UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DESIGN OF MOTION STRATEGY FOR MOBILE ROBOT IN RECONFIGURABLE MANUFACTURING SYSTEM

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

by

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2015

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **Design of Motion Strategy For Mobile Robot In Reconfigurable Manufacturing System**

SESI PENGAJIAN: **2014/2015 Semester 2**

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ABSTRACT

Mobile robots have been widely used in manufacturing industry to provide autonomous environment onto the system. Most of the time, mobile robot is being utilized to ease and automate material handling process. In order to navigate and command the mobile robot, guided navigation method such as magnetic tape has been used. This method is commonly implemented in a fixed manufacturing system. However, in order to respond for a sudden change in market, fixed manufacturing system is no longer relevant to the industry. This situation affect the used of mobile robot in the industry that utilizing the magnetic tape navigation method which suitable for fixed manufacturing system. Nowadays, most industries have implemented the Reconfigurable Manufacturing System (RMS) approach which is able to adapt with rapid change either in term of hardware or software component. In other word, the system for RMS is involving changeable layout in the manufacturing system. Hence, to implement the mobile robot in RMS, an appropriate guidance system for the mobile robot is needed to adapt with the change in the manufacturing system especially its layout. This change involves new cost and reprogramming effort. In order to complement the issue, for the mobile robot to be implement in the RMS without utilizing the fixed navigation method, this project proposed and developed reconfigurable motion strategy for mobile robot platform to work in RMS environment. This project will focus on the National Instrument (NI) LabVIEW robotic module as the programming language. The implementation of this project will be conducted in by using LabVIEW Robotics Environment Simulator. The A-Star path planning algorithm was being implemented along with the pre-selection

programming configuration. Prior to the design and development of the motion strategy, a study on the motion capability for the NI mobile robot platform had been conducted. The simulation was run along with the front panel which has several buttons to choose the mobile robot input layout. Each of the buttons was tested to make sure the mobile robot able to move for each input layout. The significant finding of the study is that the use of pre-selection programming configuration with the A-Star algorithm motion strategy can be implemented as that the mobile robot able to move according to shortest generated path in various RMS layout. The implementation of the project is hoped to provide a fresh idea for further usage of mobile robot in manufacturing industry.

ABSTRAK

Robot mudah alih telah digunakan secara meluas dalam industri pembuatan bagi menyediakan sebuah persekitaran autonomi ke dalam sistem pembuatan. Kebiasaannya, robot mudah alih telah digunakan untuk memudahkan dan mengautomasikan proses pengendalian bahan. Dalam usaha untuk menunjuk arah dan memberi sesuatu arahan kepada robot mudah alih, kaedah navigasi berpandu seperti pita magnet telah digunakan. Kaedah ini biasanya dilaksanakan dalam 'Fixed Manufacturing System' atau Sistem Pembuatan Tetap. Walau bagaimanapun, bagi perubahan mendadak dalam pasaran produk, sistem pembuatan tetap tidak lagi relevan kepada industri. Keadaan ini memberi kesan kepada robot mudah alih yang bergerak dalam industri menggunakan pita kaedah navigasi pita magnet yang sesuai untuk sistem pembuatan tetap. Pada masa kini, kebanyakan industri telah melaksanakan 'Reconfigurable Manufacturing System' (RMS) atau Sistem Pembuatan Ubah-suai, iaitu sebuah pendekatan yang sesuai dengan perubahan yang pesat sama ada dari segi perkakasan atau komponen perisian. Dengan kata lain, sistem RMS melibatkan susun atur yang berubah-ubah dalam sistem pembuatan. Oleh itu, untuk melaksanakan robot mudah alih di RMS, sistem panduan yang sesuai bagi robot mudah alih diperlukan untuk menyesuaikan kondisinya dengan perubahan dalam sistem pembuatan terutama susun atur sistem. Perubahan ini melibatkan kos dan usaha pengaturcaraan semula yang baru. Dalam usaha untuk mengatasi isu ini, untuk robot mudah alih bergerak dalam RMS tanpa menggunakan kaedah navigasi tetap, projek ini dicadangkan dan dibangunkan satu strategi usul pembentukan semula untuk platform robot mudah alih supaya dapat mengadaptasi

dalam persekitaran RMS. Projek ini akan memberi tumpuan kepada Instrumen Nasional (NI) LabVIEW modul robot sebagai bahasa pengaturcaraan. Pelaksanaan projek ini akan dijalankan dalam dengan menggunakan LabVIEW Robotik Simulator. A-Star algoritma telah dilaksanakan bersama-sama dengan konfigurasi pengaturcaraan pra-pemilihan. Sebelum reka bentuk dan pembangunan strategi itu, kajian mengenai keupayaan gerakan bagi platform robot mudah alih NI telah dijalankan. Simulasi dijalankan bersama-sama dengan panel hadapan system yang mempunyai beberapa butang untuk memilih susun atur input robot mudah alih. Setiap satu daripada butang telah diuji untuk memastikan robot mudah alih mampu bergerak untuk setiap susun atur input. Dapatan penting kajian ini ialah penggunaan konfigurasi pengaturcaraan pra-pemilihan dengan strategi A-Star algoritma boleh dilaksanakan supaya robot mudah alih mampu bergerak mengikut laluan terpendek dijana dalam pelbagai susun atur RMS. Pelaksanaan projek ini diharap dapat memberikan idea yang baru untuk kegunaan selanjutnya robot mudah alih dalam industri pembuatan.

DEDICATION

I would like to dedicate to my beloved family members and friends who help me throughout the project.

