Faculty Of Electrical Engineering
Universiti Teknikal Malaysia Melaka

THIS IS MY THESIS LEARN BY DEMONSTRATION CONTROL ALGORITHM FOR CLEANING ROBOT

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Bachelor Degree of Mechatronics Engineering

2016

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" I hereby declare that I have read through this report entitle " Learn By Demonstration Control Algorithm For Cleaning Robot " and found that it has comply the partial fulfilment for awarding the degree of Bachelor of Mechatronics Engineering"

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Date : 23/6/2016

LEARN BY DEMONSTRATION CONTROL ALGORITHM FOR CLEANING ROBOT

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A report submitted in partial fulfilment of the requirements for the degree of bachelor of Mechatronic Engineering

Faculty of Electrical Engineering
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2016

I declare that this report entitle "*Learn by Demonstration Control Algorithm for Cleaning Robot*" is the result of my own research except as cited in the reference. The report has not been accepted for any degree and is not concurrently submitted in candidate of any other degree.

Signature : .....

Name : NURZAIKHANAZIRA BT MOHD KHAIDZIR

Date : 23/6/2016

To My Supervisor and Family

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ABSTRACT

"*Learn by Demonstration Control Algorithm for Cleaning Robot "*is a new techniques that build upon many standard machine learning methods that have great success in a wide range of applications. This project which undertaken in purpose for revolving current issues problem especially in household chores due to majority of working parents are not able to looked their kids or children of their surrounding environment. This will make lacked in focusing the healthiness, therefore it can cause health problem in the society. Other than that, it would help to save their times which suitable of this robot purpose in the application. These robots consist of two control mechanism which is record mode and the other is a replay mode which is design based on the Learn by Demonstration behavior of cleaning robot. In this project, the objectives are to develop a new control Algorithm using a fuzzy logic controller for learns by demonstration cleaning robot and to analyze the performance of new control algorithm in term of path error. To achieve the objectives in this project, a Learn by demonstration control algorithm for cleaning robot is developed by used of fuzzy logic control system. In order to conduct analysis, fuzzy logic control algorithm is applied to the robot. An experiment such as position of x-axis and y-axis is calculated and the performances of graphs obtained are analyzed. The performance of curves position is still not achieving the desired due to several circumstance from the algorithm of fuzzy control system. All experimental results are justified with the proposed methodology. In summary, the huge differentiation between closed loop system and fuzzy control system can be defines in term of path error with angle of jerking can be minimized. Therefore, result shows the smooth motion can be found on real times after implement of fuzzy control system.

ABSTRAK

"*Learn by Demonstration Control Algorithm for Cleaning Robot "* adalah satu pendekatan teknik yang baru yang membina piawai mesin pembelanjaran yang dapat membantu dalam bidang aplikasi. Project ini dilihat untuk mengurang isu semasa iaitu pengurusan kerja rumah oleh disebabkan era teknologi yang tinggi. Ini membolehkan ibu bapa yang bekerja tidak mampu melihat keadaan anak mereka dengan sepenuh perhatian disebabkan waktu bekerja yang padat. Oleh disebabkan itu fukus terhadap kesihatan boleh menyebabkan masalah kesihatan kepada masyarakat. Oleh yang demikian, robot ini mampu menjimatkan masa individu dan iainya sesuai dengan cadangan yang perlu ada pada aplikasi robot ini. Robot ini mempunyai dua mekanisma utk mengawal setiap keadaan pada "*Learn by Demonstration Control Algorithm"* system. Dalam projek ini, objektifnya adalah untuk membina "*develop a new control Algorithm using a fuzzy logic controller for learns by demonstration cleaning robot and to analyse the performance of new control algorithm in term of path error*". Untuk mencapai setiap objektif ini adalah dengan menggunakan kawaln fuzzy sistem untuk memperoleh analysis, fuzzy system ini akan dilaksanakan pada robot tersebit. Dalam eksperimen adalah untuk mencari posisi pada x-axis dan juga y-axis yang dikira menggunakan excel dan menerangkan prestasi yang dapat dilihat apabila graf yang dikeluarkan data real time data. Prestasi ynag ditunjukkan pada posisi lengkuk tidak begitu baik ini adalah kerana terdapat beberapa keadaan yang menjadi limit apabila menggunakan fuzzy sistem secara kesimpulannya, terdapat perbezaan yang besar pada kedua dua sistem iaitu sudut pada sistem kawalan tertutup dapat dikurangkan apabila kesalahan pada jarak sudut dapat diminimakan seperti yang ditunjukkan pada kawalan fuzzy. Oleh yang demikian, keputusan untuk memastikan robot bergerak dengan lancar adalah Berjaya.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

