UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEVELOPMENT OF MOBILE ROBOT USING RASPBERRY PI FOR SWARM ROBOTICS

This report is submitted in accordance with the requirement of Universiti Teknikal Malaysia Melaka (UTeM) for Bachelor's Degree in Electrical Engineering Technology (Industrial Automation and Robotics) with Honours

by

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…….

(Muhammad Salihin Bin Saealal)

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ABSTRACT

Swarm robotics is the study of the coordination of multi-robot systems which consist of large numbers of mostly simple physical robots. The swarm robotics inspired form nature which was combined of swarm intelligence and robotics and it has a great potential in several aspects. Although swarm robotics consists of many robots but without formation, it can do nothing. In industry, swarm robotics controlled by using formation and it will be helped to improve the performance of the operation system. This project focuses on the development of mobile robot using Raspberry Pi for swarm robotics. The model for swarm robotics is draw by using Solidwork Software. Three robots have been developed which remotely controlled. Python language is needed to program the robot by mean of wireless application in order to cooperate to perform a column and triangle pattern formation. A performance comparison between the need of infrared and ultrasonic sensor for distance between robots have been done. From the experiment, the ultrasonic sensor gives more accurate measurement compare to infrared sensor. Besides, PUTTY will be uses to set the algorithm calculation for the Raspberry Pi. The testing and analysis of the robot will be done in different parts of process to maintain the performance of swarm robots.

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ABSTRAK

Swarm robotics adalah kajian tentang penyelarasan sistem multi-robot yang terdiri daripada sejumlah besar robot fizikal. *Swarm robotics* ini adalah inspirasi dari alam di mana gabungan kecerdikan dan robotik mempunyai potensi yang besar dalam pelbagai aspek. Walaupun *swarm robotics* terdiri daripada banyak robot tetapi tanpa pembentukan ia tidak boleh melakukan apa-apa. Dalam industri, *swarm robotics* dikawal dengan menggunakan pembentukan, ini akan membantu meningkatkan prestasi pengendalian sistem. Model untuk *swarm robotics* adalah dilukis dengan menggunakan perisian Solidwork. Tiga robot telah dibangunankan yang jauh dikawal. Bahasa *python* adalah diperlukan untuk program robot. Robot-robot dikawal oleh aplikasi tanpa wayar untuk bekerjasama dalam melaksanakan pembentukan corak tiang dan segi tiga. Perbandingan prestasi antara keperluan sensor *infrared* dan *ultrasonic* untuk menentukan jarak antara robot telah dilakukan. Dari eksperimen, sensor *ultrasonic* memberikan ukuran yang lebih tepat berbanding dengan sensor *infrared*. Selain itu, projek ini akan menggunakan PUTTY untuk menetapkan pengiraan algoritma untuk Raspberry Pi. Ujian dan analisis robot yang akan dilakukan dalam pelbagai bahagian untuk mengekalkan prestasi dari *swarm robotics*.

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DEDICATIONS

Specially dedicated:

To my father, mother and sister

To my kind of lecturers

And

All of my fellow friends.

For raising me become who I am today.

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LIST OF SYMBOLS AND ABBREVIATIONS

PWM	-	Pulse Width Modulation
CPU	-	Central Processing Unit
DC	-	Direct Current
WLAN	-	Wireless Local Area Network
IR	-	Infrared
LED	-	Light-Emitting Diode
PCM	-	Pulse Code Modulation

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CHAPTER 1
INTRODUCTION

1.0 Introduction

Swarm robotics is the study of the coordination of multi-robot systems which consist of a large numbers of mostly simple physical robots and it normally will combine with pattern formation to perform a specific task. Nowadays, swarm robotics has been concerned by the research of robotics, and generally they used platforms are formation, pursuit-evasion and Robot world cup.

In this way, human can control the robot to do any formation or pattern. But, this project involves not only one robot, it involves minimum three robots. So that, this project needs all robots to cooperate to form a particular shape or pattern to achieve some special task. This is a new venture that is focused on intelligent swarm robotics that must be autonomous robots in which the robots are able to sense and actuate in a real environment.

The hardware part of this project included electronic component and mechanical component. The electronic parts will be used to develop this project are Raspberry Pi, Direct Current (DC) motor, RaspiRobotBoard V2, Wi-Pi, infrared ray sensors and so on. On the other hand, the mechanical parts are wheels and chassis of the robot.

Solidwork will be used to design the chassis of the robots. Besides, PUTTY will be used to write the code to the Raspberry Pi in order to simulate the operation system.

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1.1 Background

Swarm robotics is the study of a field of multi-robotics in which a large number of robots that are coordinated in a distributed ways. It is based on the use of local rules, and simple robots compared to the complexity of the task to achieve, and inspired by social insects. Large number of mobile robots can perform complex tasks in a more efficient way if compare with a single robot, giving robustness and flexibility to the group. In this project, an overview of swarm robotics is given to introduce the main properties, characteristics and comparing it to general multi-robotic systems by researching and investigating from experimental results.

