe in me to complete this project and report.

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LIST ABRREVAITIONS, SYMBOLS AND NOMENCLATURES

PPE	-	Personal protective equipment
FKP	-	Faculty of Manufacturing Engineering, UTeM
UTeM	-	Universiti Teknikal Malaysia Melaka
SPT	-	Shortest Processing Time
IFR	-	International Federation of Robotic
ISO	-	International Organization for Standardization
SCARA	-	Selective Compliance Assembly Robot Arm
DOF	-	Degree Of Freedom
FMS	-	Flexible manufacturing system
ABB Robots	-	Asian Brown Broveri Robot
OTC Robots	-	Osaka Transformer Company Robot
OSHA	-	Occupation Safety And Health Administration
ANSI	-	America National Standard Institute
COM	-	Component Object Model Computer Aided
CATIA	-	Three-Dimensional Interactive Application
FCFS	-	First Come First Serve

CHAPTER 1

INTRODUCTION

This chapter presents the background of the study, problem statements, objectives of the study, and the scope of study. The background of the study is focused on the development of framework for robot arm in work cell configuration. The problem statements reveal the important of the configuration system in manufacturing factory. In the objectives, the purpose of this study is to develop a framework for robot arm and workstation in certain selected process; welding process. At the end of this chapter, the scope of the study will highlights the focus and limitations involved in the study .

1.1 Background of Study

The recent statistic issued by the International Federation of Robotics (IFR) in its 2015 World Robotics as shown in Figure 1 indicates the enormous increase of industrial robots supply to the industry by nearly 30% from the previous year to 229, 261 worldwide in 2014. The statistic shows that the demand for the industrial robots has accelerated considerably due to the ongoing manufacturing trends toward automation as well as continued innovative technical improvements of technology (<http://www.ifr.org/industrial-robots/statistics/>).

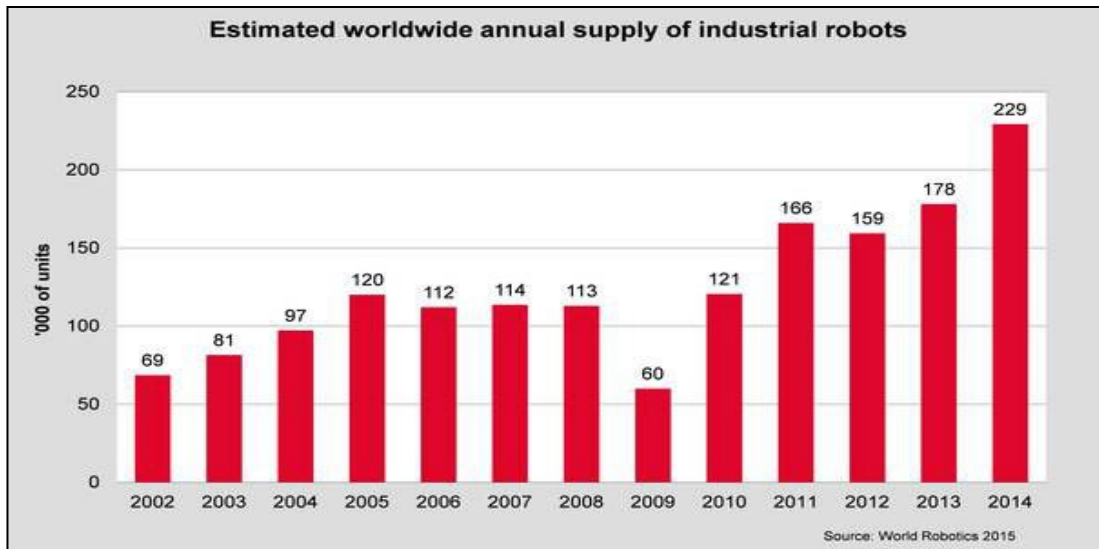


Figure 1.1: Estimated Worldwide Annual Supply of Industrial Robots, IFR 2015.

Based on the trend, IFR has predicted that by 2018 onward, global sales of industrial robots will go on with the average grow year on year by at least 15 percent (World Robotics, 2015). This prediction will further highlighted the importance of industrial robots role's in enhancing the global competitiveness of future industrial production.

