UNIVERSITI TEKNIKAL MALAYSIA MELAKA

ROBOT COMAU PROGRAMMING FOR COMPLEX PATH

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

By

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TAJUK: **Robot Comau Programming For Complex Path**

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DECLARATION

I hereby, declared this report entitled “Robot Comau Programming for Complex Path” is the results of my own research except as cited in references.

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Author’s Name : Zalina Binti Abu Lukman

Date : 22 May 2009

APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTEM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Robotic and Automation) with Honours. The members of the supervisory committee are as follow:

(Signature of Supervisor)

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ABSTRACT

An approach based on off-line robot programming for Comau robot programming complex path in a typical industrial environment is presented in this project paper. The robot programming for complex path is implemented by off-line programming using Workspace 5™ Software. The main objective of this project is to integrate robot programming for complex path that applied in manufacturing process into real application of Comau Robot as dry run simulation. In order of progress to successfully fulfill this objective, a programming language analysis, the accuracy of robot position by simulation in term of work envelope of a robot, and the robot motion for complex path need to be analyzed and carried out. The inverse kinematic had proposed to analyze the robot motion that generated by Workspace 5™ Software.

ABSTRAK

Satu pendekatan berdasarkan program robot Comau untuk laluan yang komplek dalam industri secara ‘off-line’ dipersembahkan dalam laporan projek ini. Program robot ini dilaksanakan secara kaedah ‘off-line’ menggunakan Perisian Workspace 5™. Objektif utama dalam projek ini adalah untuk mengintegrasikan program robot untuk laluan yang komplek yang telah diaplikasikan dalam proses industri kepada aplikasi Robot Comau yang nyata iaitu sebagai simulasi ‘dry run’. Dalam penyediaan untuk memenuhi dengan objektif tersebut jayanya, analisa terhadap bahasa yang digunakan dalam program ini, ketepatan kedudukan robot secara simulasi dalam erti kata lain analisa kawasan kerja robot antara simulasi memgunakan perisian dengan simulasi sebenar Robot Comau, dan seterusnya analisa terhadap pergerakan robot untuk laluan yang complex telah dijalankan. Kinematic songsang telah dicadangkan untuk menganalisa pergerakan robot yang dapat dihasilkan secara automatik oleh Perisian Workspace 5™ Software.

DEDICATION

For my beloved parents

Abu Lukman Bin Haji Ismail

Razali Bin Hussien

Fatimah Bt. Yahya

And for my special person and friends

En. Khairol Anuar Bin Rakiman

Nur Anis Bt. A. Rahman

Normaizatulakma Bt. Amir

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Thank you, very much.

Wassalam.

Zalina Abu Lukman

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LIST OF ABBREVIATIONS

DOF	-	Degree of Freedom
GP	-	Geometry Point
CAD	-	Computer Aided Design
D-H	-	Denavit Hartenberg

CHAPTER 1
INTRODUCTION

This chapter is describing about the history of the robot, the basic programming used for robot programming, the application of the robot in the industry. Besides, in this chapter, there are also briefly defined the problem statement involve in this project, the objectives, the scope of the project, and the project outline.

1.1 Background

In the twenty-first century, robots have come to be known by everyone. However, the term robot was first introduced to our vocabulary just a few decades ago. The word originated from the Czech word robot, which means ‘slave laborer’. Isaac Asimov (1940) coin the term robotics in his short science fiction in which he defined robotics as a study of robots. In 1988, the word robotics was including in the Webster’s New World Dictionary. As basically known, robot is a combination of motors, sensors, mechanical parts and software. Although the word has many different definitions as seen in different dictionaries and encyclopedias, the Robot Institute of America may reflect main features of modern robot systems in which a robot is a reprogrammable multifunctional manipulator designed to move material, parts, tools, or specialized devices though variable programmable motion of the performance of variety of tasks. George C. Devol (1953) develops the first robot and further George Devol JR. (1954) applies for a patent for a programmable transfer device.

In its most basic form, a robot program can be defined as a path in space through which the manipulator is directed to move. This path also includes other actions such as controlling the end effectors and receiving signals from sensors. The purpose of

robot programming is to teach these actions to the robot. There are two basic categories of greatest commercial importances nowadays are lead through programming, and textual language programming. Lead through programming consists of forcing the robot arm to move through the required motion sequences and recording the motion into the controller memory. Moreover, lead through method is used to program playback robot. In the case of point playbacks robots, the usual procedure is to use a control box which called as a teach pendent to drive the robot joints to each of desired point in the workspaces, and record the point into memory for subsequent playback. Textual programming method uses an English-like language to establish the logic and sequence of the work cycle. A computer terminal is used to input the program instructions into the controller but a teach pendant is also used to define the locations of the various points in the workspace. The robot programming language names the point as symbols in the program and these symbols are subsequently defined by showing the robot their locations. In addition to identifying points in the workspace, the robot language permit the use of calculations, more detailed logic flow, and subroutines in the programs, and greater use of sensors and communications. Accordingly, the use if the textual language corresponds largely to the so called intelligent robots.