In other word, swarm robotic can also defined as the study of how to coordinate a large group of relatively mobile robots through the use of local rules. The combination of both physically and computationally component that make a mobile robot to move around its environment. The mobile normally consists of locomotion where of itself and its environment; to sense how the robot detect and measures itself in its environment, to control how the robot generates its physically motions, to determine how the robot maps measurements in its actions and how the robot can communicate with other robots.

In a cooperative robot system, the awareness of the robots behavior within the system is important while to maintain the robot formation. This awareness can be obtained through its local sensors and communication.

The formation maintenance is the ability of a number of robots which to fixed and maintain their formation such as line, column, diamond and wedge. The movement of all robots should be same. This research is concentrated on how to make a number of robots to move synchronously.

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In this project, minimum three mobile robots will be develop and made to synchronously in diamond pattern formation cooperatively. The slave robots had move synchronously with its master robot. Figure 1.1 shows how the slave robots move synchronously with its master robot move in diamond pattern formation.

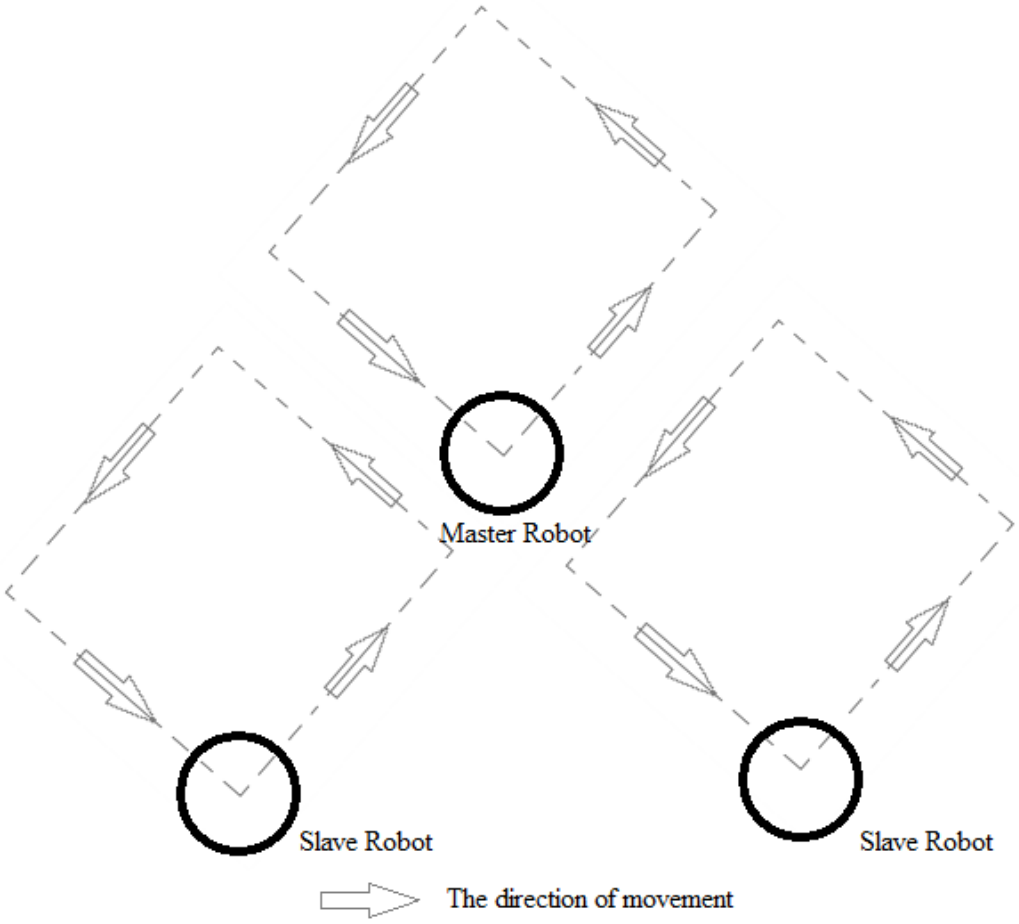

Figure 1.1: The diamond pattern formation among three robots

To maintain a formation for robots is very important. Basically, differences robots have difference speed, although it just slightly difference between them, it will make a big difference result and have a big influence to the pattern formation.

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1.2 Problem Statements

Swarm robotics is very important in our life. But, swarm robots that without formation, they have do nothing in our life. It means that the formation is quite important issue for swarm robotics. Therefore, swarm robotics should cooperate to perform specific tasks. Figure 1.2 shows the different of mobile robots that with or without formation.

