ANALYSIS REAL TIME CONTROL OF BEHAVIOR ROBOT IN ASSITING HUMAN IN CLEANING HOUSEHOLD

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“ I hereby declare that I have read through this report entitle “ANALYSIS REAL TIME CONTROL OF BEHAVIOR ROBOT IN ASSITING HUMAN IN CLEANING HOUSEHOLD” and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Mechatronic Engineering with Honor”

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HEE KEE MING

A report submitted in partial fulfillment of the requirements for the degree of Bachelor of Mechatronic Engineering with Honor

FACULTY OF ELECTRICAL ENGINEERING
UNIVERSITY TEKNIKAL MALAYSIA MELAKA

2015

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ABSTRACT

Technology of service robot keep improving from year by year due to need of human to solve difference kind of problem that face in daily life. Service robot in market is moving randomly when operate and this will cause it miss out some of the part in the room and increase the time needed to completely clean up the room. In order to overcome this problem, a prototype that able to learn by demonstration will be create to make the cleaning robot able to clean the room more efficiency. Cleaning robot that design will not include avoid obstacle sensor to reduce the complex of this project because main focus for project is learn by demonstration and human will avoid obstacle when doing demonstrate trajectory. Prototype will have two mode that is record mode that memory demonstrate trajectory by user and replay mode that redo the trajectory did by user. Basic sensor like encoder and digital compass sensor will be used in this project to detect distance travel and facing angle of cleaning robot. Number of step of encoder for one complete cycle and accuracy of digital compass sensor had been test in this project. Two difference system that is open-loop system and closed-loop system had been test to find the best system to operate cleaning robot. Cleaning robot able to show out the trajectory by using both of the system but closed-loop system is much more better compare with open-loop system because the end point of desired and actual point for closed-loop system is closer compare to open-loop system.

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ABSTRAK

Teknologi perkhidmatan robot terus meningkatkan dari tahun ke tahun kerana keperluan manusia untuk menyelesaikan perbezaan jenis masalah yang dihadapi dalam kehidupan seharian. Robot perkhidmatan seperti robot vakum di pasaran bergerak secara rawak apabila beroperasi dan ini akan menyebabkan ia terlepas beberapa bahagian di dalam bilik. Jalan rawak akan terlepas beberapa kawasan pembersihan dan akan meningkatkan keperluan masa diperlukan untuk membersihkan bilik. Untuk mengatasi masalah ini, prototaip yang dapat program jalan pembersihan akan mencipta untuk membuat robot pembersihan dapat membersihkan bilik kecekapan lanjut. Prototaip ini tidak akan mengandungi sebarang sensor untuk mengelakkan halangan kerana pengguna akan mengelakkan halangan apabila pengaturcaraan jalan pembersihan untuk robot. Prototaip akan mempunyai dua mod iaitu mod rekod memori mencatat trajektori oleh pengguna dan ulangan mod yang buat semula trajektori yang lakukan oleh pengguna. Sensor asas seperti pengekod sensor dan kompas digital akan digunakan dalam projek ini untuk mengesan perjalanan jarak dan menghadap sudut pembersihan robot. Bilangan langkah pengekod untuk satu kitaran lengkap dan ketepatan sensor kompas digital telah ujian dalam projek ini. Dua sistem perbezaan iaitu sistem gelung buka dan sistem gelung tertutup telah ujian untuk mencari sistem yang terbaik untuk mengendalikan pembersihan robot. Pembersihan robot dapat menunjukkan daripada trajektori dengan menggunakan kedua-dua sistem itu tetapi sistem gelung tertutup adalah lebih baik berbanding dengan sistem gelung buka kerana titik akhir titik dikehendaki dan sebenar untuk sistem gelung tertutup adalah lebih dekat berbanding dengan membuka gelung system.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Research background, motivation, problem statement, objectives and scope will be present in this chapter.

1.2 Research Background

Cleaning is an important activity that happens in our daily life. Clean environment able to maintain human body stay in health and comfortable. To maintain housing area always in clean condition although human does not have time do household chores, cleaning robot is one of the best solution. There have many types of cleaning robot that exists in the market and able to assist human doing household chore likes road cleaning robot, vacuum robot, window cleaning robot, floor cleaning robot and swimming pool cleaning robot. The image of the cleaning robot then mention was shown in Table 1. The reason that cleaning robot able to assist human doing household chores is because it is able to operate automatically and clean desired place. Some of the cleaning robot is able to detect surrounding obstacle that blocking the way and avoid it. Besides, cleaning robot like vacuum robot contain dust sensor that able to detect surrounding dust and clean the dust area. After the statement mention above, it show that cleaning robot able to clean housing area although no body in the house. Unfortunately, most of the cleaning robot in the market moving trajectory are in random motion. To overcome the problem, designer include some sensor to prevent collision occur. In this project, a bathroom cleaning robot that able to learn from human demonstrate trajectory and redo the demonstrate trajectory will be develop. With this kind of cleaning robot, user is able to program trajectory of the cleaning robot compare with

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cleaning robot in the market that move randomly. Besides, the sensor that detect surrounding environment will not be include in this project.