Robotics has rapidly moved from theory to application and from research labs to industries over the last 20 or so years. Robotics is going to be a prominent component of manufacturing industry, which will affect human labour at all level, from managers of production to shop floor unskilled workers. Robots are useful in the industries in many ways. In today's economy, industry needs to be efficient to cope with the competition. Installing robots in the industry is often a step to be more competitive because robots can do certain tasks more efficiently than humans. Some of the tasks robots can do better in handling dangerous materials, assembling products, spray finishing, polishing and cutting, inspection, repetitive, backbreaking and unrewarding tasks, and tasks involving danger to human or dangerous tasks.

Figure 1.1: A teach Pendant

1.2 Problem Statement

In this project, finding the programming code in off-line programming for complex path, and analyzing the motion path planning of the robot has need to be done. The suitable language code of robot programming and the software involving in this project need to be explored and learn. The most important, the robot programming has to simulate with the robot as dry run for complex engineering part that has been identified as an imagination product in simulation.

1.3 Objectives

The primary objectives of this project are:

a. To integrate robot programming into real application (dry run).
b. To determine the accuracy of robot position by simulation.
c. To analyze the robot motion for complex path.

1.4 Scope of The Project

There are several scopes that focused on this project:

a. To study the theory of motion planning.
b. To identify the complex engineering part to be the product for programming.
c. To explore and learn the related software involve in this project.
d. To generate the suitable code for programming language and transfer into real simulation.
e. To carry out the programming and simulate the Comau Robot.

CHAPTER 2
LITERATURE REVIEW

This chapter will describe about the past researches review that related to the project. From Oxford Advanced Genie dictionary, Literature means the pieces of writing or printed information on a particular subject. This literature review is important to make this project relate with the past researches and for the next chapter.

Before proceed in the detail about the researches theory and information that related to the project, its better we see first the evidence overall past researches about programming robot for complex path. In this project, we use off line programming without using online programming. Robot Institute of America (1979) defines a robot is a reprogrammable, multifunctional manipulator designed to move material, parts, tools or specialized devices through variable programmed motions for the performance of a variety of tasks.

2.1 Evidence of Programming Robot for Complex Path

George, Z. *et. al*: (2008) presents a force control assisted path generation system that can significantly reduce the time, effort and expertise requirements for programming complex paths in a typical industrial environment. The basic idea is to let the user first teach a few approximate positions along the desired path using a force control lead through method, and then the robot executes a force feedback contour following task with the guidance of the approximate points. The actual tool path is recorded during the contour tracking process. Post processing algorithms are applied to make additional adjustments to the recorded path if needed. Tests using real life applications have demonstrated the robustness and effectiveness of the presented

system in industrial settings. Figure 2.1 shows a water pump cast that needs to be deburred around its edge in a cell shown in Figure 2.2. As can be seen, the edge is a complicated 3D contour that requires the deburring tool change its orientation and depth at different parts of the contour. Programming this contour took the system integrator almost one week using a position controlled robot and joystick teaching. The force control assisted path generation system cut this time to half hour, most of which is spent on teaching the guiding path. Contour following and path program generation takes less than 1 minute. Figure 2.3 shows the contour following in action. The guiding path has 66 points. After the contour following and the real-time path recording with line recovery, the final path contains 454 points (Figure 2.4).

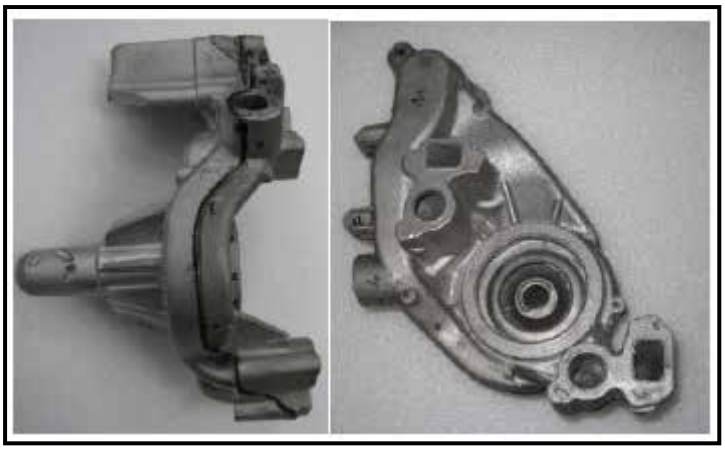

Figure 2.1: A water pump to be deburred (the marked line shows the desired deburring path). The side (left) and front (right) views are shown as one of the complex part that is need to be program (George, Z. et. al: (2008).

