VISION BASED AUTOMATED FORMATION FOR MULTI ROBOT COOPERATION

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Specially dedicated to:

My beloved family, lecturers and all friends for their external support, encouragement, and inspiration throughout my journey of education.

MAY ALLAH BLESS US

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ABSTRACT

In a multi robot system, robots are required to cooperate with each other, and therefore should have the ability to make their own decision based on multiple input sensors not only from the robots, but also from nearby robots. The task of carrying oversized objects of different shapes poses a challenge in selecting an appropriate group formation. Hence, the main objective of this project is to establish an algorithm that enables multi robot system to carry large load by automatically selecting the required group formation to successfully execute the task. At first, a robot will need to identify the shape of the object (oversized bar, rectangular, square or circular shapes). Then, the robots will form a suitable formation to carry the object. There are two main problems in this project. First, the capability of the robot to identify the shape of the object because the object's image will be a bit skew form the actual shape, due to the slanting angle of the camera used to detect the shapes of the objects. The second challenge is maintaining the formation of the robots, while carrying the load on top of the robots, to a specified destination. A multi robot system, built in-house is used in the experiments to investigate the performance of the algorithm proposed. Algorithms implemented in this project are leader-follower and behaviour based strategy. One of the robots will operate as the command giver or the leader to the other robots. The algorithm consists of communication strategies and autonomous decision making capability. The robot will be communicating with each other using Xbee wireless modules and extracting the behaviour of the other robots. Sensors placed around the body of the robots are utilized to detect their relative distance, and hence, used to maintain their formation, so as to prevent the load from falling down. All the decisions are made by the robots autonomously via the onboard controllers. The multi robot system is shown to be able to autonomously determine the shape of the different oversized objects, thus appropriately change into formations capable of transporting large objects to a specified destination point autonomously, with no outside intervention.

ABSTRAK

Dalam sistem berbilang robot, robot-robot perlu untuk saling bekerjasama, dilengkapi dengan kemampuan membuat keputusan sendiri bergantung kepada peranti-peranti input yang bukan sahaja daripada robot tersebut, bahkan daripada robot berdekatan. Tugasan untuk membawa objek besar yang terdiri daripada beberapa bentuk yang berlainan adalah mencabar dalam menentukan susunan robot yang sesuai. Objektif utama projek ini adalah melaksanakan satu algoritma yang membolehkan berbilang robot untuk mengangkut objek besar secara automatik dan menentukan susunan kumpulan robot berdasarkan bentuk objek yang perlu diangkut. Pada peringkat awal, sebuah robot perlu mengenal pasti bentuk objek yang akan diangkut (bentuk batang panjang, segi empat tepat, segi empat sama atau bulatan). Seterusnya, robot-robot tersebut akan membuat susunan yang sesuai dengan bentuk dan saiz objek, untuk mengangkut objek tadi. Terdapat dua masalah utama dalam projek ini. Pertama, kemampuan robot untuk mengenal pasti bentuk objek kerana imej objek adalah sedikit senget daripada bentuk sebenar, berikutan sudut kamera tidak terus dari atas objek. Cabaran kedua adalah mengekalkan susunan kumpulan robot tadi apabila objek diangkut di atas robot, ke destinasi yang ditetapkan. Sistem berbilang robot yang dibina sendiri digunakan dalam eksperimen ini bagi mengenal pasti kemampuan algoritma yang dicadangkan. Algoritma yang digunakan dalam eksperimen ini adalah ketua-pengikut dan strategi berdasarkan kelakuan. Satu robot akan berfungsi sebagai pemberi arahan kepada robot lain. Algoritma ini ada strategi komunikasi dan kemampuan membuat keputusan secara automatik. Robot-robot ini akan berhubung dengan menggunakan modul tanpa wayar Xbee dan ekstrak kelakuan robot satu lagi. Peranti yang diletakkan sekeliling badan robot diguna untuk mengetahui jarak relatif yang digunakan untuk mengekalkan susunan robot bagi mengelakkan beban daripada jatuh. Semua keputusan dibuat robot itu sendiri secara automatik dengan kawalan litar papan. Sistem berbilang robot menunjukkan ia mampu secara automatik untuk menentukan bentuk objek besar dan menentukan susunan yang mampu membawa objek tersebut daripada titik destinasi yang ditentukan tanpa bantuan daripada luar.

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CHAPTER 1

INTRODUCTION

Distributed robotic system became an interesting field of study, which bloom around recent millennium era because it is more convenient against single robot system [1]. It can be classified to many areas such as communication, dealing with difficult task [2], task allocation and control [3], localization [4], exploration, large object transportation [5], motion coordination and biological inspiration. All these topics are discussed in multi robot system.

Object transport and manipulation

Robots will be collaborated to carry, move or manipulate object. Most of the projects only use simulation or software verification. The projects on object transportation normally study on constrain motion, numbers of robot, mechanism to hold and grasp load, undefined workspace and so on. There are also various methods in handling the object [6]. It can be pushed, griped, and pull using rope and others.

Motion coordination

In this application, it involves path planning [7,8], traffic control, formation generation and maintaining the formation. The issues that commonly come out are about target

tracking, target search and multi-robot docking behavior. The approach used normally marking some checkpoints for the robot, using dynamic priority assignment, generation of cooperative gait and vision based robot. [9]

Formation control is the popular subject in multi robot area of study where the robot communicates and able to move to destination point in desired robot orientation. The formation control could be a bit complex in term of stability and convergence when the multi robot is tasked to transport an object to a target point.