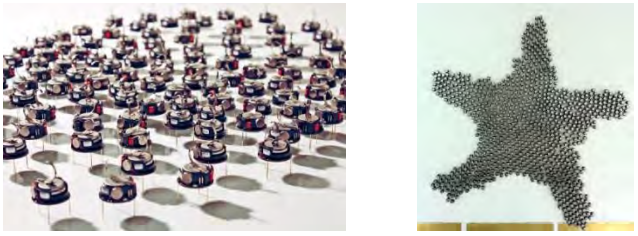

Figure 1.2: The mobile robots that (a) without formation and (b) with formation.
(www.cbc.ca)

The different in between swarm robots and single robot are swarm robots have larger range of task domain, greater efficiency, robustness, fault tolerance and improved system performance. It seems that swarm robots are quite better than single robot.

Swarm robotics can do many specific tasks that helped human to solve many problems such as swarm robots can take the load that human unable to take it, swarm robots can increase the productivity by means its can transport the product from one location to another location continuously in a long time. Figure 1.3 shows the Kiva robots that used in industry and it seems like help and human life more easily.

Figure 1.3: Kiva robots used in industry.
(Raffaello D'Andrea et al. (2008))

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Nowadays, there have many types of swarm robots that used in our life. But, not all types of swarm robots have same level of performance. The performance of swarm robotics is more related to what type of processor or controller that used. There have many types of main controller used in swarm robots such as Arduino, Beagle Board, PIC and so on.

Besides, the efficiency of the formation is directly influences by the performance of the systems, while doing some special cooperation task. Therefore, a high quality and suitable material is needed for create the multi-robot.

The ideal controller for this project is Raspberry Pi if compare with other controller. Raspberry Pi basically is a mini computer. It give a high efficiency performance, an extremely low power draw, small form factor, no noise, expansion capabilities, multiple uses and other feature make it an attractive solution to choice as serve for making a swarm formation robots.

When multi-robot had perform a task, energy supply underlying was a big problem. Besides, real time quality is important and should not be ignoring. Sometimes, the robots function had delayed much more, this should not be happened. Yet, these types of problem had been overcome by Raspberry Pi. Swarm Formation Robots should operate by Raspberry Pi to have a best performance in operation.

1.3 Project Objectives

There are two main objectives that reason in studying and developing this kind of swarm robot. The idea of this project is to develop Raspberry Pi in order to control a number of robots to do a pattern formation to achieve some special task.

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The main objectives of this project are as follows:

i. To design and fabricate a mobile robots for swarm robotics.
ii. To develop a pattern formation to show swarm robotics operation.

The addition aim of this project is to apply a skill dealing with electronic component and circuit to control the system. This project also gives the opportunity to apply programming skill and to understand the operation of each part component of the robot. Besides, the project also gives the chances to study a wireless application to control a number of robots.

1.4 Scopes

This project is focuses on the theory of swarm robotics which is a number of robots had controlled to do pattern formation to achieve some special task. The scope of this project is more related to the objectives.

To design and fabricate a mobile robot for swarm robotics, it had related the scope below:

i. The development of autonomous mobile robot by using Raspberry Pi as a main controller.
ii. To fabricate minimum 3 semi-sphere shape mobile robots for swarm robotics to make the robot more suitable to detect with other robots.
iii. DC motor is use to make the robot can more efficiency to move faster from one place to another place.

To develop a pattern formation to show swarm robotics operation, it had related the scope below:

i. To develop algorithm to show pattern formation of swarm robotics such as a line formation, column formation, diamond formation and wedge formation.

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ii. Use three sensors to find the best position for measuring the distance between the robots.

iii. The mobile robots must move and maintaining fixed distance in between with other robots.

In a nutshell, this project is to develop a mobile robot in which remotely controlled by mean of wireless application. The control is to be done through by using Raspberry Pi as a main controller. The robot must also be capable providing feedback through the use of electronic device. This project involves hardware and software part. For the further operation, this project has also several applications in surveillance such as swarm robots control algorithm to approach the problem of patrolling an open or closed line.

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CHAPTER 2
LITERATURE REVIEW

2.0 Introduction

This chapter is to consider about the article that are linked to this project. This chapter covers the theory and applications of the project hardware, software and equipment that used in previous project that already done.

Mobile robot design is about art and skill development to create the useful robot for human application. Each part of the robot that included electrical, mechanical and software should be studies to make sure that application of the mobile robot can operate smoothly and can complete the specific task that given. This project need a lot of research in electrical and software part in order to fabricate a mobile robot at low price, robust and good performance. While in hardware part, the measurement of designing a mobile robot should be details and fixed due to the issue of stability and functionality of the mobile robot.

2.1 Design

Rubenstein et al. (2012) introduce one type of swarm robot which is Kilobot. This paper used algorithm by means to control collectives of thousands of robots in order to do a specific task. Figure 2.1 shows the design of Kilobot. Based on Figure 2.1, it shown the isometric (left) and bottom (right) views of a Kilobot. Some key features are: (A) Vibration motors, (B) Lithium-Ion battery, (C) Rigid supporting legs, (D) Infrared transmitter/ receiver, (E) Three-color (RGB) LED, (F) Charging tab, and (G) Ambient light sensor.

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