Table 1.1: Cleaning Robot exists in Market

Road Cleaning Robot	
Vacuum Robot	
Window Cleaning Robot	
Floor Cleaning Robot	
Swimming Pool Cleaning Robot	

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1.3 Motivation

Cleaning is an important task for human to maintain healthy life. Unfortunately, human now are busy working and lack of time to clean their housing environment. To overcome this problem, they need a cleaning robots that able to assist them to conduct household chores. Although market already have many types of cleaning robot for household chores but cleaning robot that designed to clean bathroom still not familiar.

One of the motivation for me to conduct this project is because one of the magazine [1] title "When Will We Have Robots To Help With Household Chores?" from IEEE Spectrum. From the title of the magazine, it show that human are willing to have a cleaning robot that able to reduce their working task to finish their household chores. In this magazine, it mention that big company like Google has recently start buying spree of Robotics Company. It show that cleaning robot become important for the future and it will improve quality of life of human. With the research of big company, it will greatly improve or accelerate robotics technology in the world. This is because big company willing to pay huge amount of money for research.

Another magazine [2] from IEEE Spectrum "So, Where Are My Robot Servants?" mention that the idea of robots doing chores around the house has long captured by people's imaginations and robot would help them live independently longer and providing care. From both of the magazine, it show that the demand of human on cleaning robot are keep on increasing and many research for household chore robot are in progress.

Besides, most of the cleaning that sell in the market are move randomly. Cleaning robot that move randomly does not able program their trajectory. They are moving in random path and using sensor to detect surrounding environment to prevent collision like wall and obstacle. Besides of that, when cleaning robot move randomly path, some of the area will be left out. Therefore, to ensure cleaning robot able to clean housing area more efficient, an idea to develop a bathroom cleaning robot that able to program trajectory by human was coming out. Cleaning robot that able to program trajectory able to clean housing area as user like. Therefore, cleaning robot will not move randomly and miss out some area like corner of the room. To provide better housing environment for human, bathroom cleaning robot

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that able to learn to do what they do will be design in this project to reduce time taken to finish chores and user is able to program cleaning robot trajectory motion as they like.

The cleaning robot that fix to clean bathroom is just a prototype, the main focus of this project is the technology that able to program trajectory of cleaning robot as user demonstrate and redo the trajectory. This technology able to include into every cleaning robot if successful.

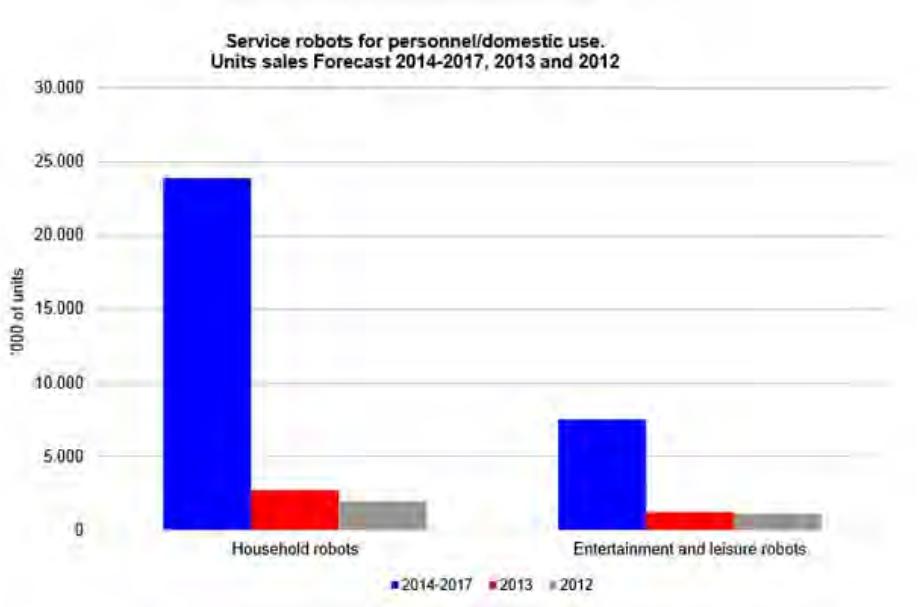

Figure 1.1: Service Robot for Personal/Domestic Use[3]

From the figure 1 it show that units of household robots are keep on increasing year by year. It show that demand of human to household robot will keep on increasing. Therefore, human will need household robot to help them solve daily life in their life.