I dedicate my dissertation work to my family and many friends. A special feeling of gratitude to my loving parents, Hasbulah and Norhayati whose words of encouragement and push for tenacity ring in my ears. My brothers and sisters have never left my side. Without my family support and councel, I could not completed this project. I also dedicate this dissertation to my many friends who have supported me throughout the project. I will always appreciate all what they have done.

Thanks to all for giving the continuous support to fulfill my needs of Final Year Project task. Thank you for all the supportive and always give me and advice to lift-up my spirit.

ACKNOWLEDGEMENT

In the name of Allah, the Most Gracious and the Most Merciful

At first, I wanted to express all my deepest gratitude to Allah SWT for His blessing so that I, Muhammad Haziq Bin Hasbulah, able to complete my Bachelor Degree Project and this report.

A special thanks to Dr. Muhamad Arfauz Bin A Rahman, my supervisor for his countless hours of reflecting, reading, encouraging, and most of all patience throughout the entire process. He also willing to give a lot of advices guidance and support during this research process.

I wish to thank my National Instrument LabVIEW committee members who were more than generous with their expertise and precious time. I would like to acknowledge and thank my faculty of Manufacturing Engineering for allowing me to conduct my research and providing any assistance requested. Their excitement and willingness to provide feedback made the completion of this research an enjoyable experience. The facilities and services that have provided have always been such a convenience and assistance in order to complete this project.

My special appreciation also goes to my parents, family and my fellow friends that have been always giving their support in during my studies.

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LIST OF ABBREVIATIONS

AGV	-	Automated Guided Vehicle
NI	-	National Instrument
RMS	-	Reconfigurable Manufacturing System
I/O	-	Input and Output
FPGA	-	Field Programmable Gate Array
CIM	-	Computer Integrated Manufacturing
GVG	-	Generalized Voronoi Graph
SLAM	-	Simultaneous Localization and Mapping
FMS	-	Flexible Manufacturing System
LIDAR	-	Light Detection and Ranging
API	-	Application Programming Interface
CSO	-	Configuration Space Obstacle
VI	-	Virtual Instrument
A*	-	A-Star
AD*	-	Dynamic A-Star

CHAPTER 1

INTRODUCTION

1.1 Project Background

Mobile robot is a mobile platform with a large mobility within its environment (Gregory and Michael, 2000). Mobile robots have a lot of applications nowadays. For example, the vacuum robot that are able in the market. The mobile robot also able to move autonomously without human operator.

Nowadays, mobile robots have an important role in manufacturing system. Mobile robot is one of the hardware that involve in the reconfigurable manufacturing system. In manufacturing system, the mobile robot is being used for material handling process and the mobile robot is being called as AGV (Automated Guided Vehicle). AGV is a mobile robot that use a guidance system that guide the robot movement throughout the manufacturing system such as reflective tape or wires on the floor.

Manufacturer now has to confront a new market conditions characterized by two things which is: (1) short windows of opportunity for new products and (2) large fluctuations in product demand. A reconfigurable manufacturing system is designed for rapid adaptations of production in term of capacity and functionality. The adaptations will involve rearrangement or change of its hardware and software components. The key is that reconfigurable systems must be designed at the outset to be reconfigurable, and

must be created by using basic hardware and software modules that can be arranged quickly and reliably.

In order for the mobile robot to achieve tasks in RMS, it has to be intelligent to decide its own action for plan its movement throughout the RMS layout. For compensate to the keep-changing environment, the robot have to be able to make topology mapping and move around with the ability to avoid obstacle and complete the task. There are basic requirements for mobile robot motion control. The motion control strategies should have solid foundations of the following criteria (Ahmad, 2013):

i) Kinematic or dynamic models of the robot
ii) Model of the interaction between the wheel and the ground
iii) Definition of the required motion-speed control and position control
iv) Control law that satisfies the requirements

The major challenge in mobile robotics is the position must be integrated over time, which sometimes leads to inaccuracies of the position and motion estimation.

For this project, it is involve the LabVIEW software that will be use to design the motion strategy of the mobile robot in the reconfigurable manufacturing system. LabVIEW is the graphical programming language that has been adopted widely in the industry. So, this project involves the graphical programming language to command the robot for achieving goal. The mobile robot to be use is the NI LabVIEW Mobile Robot. It is fully assembled mobile robot base starter kit. The controller used is based on NI Single-Board RIO and this robot involves real time decision making and FPGA-based I/O processing. The implementation of the motion strategy will be based on the simulation environment. Overall, this project is about to create the motion needed for this mobile robot to roaming in the Reconfigurable Manufacturing System (RMS) and it will be tested in the form of simulation.

1.2 Problem Statement

In manufacturing system, the mobile robot used moves based on the navigation system which are laser triangulation, inertial, magnetic tape, magnetic grid, natural feature, wire and optical. These navigation systems are only suitable in a fixed type of manufacturing system. Since RMS involves changeable in layout, navigating the mobile robot in RMS requires change of motion strategies. It is because the navigation system such as magnetic tape, magnetic grid and wire are fixed in the manufacturing layout. Since the RMS involve changeable layout, the fixed navigation method need to be redesign and implement again in the RMS. Hence, the navigation system is being changed or the robot need to be reprograms. It requires time and reprograms effort to make sure the mobile robot able to navigate in RMS. Hence, a appropriate motion strategy need to be designed so the mobile robot able to move and adapt in various RMS layout.

1.3 Objectives

The objectives need to be achieved for this project is as follow:

1) To review the layout of the Reconfigurable Manufacturing System (RMS)
2) To analyze the motion capability of the NI Mobile Robot platform.
3) To propose and develop the motion strategy for mobile robot in various layout of RMS