Reconfiguration Robotics

In this research area, reconfiguration robotic is about multi robot that can be adjusted or adjusting itself either manual or automatic depend on the current situation [10,11]. These types of robot give a great versatility and robustness, because it can generate desire shape to fulfill certain function which changes from time to time.

1.1 Overview

Since the past decades, many robots have been built to fulfill human needs and interests. In movies also, the development of robotics have grown, for example the movie 'Transformer'. The movie has been made in many series, which indicates that many people around the world like robots and machinery thing. Competitions involving robots nowadays are numerous to improve the design of robotic system and to generate new ideas in the robotics field such as 'Robot Soccer', 'ABU Robocon', 'Robo Sumo', 'Robofest' and many more.

There are many objectives on robotic research because of the usage of robot is very wide. These include the usage in dangerous environment, complete difficult tasks [4] given, assist human in daily work or routine, transport large objects [5], and doing

repeated task over and over again. In some cases use of a single robot is not sufficient and can only cover very limited tasks. So, it requires more than one robot to work in collaboration, so that the task will be completed successfully. In the real world environment, the robots must alter their formation by simple navigation strategies [1], behavior based control [10,11], virtual structures [7,8], formation vector [3], hierarchical formation, omnidirectional vision [9], etc.

There is an increasing research interest in systems composed of multiple autonomous mobile robots exhibiting cooperative behaviors. Groups of mobile robots are constructed, with the aim of studying such issues as group architecture, resource conflict, origin of cooperation, learning, and geometric problems. Below are some of the advantages of using multi robot systems against single robot systems [2]:

1) A large range of task domains
2) Greater efficiency [12]
3) Improved system performance
4) Fault tolerance
5) Robustness [12]
6) Lower economic cost [13]
7) Ease of development
8) Distributed sensing and action

As yet, few applications of cooperative robotics have been reported, these include cooperative manipulation [10], navigation, and planning that is used for a group of airplane maneuvers [7]. Supporting theory is still in its formative stages [14].

1.2 Problem Statement

Navigation strategy, maneuvering, manipulation, and mission planning are main problem in mobile research study [15]. The implementation of behavior-based system rather than common mobility systems for a mobile robot field gives a challenging in part of research aspect to this multi robot study. Existing UTM researches only deal with robot navigation and load transportation. Designing controller for behavior based multi robot system is challenging because of two factors [16]. Firstly, a behavior-based system has possibility to act on its own because the surrounding changes very fast and the robot has many inputs to be processed. Next, its algorithm model is not complete yet and mostly still unknown. So, in order to design a controller for this dynamic system, it needs to use some approaches depending on knowledge, or model. In the case of a robot, this system consists of the robot itself and the environment in which it operates for example in a laboratory. However, the situation is different when a robot is worked in the real world environment with many things need to be considered and take into account.

1.3 Research Questions

In this project, researcher tries to find out how the multi robots cooperate together to complete a given task that changes depending on the environment or stimulate condition? Will the robots able to differentiate the dissimilarity of the situation and from that able to make good respond together, not just a robot?

1.4 Research Objective

Multi agent robot system consists of mobile robots with similar attribute and can move freely. This team can be operated by minimum presence of two-robot. The outcomes of this collaboration of robots are:

1) to bring an oversized object to a fixed defined destination using a leader-follower strategy automatically.

2) to identify what formation that the robots will make, depending on the image of the object that it captured without external support.

3) to design a behavior based controller (software) for a team of multi agent robots to do a single task regarding communication and cooperation between both robot.

1.5 Scope of Research

In the limitation of the time of the project, author will state some of scopes of the project in order for the project work perfectly and complete in the given time frame. Firstly, in this project, UTM Multi Robot that is already available in Robotic Laboratory is used. This is because it needs a vast amount of time and effort to come out with a brand new robot.

Second, the technologies that have been used depend on what already build-in with the UTM Multi Robot. The robot equipped with many sensors and system, but the technologies are a bit outdated.

Next, the experiments to try out the early hypothesis have been carried out in the Fakulti Kejuruteraan Elektrik, UTM Robotic Laboratory because the robot is heavy and it easier to commence the experiment or doing modification on the spot.

Lastly, this project will use Visual Studio as programing software. Visual studio enable programmer to interface the sensor with graphic on the screen. This attribute indicates either the sensors working or not, by graphic interface on laptop.

1.6 Thesis Outline

This thesis consists of five chapters in total. In the second chapter, it will describe the study of previous researches. It will discuss about leader follower technique in multi robot system, environment adaptive method and image processing in recognizing object that will be transported. The details about the robot used in this project shall also be described in this chapter.

Next, Chapter 3 explains about the methodology of this project from hardware part to software thing. It includes how the robot recognized the shape of the object in front; gave command to the follower robot, formed suitable formation, and transported load to the destination successfully.

Then results from the experiment are presented in Chapter 4. It also contains discussion about the results, including the comparison of the result obtained with the expected outcome (theory). The result will also be presented not just by the camera snapshot in the experiment that been carried out. It also will be presented in trace form, in order to clearly present what really happen in the experiment.

Last chapter, will conclude the project that has been done and proposed suggestion for future project in multi robot system field of study.

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