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1.4 Problem Statement

The main function of cleaning robot is to clean the selected area nicely. Cleaning robot should be able to clean the surface that passes by perfectly. Most of the bathroom floor is rough surface to prevent human fall down because of slippery. Therefore, the material of the brush is important enough when clean the surface. Material for brush to clean rough surface should be strong enough to clear the dirt inside slit.

Besides, weight of cleaning robot is also important when design the prototype. The weight of bathroom cleaning robot should be big enough to pull down the body of cleaning robot. This is because when body of cleaning robot is light, surface of brush and floor does not able to contact nicely to clean the floor. Besides, bigger weight will increase the grip between the tires and floor. Tires that have proper grip on the floor is able to prevent cleaning robot move out of desired trajectory. The brushes that rotate to clean surface will also well contact when weight pull down the body of robot.

DC motor with encoder was used to detect the motion of tires and store it into memory. Data that store in memory will be used when bathroom cleaning robot operate. Rotation motion of brush will create unwanted force that will affect BCR does not move in desired trajectory. Compass sensor was used to overcome the problem when desired angle and real-time angle are difference. Compass sensor that use able to record the angle of cleaning robot facing when human demonstrate the trajectory.

The position of digital compass sensor place in body of cleaning robot is important. If the sensor place position not suitable, data that collected is not accurate and bathroom cleaning robot will not face to selected angle. When bathroom cleaning robot faces to difference angle and move, this will increase the path error when cleaning robot redo trajectory that programed. Therefore, position to place digital compass sensor should be test for few times and get the best position to place the sensor.

Encoder will detect one step when rotary encoder rotates in a specific value of angle. For the encoder that use in this project it will detect one encoder step when it rotate 1.44 degree. Therefore, one whole cycle that contains 360 degree will contains 250 steps of encoder value.

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1.5 Objectives

The objectives for this project are:

1. To design a prototype cleaning robot that able to clean bathroom environment.

2. To develop a bathroom cleaning robot that able to learn from human demonstrate trajectory and redo the demonstrate trajectory.

3. To analysis the performance of developed cleaning robot in terms of direction, maneuverings movements and path error.

1.6 Scope

To achieve the objectives that mention, scope for this project was list as below:

1. Material to design prototype will be plastic, rubber and metal that easily get from market.

2. Bathroom cleaning robot (BCR) that design only allows to operate on floor that is flat surface. The BCR does not able to climb up or move to another level when operate.

3. Analysis of cleaning robot will be done in three difference shapes like straight line, round shape and square shapes.

4. Angle that able to detect by digital compass sensor in cleaning robot only in X- Axis and Y-Axis.

5. Bathroom cleaning robot does not include avoid obstacle function.

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CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter the concept to design learns by demonstrate bathroom cleaning robot will discuss. Besides, theory and component used will be discussed in this chapter.

2.2 Design of Cleaning Robot in Market

There are many cleaning robot for household chores in the market. Unfortunately, most of the cleaning robot are moving in random position and use sensor to detect surrounding to prevent collision. After go though some journal, it show that most of the cleaning robot in market are using collision sensor, infrared sensor, dust sensor, ultrasonic sensor, sonar range sensor, laser ranger finder and acceleration sensor to detect surrounding environment when moving in random[4]. Many types of sensor will be include in the cleaning robot just to prevent cleaning robot stuck or collide of cleaning robot and obstacle. This is because cleaning robot that sell in market is design to clean user house and every house will have difference size and contain obstacle.

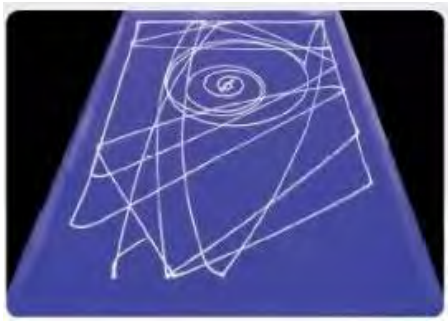

Figure 2.1: Random Path Planning

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2.3 Idea to Develop Bathroom Cleaning Robot (BCR)

The general idea to design path learning bathroom cleaning robot (BCR) is based on the journal [7]. It writes about the idea to program robot trajectory follow a person demonstration. Therefore, this project is to design a prototype of BCR to learn human demonstrate trajectory and show the trajectory movement when operate. The way they use to program cleaning robot is using a broomstick to move cleaning robot. Cleaning robot will automatically generated trajectory that demonstrate and matches the trajectory when operate.