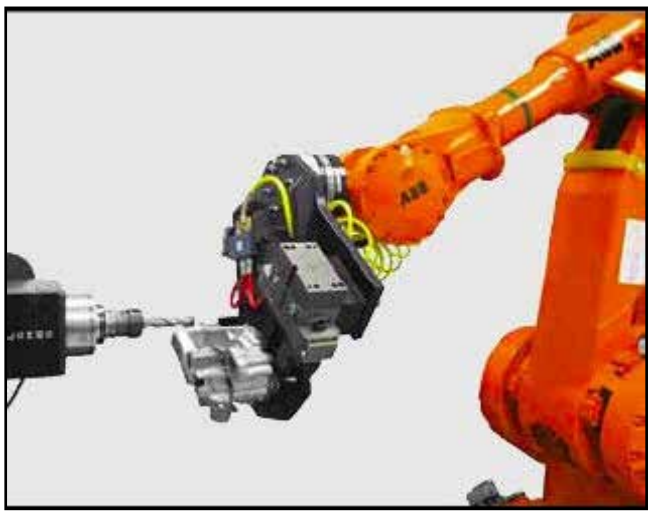

Figure 2.2: Water pump deburring cell setup (George, Z. et. al: (2008).

Figure 2.3: Pictures taken while the tool is in force control mode and programmed to follow the edge of the water pump (George, Z. et. al: (2008).

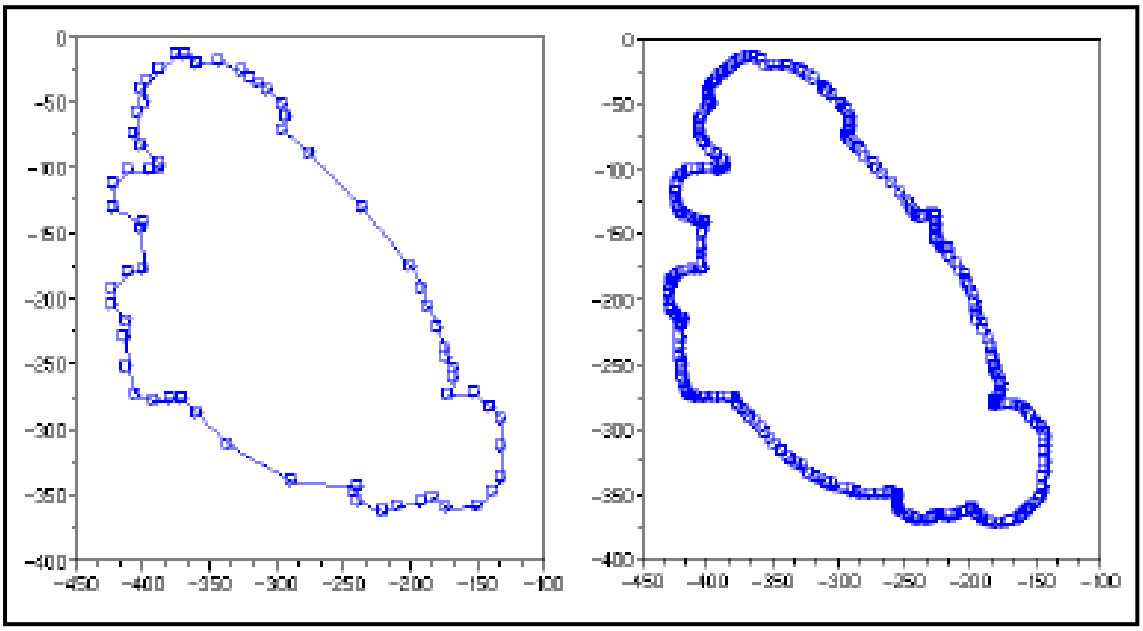

Figure 2.4: Guiding path (left) and recorded path (right) (George, Z. et. al: (2008).

George, Z. et. al: (2008) target that this system targets the foundry industry need for significantly reducing the time, effort and expertise typically required for programming complex paths. Contour following is the key component of this system, which enables the robot to learn 3D paths. This system requires the user to teach a

number of guiding points in order for the contour following to be executed at a reasonable speed. Obviously this approach chooses simplicity and economy over the full autonomy provided by some hybrid force/vision approaches. Because this system is intended for industrial usage, this approach is justifiable. Real life applications and customer feedback have confirmed the effectiveness of the presented system.

Stocco, P. et al: (2008) have made a research on the optimization of real time complex path generation in constrained intelligent motion applications based on IPM motor drives. The improvements in the constrained real-time path generation for high performance motion control systems are presented in this paper.

2.2 Programming Robot

There are two categories of robot programming by means to explain the robot programming its application in industry and real life. The first category is off line programming and the second is online programming. Dixon, K.R. *et al:* (2002) classify robot programming has evolved into two mutually exclusive paradigms, offline and online programming, each having its advantages and disadvantages. According to their finding, in offline programming, users move a simulated version of the robot to each waypoint using a CAD model of the workspace. In online programming, users move the robot itself to each waypoint using some type of control device in the actual workspace. Offline programming packages allow users to design a robot program in simulation without bringing down production and can optimize according to almost any imaginable criterion. Typical optimizations involve production speed, material usage, and power consumption. Offline packages generally require that programs be written in a sophisticated procedural programming language. The transfer of the offline program to the robot controller requires translating the offline programming language to a form that the robot can understand. Not surprisingly, arcane problems can occur during this translation, especially with the process specific instruction, controller models, and inverse kinematics. To achieve the high accuracy required in many applications, the physical workspace must be calibrated with the simulated environment. Otherwise, online fine-tuning