There are various definition of industrial robots. One of the most general definition is defined by the ISO 8873 that industrial robots is defined as a mechanism or machine which can be automatically controlled, reprogrammable, and multipurpose manipulator reprogrammable machines which capable to acts in 3 axis or more to perform the given tasks (ISO 8873). The construction of industrial robots consist of few basic components. Figure 2 shows the main components in any industrial robots based on the ISO definition.

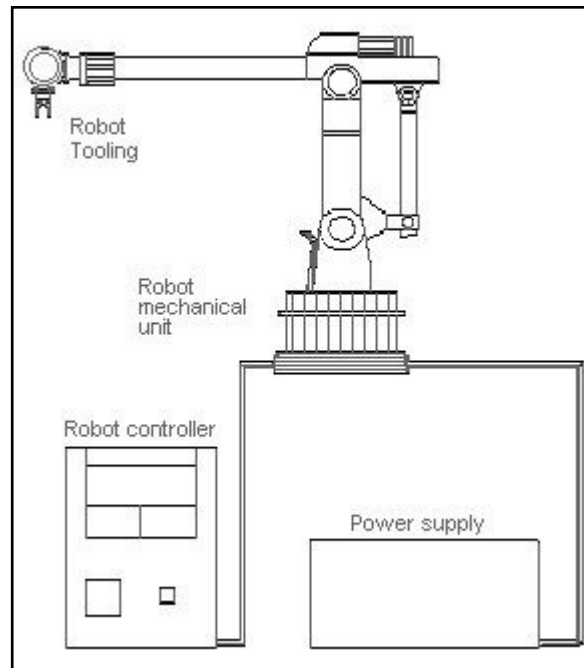


Figure 1.2: Main Components of Industrial Robots

(Source : American National Standards Institute (ANSI) American National Safety Standard ANSI/RIA R15.06-1992. Industrial Robots and Robot Systems - Safety Requirements. American National Standards Institute, Inc., 1430 Broadway, New York, New York 10018, 2012)

The components in the robotic work cell included the controller, power supply, mechanical structures and the tools. These components are the basic anatomy for any types of industrial robots. There are various types of industrial robots that bases on various classifications. Among the common types are Cartesian, Selective Compliance Assembly Robot Arm (SCARA), Gantry and Parallel robot. Figure 3 shows a typical structure of an articulated 6 degree of freedom (DOF) of an industrial robot that mostly seen in the manufacturing process industries.

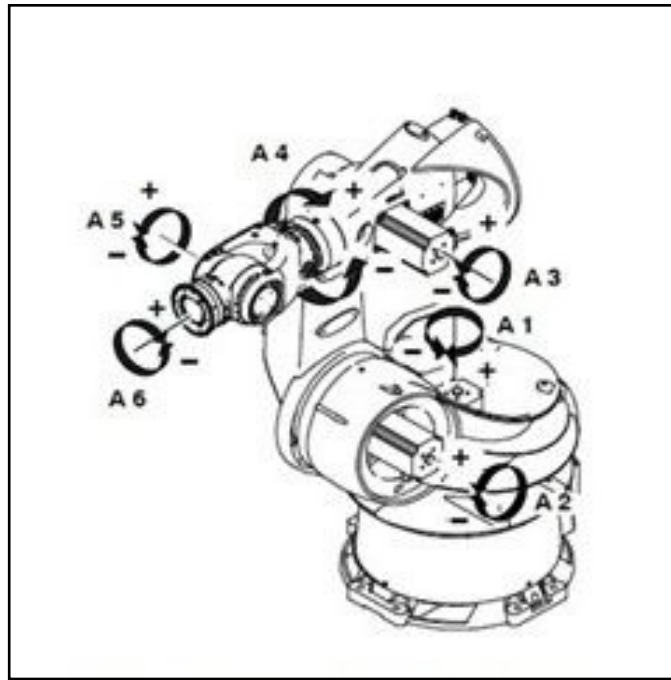


Figure 1.3 : A Typical Structure of an Articulated 6 DOF of Industrial Robot

(Source : *IEEE Transaction On Automatic Control*, Vol. AC-28, No.2, February 1983, *An Anatomy of Industrial Robots and Their Control*, by J.Y.S LUH, Senior Member, IEEE,)

A typical applications of the industrial robots includes performing welding, painting, assembly parts (automation production), pick and place (packaging, palletizing, and Surface Mount Technology (SMT)), product inspection and product testing. One of the typical applications of industrial robots that widely used is welding robot. Figure 1.4 shows the typical industrial robots uses in welding of products in the manufacturing industry.