In this world of sophisticated and high technology, the use of equipment and powerful machine is needed to improve the standard of human living in order to achieve satisfaction and leisure that required by human beings. Therefore, many behavior-based robot researches are increasing due to the growing lifestyle of society which focusing on new technologies to assist their self needs. With this optimize control of the robot; it will help to fulfill their desired on certain tasks. So, in reducing the error occur on certain task, researches on behavior robot type have been focused throughout the decade. Most of the researches use control algorithm in order to reduce the error produced by behavior-based Robot. On top of that, diversity and advanced technologically robot must have the characteristics of safety and convenience when applying the mobile robot in everyday life.

Furthermore, many sort of controllers such as Proportional (P), Proportional Integral (PI), Proportional Derivative Integral (PID), Adaptive and Fuzzy Logic Controller (FLCs), have been developed for speed control of dc motors [1]. These applicable controllers would improve the performance of the system. The fuzzy logic controller has been proposed to minimize error by controlling speed of motor and angle of compass. The fuzzy logic controller (FLC) is indeed capable of providing the high accuracy required by high performance drive system without need of mathematical model [2]. Apart from that, FLC accommodates non-linearity without Utilization of mathematical model [2]. In this paper, the use of fuzzy logic as design methodology can be applied to developing non-linear system for implemented control.

1.2 Project Background

As stated by the International Organization for Standardization based on ISO 8373 [3], robot is defined as an automatically controlled, programmable, multipurpose, manipulator programmable in three or more axes, which can be fixed in place or mobile. Nowadays, robots are one of the greatest technologies invented by human brain capability that can accomplish every task given. There are three types of robots that are commonly used such as mobile robot, KUKA robot and humanoid robots like ASIMO. These robots can be classified according to their degrees of freedom. As for the mobile robot, it has about one and two degrees of freedom, KUKA has one to seven degrees of freedom, and humanoid can be up to 26 degrees of freedom. All of these robots have their own control algorithm in order to control and reduce the error of the robot operation.

In this project, control algorithm for the cleaning robot is only considered Learn by Demonstration Control Algorithm as this research only focusing on reducing the error of operation for the cleaning robot such as position, velocity, and distance. A fuzzy logic control technique is used in this research to improve the performance of cleaning robot with respect to the parameters. The data from the analysis will be used to design and develop a control algorithm of learn by demonstration method.

Fuzzy logic control is derived from fuzzy set theory introduced by Zadeh in 1965. Boundaries of fuzzy sets can be vague and ambiguous, making it useful for approximate systems. Fuzzy logic controller is an attractive choice when precise mathematical formulations are not possible [2]. Fuzzy logic control is a technique to tune existing controller which will improve the performance of the controller in term of sensor accuracy and many more. Fuzzy logic will imitates human intelligence, which underlying modes of reasoning that are very closely to human reasoning than formal logic in real world [4]. This fuzzy logic controller is said to become a great achievement because it is simple to design and have better performance than other controller. As an example, to control the speed of a variable speed drive is by using slip power recovery configuration. The slip power recovery configuration is a scheme for variable speed drive with has lower performance control. By applying fuzzy logic control to the slip power recovery configuration, the number of sensor and observers is reduced and the parameter variation, disturbances and some faults are

rejected from the system [4]. Moreover, fuzzy logic control has already been applied in many field and become a great achievement for the industry.