This is because cleaning robot that move randomly contain some disadvantages. That is cleaning robot will miss out some part when doing cleaning process[5]. Beside of that, time taken for cleaning robot that moving randomly to finish cleaning process will be longer compare with cleaning robot that able to program trajectory[6]. To reduce the component use to build up a cleaning robot and reduce time taken for cleaning robot finish cleaning process, a bathroom cleaning robot that able to learn from demonstrate trajectory and redo demonstrate trajectory will be create.

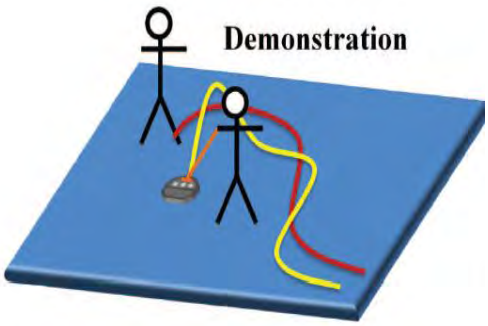

Figure 2.2: Demonstration for Cleaning Robot.

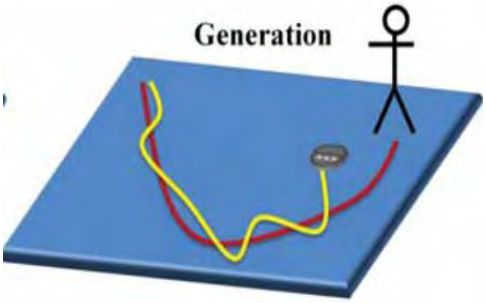

Figure 2.3: Path Learning of Cleaning Robot

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2.4 Component Selection

2.4.1 Type of Distance Travel Sensor

There are many types of sensor that able to measure travel distance of an object. Sensor like infrared sensor[8], ultrasonic sensor [9], acceleration sensor[10] and encoder [11] that are able to measure the travel distance of robot.

The infrared sensor and ultrasonic sensor are using the concept like detect surrounding and calculate move distance. This kind of sensor is not suitable for difference types of room space. For acceleration sensor, it is able to calculate the distance travel according to the velocity that detected.

Besides, sensor like encoder able to measure travel distance of object according to number of step detected. In journal [11], it mention that encoder was used to estimate the size of the cleaning room. They attach collision detector and encoder on the body of cleaning robot to detect the size of room. They create two environment of room to conduct experiments: with furniture and without any furniture. For experiment in room without furniture, cleaning robot is able to measure the size without any obstacle and get better results. Encoder is able to calculate the horizontal distance and vertical distance of the room according to the value of encoder come out with some mathematical calculation and get the actual size of the room.

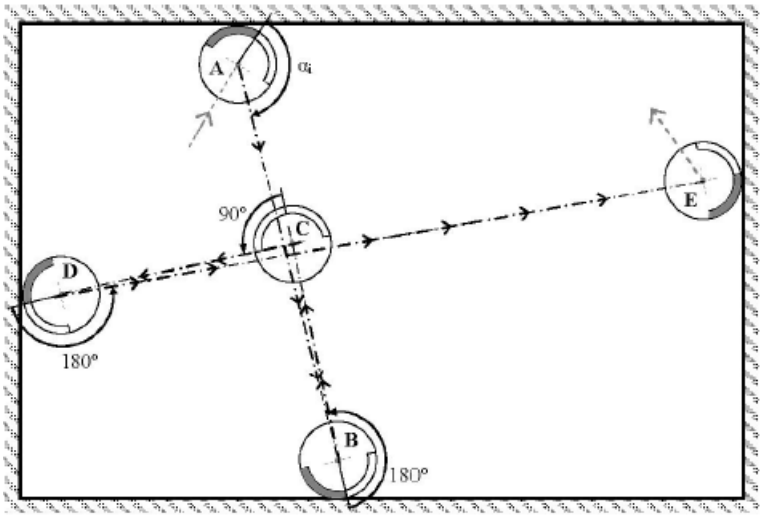

Figure 2.4: Example of “cross exploration”.

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Data that collected from encoder sensor is much more accurate compare with other infrared sensor, ultrasonic sensor and acceleration sensor that mention at above. This is because encoder is measure the rotation angle on the wheel but infrared sensor, ultrasonic sensor and acceleration sensor is measure distance travel of the robot with mathematical formula. If the position of sensor attach on body of cleaning robot is not suitable, it will affect the results of whole project. Therefore, encoder sensor was selected to measure the travel distance of bathroom cleaning robot.