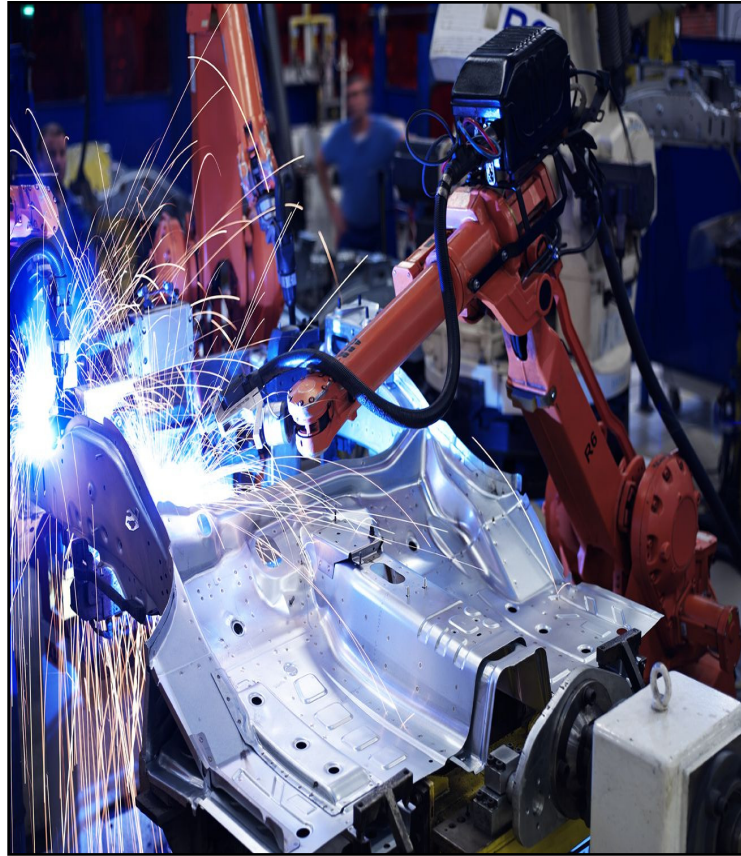


Figure 1.4 : Example of the Industrial Robot Used in Welding Process

(Source : [Used robots.com/articles/viewing/welding robots increasing production for more than three decades](https://usedrobots.com/articles/viewing/welding-robots-increasing-production-for-more-than-three-decades))

To stay competitive in industrial robot global market, most of the manufacturing industries are forced to improve their production processes to be faster and has lower production costs. With further improvements of advance robotics technologies and continuous development of intelligent technologies in recent years, robotics application areas have become broader and more became more reliable cost effective. Further development and enhancement in robotic technology, it is undoubtedly that the use of industrial robots has plays an important roles that drives this development. Nevertheless, to meet with the dynamic and advanced usage of industrial robots technology, a new challenge is faced in configuring the current robotic work cell as well as their future robotized factories accordingly. The main control system and configuration system for the robotics work cell in industries will presumably hard to maintain and tricky. This is due to the limitation faces by the engineers to configure the layout of the industrial robots based on its capability to perform difference tasks as well as depending on variation of demands.

The initiation of this study is to develop a framework for easy configuring the current and future robotic work cell at lower cost and minimum human involvement. This study are aimed to aid the future engineers to easily configure their robotics work cell based on the appropriate standards. The framework will capable to perform a simple algorithm of calculating the shortest process time and shown a two dimensional layout platform which prior to the development and configuration of the real robotic work cell. The outcomes of this framework will simplify the process of configuring the robotized factories in the future. It will also further enhance the human-industrial robot interaction as well as maximizing the usage of the industrial robots working within the current and future work cell. This will undoubtedly reduce cost and save future investment as well as reduce the time for developing a new robotic work cell.