1.3 Motivation

In preferable lifestyle nowadays, cleaning becomes a difficult routine especially for the working parents as they mostly spend their time on their career. They do not realize that a clean environment is very important for health wellness and their children growth. In order to maintain a clean environment, they face some difficulties. Due to pack schedule, some working parents overlooked on certain things like house chores, children and living environment. Therefore, inventors have come out with an idea to create a cleaning robot as the main goal to overcome problem.

We can say that there are many technologies that appear and accordance to the current situation that take place. However, cleaning robot is most widely used by the community as they have improved their lifestyles to become better. Based on an article from the magazine [5] called "T3: The Gadget Magazine "entitled "Best robot vacuum cleaners: clean your home without lifting a finger". From this article, it shows that many cleaning robots have been created with different design and features. We can conclude that the major factors of these development is related to human busy lifestyle as they need something to assist them to manage their routine especially in cleaning the household chores. Furthermore, different company comes with different design to fulfill the consumer's desires needs which inadvertently upgrade the cleaning robot so they are on a par with today's technology.

Besides that, another magazine [6] named "Health Facilities Management". This magazine contains an article titled "Advances in floor cleaning equipment" which explain the advantages of the cleaning robot that concern patient safety and experience while keeping an eye on the costs. It also mentions in raising the productivity and reducing cleaning costs at the hospital which addressing issue about the high cost maintenance and budgets. In addition, from the market recent issue that includes solutions for hard to clean and high traffic areas as stated by Rick John, health care manager. He stated that "new technology is available that can reduce the use of conventional cleaning chemicals, reducing exposure to

volatile organic compounds and fragrances foe patients who may have chemical sensitive" [6].

Based on the analysis in the market, it shows that the potential of service robots can be high demand in the global market outlook. From time to time, demands for service robots by the consumer are increasing because they have realized the benefits. These cleaning robots needs to have solid build quality, effortless obstacle avoidance and reasonable programming function as the ideal choice for consumers [1]. So, in this project, the reason to learn by demonstration from the desired trajectory by the users is to reduce their time to finish the chores and able to program the path as they like. Therefore, in Figure 1.1 below shows graph of a potential of Robotic Business Review that: Industrial robotics market forecast growing at a CAGR of 6.2% from 2014 to 2020. Service robotics (combined personal and professional) market is expected to grow at a CAGR f 21.5 % from 2014 to 2020 [7].

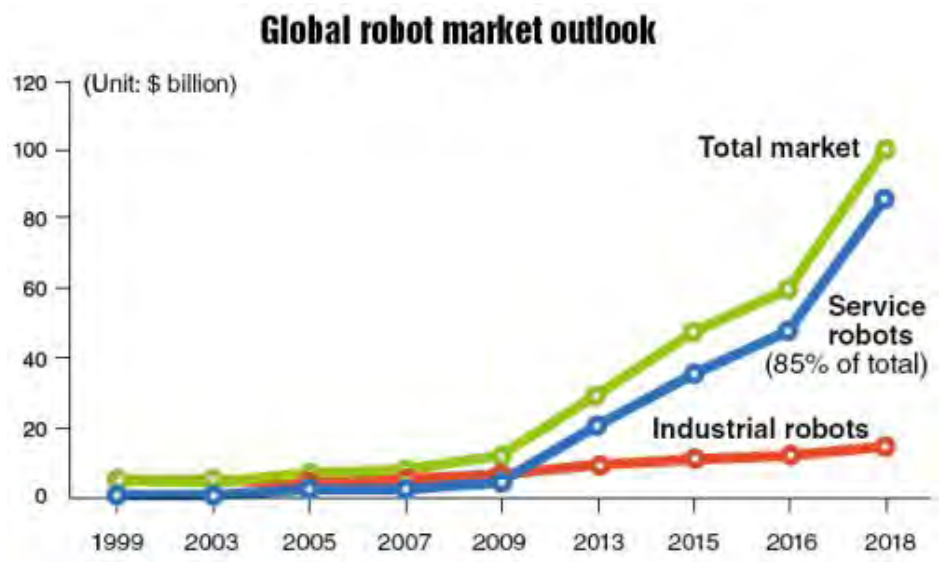

Figure 1.1: Global robot market [3]