2.4.1.1 Digital Compass Sensor

When cleaning robot moving, the trajectory maybe does not fully follow demonstrate trajectory did by user. One of the way to tune the position or trajectory of bathroom cleaning robot to follow demonstrate trajectory is using compass sensor that able to modified error that occurs [12]. Compass Sensor able to detect angle of machine face to when user start to demonstrate trajectory until the end. Data that collected will be used to compare with actual angle of bathroom cleaning robot facing when testing prototype. Angle of bathroom cleaning robot will be tune when actual angle and desired angle are difference.

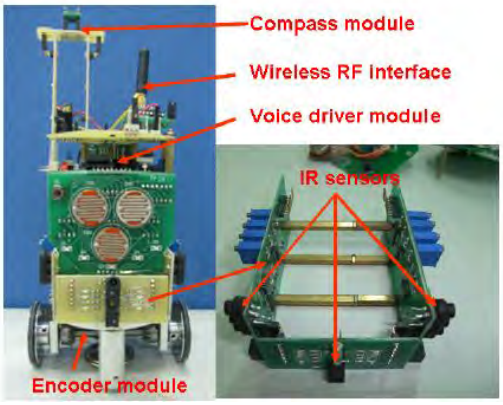

Figure 2.5: Robot with Compass Module

Navigate trajectory motion system needs digital compass and angle sensor to acquire the position and posture information of the BCR[13]. The angle of BCR facing will be calculated according to distance robot move in X-Y Axis by using triangle rule. When direction or angle contain error, two input data from encoder and compass sensor will be used by controller and control robot toward the desired path.

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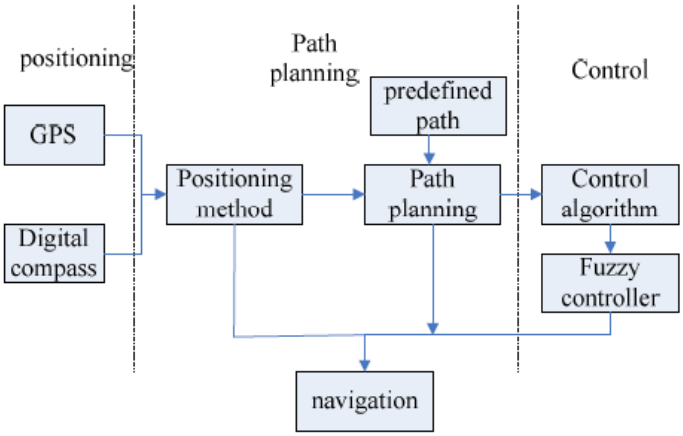

Figure 2.6: Block Diagram of Navigate Trajectory Motion System

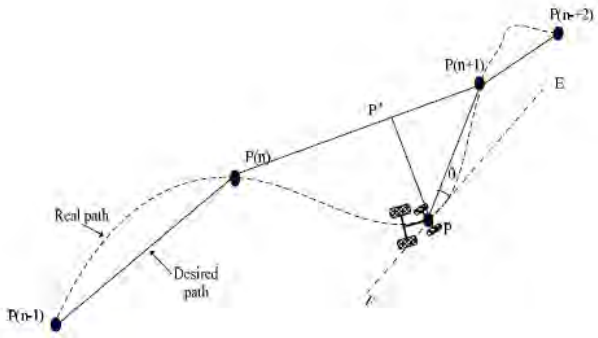

Figure 2.7: Path Tracking Method for Vehicle

Journal that wrote by students from University Malaysia Pahang (UMP) [14] show that compass module is able to track position of robot face. In their journal it is discuss to develop a straight line robot movement by using digital compass module. Although unexpected external force changing the moving path of robot, robot still able to veer back to original set-point direction to achieve smooth and stabilized movement.

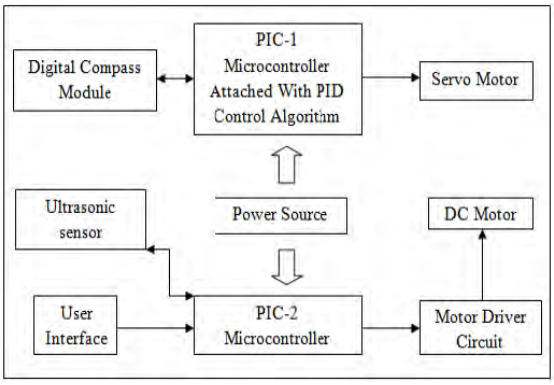

Figure 2.8: General System Block Diagram

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