1.2 Problem Statement

Most of the industries try to utilizing their industrial robot are facing an issue of ways or methods to maximize the usability of their industrial robots (Charles C. Kemp, Aaron Edsinger and Eduardo Torres-Jara, “Challenges for robot manipulation in human environment”, IEEE Robotic and Automation Magazine, March 2007). One of an appropriate approach in configure and reconfigure the robotic work cell to adapt with the future changes need to be conduct. Since the industrial robot is introduced in the manufacturing industries, it has unintentionally created a new challenges for configure the layout of robotic work cell within factories . In order to configure the type of sophisticate robotics system, a truly robot expert is needed to consult with the configuration progress. This involves enormous amount of money and eventually will encompasses some time for the consultant engineer to assist in the designing the desired robotic work cell’s layout. Upon approval of the design layout, the cost of the installation and configuration will be another issues since there is no system or simulation software to forecast the outcome of the system that include the processing time, installation process, configuration cost and efficiency of the designed layout. The current approach for configuration of the industrial robot to

perform new or different tasks requires high cost of investment, more rigorous time and a lots of human involvement.

This study is essential to save the configuration time and cost for robotic work cell in manufacturing industries. The framework capable to show the flow of the process movement in 3D so that engineers can predict and calculate the efficiency of the design without based on field's data to forecast the effectiveness of the system before installation. This study help in improving the flexibility and agility of the industrial robot in the work cell and utilized the industrial robot's performance in production line. By the further study, this framework can aid in boosting the productivity and utilize the performance of the industrial robot in manufacturing industries.

This study eventually is to develop and validate the current issues through the development of an appropriate framework system is a software which purposely develop for reconfiguration of the industrial robot in manufacturing industries. This Framework will aid in developing, designing and giving the 2D layout for the view of the designed robotic work cell according to number of work cells (n) that been given, Degree of Freedom (DOF) of the industrial robot, industrial robot's envelop, process description, types of end effector and industrial robot's performance task.

1.3 Objectives

The objectives of this study are:

- a) To evaluate the current configuration approach of the robotic work cell in manufacturing industry.
- b) To develop the executable framework for the robotic work cell configuration.
- c) To execute the designed framework.

1.4 Scope of Study

In order to ensure the feasibility of this study, the project scopes for developing the framework have been clarified. The development of this framework will be based on various criterion as follows:

1. The type of selected process for the project,
2. The type industrial robots and number of degree of freedom (DOF),
3. Number of industrial robots working within the work cell,
4. Dimension of the simulation framework,
5. The selected rules for the configuration framework, and
6. Programming and computer aided design (CAD) software for the development.

The selected type of process for the study is welding process. The process is chosen due to the fact that most of the industries utilizes their industrial robots for this type of process. The study will be focusing on the involvement of industrial robots within the welding process. This includes the structure of the gripper and tools used within the work cell. The propose framework will also depend on the type of industrial robots and its DOF selected. At this stage a six (6) DOF of an articulated type of industrial robots has been chosen. The main reason for choosing this type of industrial robots is due to its higher complexity that covers most of the other type of industrial robots. In this study, the structure and anatomy of various single 6-DOF articulated type of industrial robots will be taken into consideration.

Another consideration is the limitation for the number of industrial robots working within the work cell. For the purpose of this project, a maximum six (6) industrial robots are capped for the developed framework. Nevertheless, for the potential of future development of the framework, this limitation is temporary and the framework may have an endless number ('n' number) of industrial robots within its system. In order to ensure the framework will be much appreciated at the end of its development, the simulation work will be in three dimensional (3D) form. This 3D form will ensure a detail layout of the proposed robotic work cell can be proposed.

One of the key important development for this framework is much dependable on the type of rules applied. The rules are seen as a potential for the development of this

framework that includes Shortest Processing Time (SPT) rules as well as forecasting rules. This rules will be applied to the framework as a basis. The successions of utilizing the rules is the key for determining a better robot's usability, performances and the cost for the implementation. Nevertheless, the rules implemented in the study will aids in improving the productivity of the product and optimized the system for better performance. For the development of the chosen rules, a suitable programming software packages are chosen.

For the initial choice, a visual basic (VB.NET) will be used for programming the framework of the rules. To ease the overall development of the framework, the development of graphical user interface (GUI) for the framework will also uses VB.NET. The final supporting form of the framework will be presented in a CAD form for easy understanding to the user of the proposed robotic work cell. The CAD software chosen is CATIA. CATIA is chosen due to its ability to be simulate the designed robot parts for gaining the data for the computation of the configuration system as well as providing a better CAD environment that can be used for other type of analysis in the future.