1.4 Problem Statement

The problems that are encountered for completing this project are to come out with the suitable control algorithm method that able to minimize the error of the performance of the cleaning robot. The performances that are included in this research are based on certain parameters such as position, velocity and angle movement of clean robot. The control algorithm will represents the operation of robot which follow human desired by imitating the trajectory which is made by human.

In the previous research, researchers use a try and error method by using an open loop and closed loop control system program. The researcher try both of the control system program in order to choose the best control system by comparing the error resulting from both system. The error will be divided into three form which straight path is 8%~9%, curve path is 4% and 6% for S-curve path. So, These resulting that desired output is not being fulfilled because the robot not accurately followed the desired path due to error that occur and jerking in path during replay mode is take place during the operation is done. Therefore, unsuitable control algorithm will resulting undesired output and make this project unsuccessful

Other than that, factors that affect the accuracy of position, velocity and angle movement of cleaning robot which relates to hardware constitution. These include the perfections of the robot such as the suitable components that will be applied for the robot. Besides, the hardware selection part also covers the components that are used to verify the parameters that will be test during the operation and also the data logging for the sensor. Thus, the hardware part need to emphasize because it showing the evidence of a task given.

1.5 Objectives

The objectives of this project are:

1) To develop a new control Algorithm using a fuzzy logic controller for learns by demonstration cleaning robot.
2) To analyze the performance of new control algorithm in term of path error.

1.6 Scope

In order to achieve the objectives above, the scope below has to be considered:

1. The Learn by demonstration cleaning robot have to operate on a flat and smooth surfaces as the hard surface will give a difficulty for the robot to move. This is because the friction between the surface and the Tyre is high and the power of encoder motor is not enough to overcome it.
2. It is limited to a certain trajectory path that the user like which only considered forward path based on encoder that count the number of step in the unit step signal which only have positive value .
3. The analysis of this project would focus about two path which are the form of straight and curved in order to specify the differences performance of the cleaning robots. The used of compass sensor would detect the X-axis and Y-axis.
4. The lack of this cleaning robot is an unable to avoid the obstacle in front by itself like other smart cleaning robots at the market because our main objective is a Learn by demonstration. So, it would follow the path as desired.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

On this chapter, another reviews would take part in order to complete the task given based on the previous researches project that are related to this project would be discussed on these chapter. To have a good brief explanation about this project is by exploring the fact at internet, references book, a few of literature review on journal or patent about these project. Apart from that, these information will become additional source to the project for be helpful to successfully.

2.2 Project Background

Mobile robot is one of the service robots which help a lot of people works in everyday life. According the pursuing of time that is now full of high technology, these service robots would give huge advantages to the consumer. Apart from this clean environment, this would able to maintain a human body to stay health and have comfortable lifestyle. So, in order to help society nowadays who is mostly working parents, another innovation has been created which is a cleaning robot. This is because working parents usually do not have enough time to clean their house because of work commitment. By the way, There are several famous types of cleaning robot which help household chores that exists in the market like a vacuum cleaning , floor scrubbing, floor mopping , pool cleaning and gutter cleaning robots [8]. This type of robot has difference function and has its own uniqueness in order to give satisfaction to the consumer. Furthermore, these service robot needs to navigate a path by using a programming which install on it to make it more precise while use it. Moreover, this cleaning robot able to avoid the obstacle given which about focusing the sensor counter approach that