SWITCHING BETWEEN FORMATIONS OF MULTI-ROBOT SYSTEMS

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To my beloved mother and father

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ABSTRACT

In this work we aim to introduce the multi agent robotic systems (MARS) to make a good understanding of how it works. In continue, most of the control algorithm like behavior based, leader follower, and virtual structure, artificial potential based control and many more methods have been covered. The control procedure of multi agent robotic is generally divided into two basic parts. First is the path trajectory and the second part is switching between the formations. Summation of these two commands will be injected to the robots actuators. In the third chapter the two main methods, Behavior-Based and Leader-Follower method is surveyed in detail to investigate the parameters that can affect the formation of the group. Basically, in the behavior based control algorithm each robot acts regardless of the group decision, which is not suitable for our goal, so we focus on the other method-leader follower- to catch the result. A method for switching strategy is mentioned at the end of chapter three that is combination of leader follower strategy with matrix based control algorithm to make the better switching controller when the group of robot is facing with the an obstacle. The controller deals with the information coming from the sensorial reading. In the case that the group is facing with an external object, the controller checks the feasibility of the formation patterns to choose one of them as the new formation. Mean Task Allocation is used in utilization function to represents the new formations of robots location in matrix form. In continue, there is a cost function to optimize the selection of new formation. The proposed algorithm has been verified using MATLAB Simulation and the results are satisfactory.

ABSTRAK

Dalam karya ini kita bertujuan untuk memperkenalkan ejen pelbagai sistemrobotik (MARS) untuk membuat pemahaman yang baik mengenai bagaimana ia berfungsi. Dalam terus, kebanyakan algoritma kawalan seperti tingkah lakuberasaskan, pemimpin, pengikut dan struktur maya, kawalan berasaskan potensitiruan dan banyak lagi kaedah yang telah dilindungi. Prosedur kawalan pelbagaiejen robotic secara amnya dibahagikan kepada dua bahagian asas. Pertamatrajektori jalan dan bahagian kedua ialah beralih antara formasi-formasi. Penjumlahan daripada kedua-dua perintah akan disuntik kepada penggerakrobot. Dalam bab ketiga kedua-dua kaedah utama, Berasaskan Kelakuan danPemimpin-Pengikut kaedah yang dikaji secara terperinci untuk menyiasatparameter yang boleh memberi kesan kepada pembentukan kumpulan. Pada asasnya, dalam algoritma kawalan tingkah laku berasaskan robot masing-masingbertindak tanpa mengira keputusan kumpulan, yang tidak sesuai untuk matlamat kita, jadi kita memberi tumpuan kepada pengikut-lain pemimpin kaedahmenangkap hasil. Satu kaedah bagi menukar strategi yang disebut pada akhirbab tiga yang merupakan gabungan strategi pengikut pemimpin denganalgoritma kawalan matriks berasaskan untuk membuat pensuisan pengawal yanglebih baik apabila kumpulan robot yang dihadapi dengan halangan itu. Pengawaltawaran dengan maklumat yang datang dari bacaan sensorial. Dalam halbahawa kumpulan yang dihadapi dengan objek luar, pengawal memeriksakemungkinan corak pembentukan untuk memilih salah seorang daripada merekasebagai pembentukan baru. Min Peruntukan Petugas digunakan dalam fungsipenggunaan untuk mewakili bentuk baru lokasi robot dalam bentuk matriks. Dalam terus, terdapat satu fungsi kos untuk mengoptimumkan

pemilihanpembentukan baru. Algoritma yang dicadangkan telah disahkan menggunakanSimulasi MATLAB dan keputusan yang memuaskan.

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CHAPTER 1

INTRODUCTION

1.1 Background of Multi-Robot Systems

It is well known that there is several tasks that can be performed more efficiently and robustly using multiple robots [1]. Nowadays, multiple robotic systems and cooperative control have become research areas with dramatically increased popularity. The idea of multiple-robot group working and cooperation was inspired by many examples in biology, such as ant swarming, bird flocking and fish schooling. Also, it is well known that multiple robotic systems, that working cooperatively under highly efficient organizations and principles, can behave as a whole, and even be guaranteed with fault tolerance and robust properties. Researchers generally agreed that multi-robot systems have several advantages over single-robot systems [2]. The most common motivations to develop multi robot system solutions are that:

1) A single robot is much more complex to be accomplished in comparison with multi robot systems.

2) The task will be distributed between the agents in multi robot systems.

3) Building several resource-bounded robots is easier than having a single powerful robot.

4) Multiple robots can solve problems faster using parallelism idea.

5) By using multiple robots the robustness of the system will be increased through redundancy.

Multi-robot applications include cooperative manipulation [3], navigation and planning that is used for a group of airplanes maneuver [5], collaborative mapping and exploration for land mining purposes, and formation control. In fact, there is extensive literature on motion planning and control of mobile robots in structured environments. However, traditional control theory mostly enables the design of controllers in a single mode of operation, in which the task and the model of the system are fixed. While control and estimation theory allows us to model each behavior as a dynamical system, it does not give us the tools to compose behaviors or the hierarchy that might be inherent in the switching behavior, or to predict the global performance of a highly complex multi–robotic system.

1.2 Problem Statement

Formation control, which is the most important research area in multi-robot coordination, aims in controlling the relative positions and orientations of the robots in a group while allowing the group to move as a whole. However, coordination of multiple robots to accomplish such tasks remains a challenging problem. In a dynamic uncertain environment, which could be consisting of obstacles, or any unexpected uncertainty, the robots must alter their formation according to the changing environment. The approaches for formation control include simple navigation strategies [7], behavior based control [3, 4], virtual structure [5, 6], formation vector [8], hierarchical formation, omnidirectional vision [9], etc. Some applications of formation applications are moving a box, spacecraft control [11], moving through obstacles faster by choosing the most relevant formations such that pass the obstacle [12], formation-based path finding in a game [13], etc. Thus, the group can maintain a desired formation and flow towards its goal configuration. The ability to maintain a prescribed formation allows the robots to perform a variety of tasks, such as collaborative, mapping, exploration and cooperative manipulation [14].

The pattern formation problem is defined as the coordination of a group of robots to get into and maintain a formation with a certain shape, such as a wedge or a chain. Current application areas of pattern formation include search and rescue operations, landmine removal, remote terrain and space exploration, control of arrays of satellites and unmanned aerial vehicles (UAVs). Pattern formation is also observed in various animal species as a result of cooperative behaviors among its members, where the individuals stay at a specific orientation and distance with respect to each other while moving, or fill a specific area as homogeneously as possible.

1.3 Objectives of the Project

The control of a system of autonomous robots that can perform such tasks requires coordination at different levels. At the lowest level, it is necessary for each robot to control its motion, to avoid collisions with its neighbors, and to move along a desired trajectory. At an immediately supervisory level it is necessary to outline a strategy for maintaining a desired formation. So in this work we are going to:

1) To study available control frameworks of formation switching from previous works and investigates between them.
2) To propose a new novel formation control strategy based on earlier methods to execute the best formation.
3) To verify the proposed strategy through Simulation via MATLAB codes.

1.4 Scope of Project

This project deals with three multi agent UTM robot, when each robot is associated with:

- A laptop on the robot for programming
- Interface Free Controller (IFC)
- Two rotary encoder
- Eight distance sensor
- Ultrasonic range finder

- Wireless communication (Zikbee)
- Pan tilt webcam
- Hokuyo laser range finder

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