IMPLEMENTATION OF SWARM INTELLIGENCE ALGORITHMS ON MOBILE ROBOTS

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Kurzthema / Subject:

Implementierung von Schwarm-Intelligenz auf mobilen Robotern
Implementation of Swarm Intelligence on Mobile Robots

Aufgabenstellung:

Definition und Implementierung von Szenarien zur Entscheidungsfindung schwarmintelligenter, mobiler Roboter.

An einem Beispiel zweier mobiler Roboter, die mittels Arduino Mikrocontroller gesteuert werden, soll Schwarmintelligenz implementiert werden.

Die Entscheidungsalgorithmen für die Schwarmintelligenz müssen auf der Arduino-HW implementiert und deren Funktionalität an Beispielszenarien demonstriert werde. Hierzu müssen die mobilen Roboter miteinander kommunizieren sowie ein geeignetes Verfahren entwickelt werden, damit die Roboter ihre Position auf den Beispielparcours finden können.

Ausführung der Aufgabe ist. Die Funktionalität der implementierten Algorithmen wird durch experimentelle Einrichtung gezeigt.

Im Einzelnen sind die folgenden Punkte zu bearbeiten:

- Implementierung der Kommunikation zwischen den mobilen Robotern.
- Entwicklung und Implementierung von Schwarmintelligenz auf den Controller der mobilen Roboter.
- Entwicklung eines Verfahrens zur Positionsbestimmung der jeweiligen mobilen Roboter
- Erprobung der entwickelten Verfahren und Algorithmen
- Dokumentation und Präsentation der Ergebnisse.

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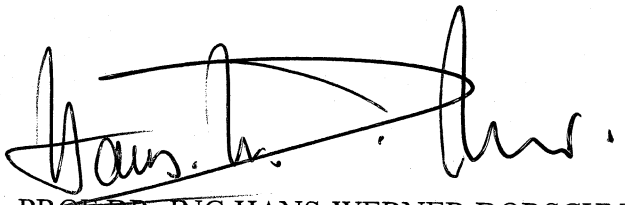
SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Bachelor of Mechatronics Engineering (Hons.).

Signature: 

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I hereby declare that the work in this thesis is my own except for quotations and summaries which have been duly acknowledged. The thesis has not been accepted for any degree and is not concurrently submitted for award of other degree.

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ABSTRACT

This thesis focusses on the implementation of swarm intelligence algorithms on multiple mobile robots. A scenario which could be used to display the swarm intelligence behavior is being designed in this thesis. Positioning or localization of mobile robots is a part of this thesis in order to determine where is the robot position on the field. Wireless communication is conducted between the mobile robots in order to carry out discussion and subsequently solving the problem in a coordinated way without any instructions given by external controller. A target point is set and three paths made from different colours are used to guide the mobile robots towards the target point. Obstacles will be placed randomly at different position on one of the paths created in order to block the robots to go to the target point. Communication between swarm agents is necessary to get a solution for the problem encountered. The result of the experimental setup can be observed in this thesis.

ABSTRAK

Tesis ini memberi tumpuan kepada pengimplimentasian algoritma "Swarm Intelligence" dalam robot mudah alih. Satu senario yang boleh memaparkan sifat tersebut telah direka bentuk dalam tesis ini. Penentuan posisi robot mudah alih adalah sebahagian daripada tesis ini untuk menentukan kedudukan robot tersebut. Komunikasi tanpa wayar telah dilaksanakan pada masa yang sama untuk menjalani proses perbincangan antara robot-robot mudah alih dan seterusnya menyelesaikan sesuatu masalah dengan selaras tanpa menerima arahan daripada pihak ketiga. Satu destinasi telah ditetapkan untuk robot tersebut dan tiga laluan yang diperbuat daripada warna-warna yang berbeza digunakan untuk membimbing robot mudah alih ini ke arah destinasi tersebut. Halangan akan diletakkan secara rawak di kedudukan yang berbeza pada salah satu laluan untuk menghalang pergerakan robot tersebut ke tempat sasaran. Komunikasi antara robot-robot mudah alih adalah diperlukan untuk menyelesaikan masalah yang dihadapi. Keputusan daripada eksperimen dapat dilihat dalam tesis ini.

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LIST OF SYMBOLS

gr	Green-red color code
grg	Green-red-green color code
grgr	Green-red-green-red color code
rgrg	Red-green-red-green color code
rgrgr	Red-green-red-green-red color code
grgrg	Green-red-green-red-green color code
yr	Yellow-red color code
yry	Yellow-red-yellow color code
ryr	Red-yellow-red color code
yryr	Yellow-red-yellow-red color code
ryry	Red-yellow-red-yellow color code
ryryr	Red-yellow-red-yellow-red color code
yryry	Yellow-red-yellow-red-yellow color code
yrg	Yellow-red-green color code
gry	Green-red-yellow color code
ryg	Red-yellow-green color code
gyr	Green-yellow-red color code
ygr	Yellow-gree-red color code
rgy	Red-green-yellow color code
ryrg	Red-yellow-red-green color code
gryr	Green-red-yellow-red color code
rgry	Red-green-red-yellow color code
yrgr	Yellow-red-green-red color code
rgyr	Red-green-yellow-red color code

rygr	Red-yellow-green-red color code
a	Actual distance measured between camera lens and color code
m	Calibrated distance measured through camera through calibrated formula
e	Relative error calculated for accuracy test
t	Time taken measured during calibration data collection
d	Distance value measured during calibration data collection
C.dist	Calibrated distance value
R1	Robot 1
R2	Robot 2

LIST OF ABBREVIATIONS

3D	Three Dimensional
eFLL	Embedded Fuzzy Logic Library
GPS	Global Positioning System
LED	Light Emitting Diode
PWM	Pulse Width Modulation
QR	Quick Response Code
RF	Radio Frequency
ROS	Robot Operating System
USB	Universal Seriel Bus
XCTU	Configuration and Test Utility Software

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

The thesis aims to implement and display the swarm intelligence behavior using the available hardware which is in this case, two mobile robots built by the students from previous projects (Labeth, 2012) (Moritz, et al., 2014). The displaying of the swarm intelligence behavior is closely and directly related to the swarm robotics. A multiple or group of mobile robots which have same properties are chosen and modelled to resemble the group of swarm agents in nature, which are the insects and animals. A flock of fishes and a colony of ants are the swarm agents in the nature while the swarm robotics are the swarm agents built and programmed by human being in engineering field to display the swarm intelligence behavior of those group of insects or animals. Swarm agents do not have any leader and instead, they work together in a coordinated way through internal communication. Interaction between swarm agents themselves and between swarm agents and the environment will be the key to allow the swarm agents to solve the problems encountered without any commander or controller. Thus, communication is the most significant part in this thesis in order to display the swarm intelligence behavior as the mobile robots need to exchange their information especially their position. In order to determine the position, a localization method is being designed and implemented in this thesis to determine the position of the mobile robots while moving towards targeted destination. A problem is created to interrupt the mobile robots while they are doing the task given and the problem mentioned is the obstacles used to block the movement of the mobile robots. An algorithm is being programmed into the Arduino microcontroller in order to detect the problem, analyze the problem and finally to solve the problem. The methodology and result will be discussed in details in the following sections.

1.2 PROBLEM STATEMENT

Swarm robotics can be implemented in the production line nowadays and can be used to replace operators in carrying out tasks without considering the human fatigue factors, which could reduce the rate of production. Operators in production line are working in a way by following the instructions from the technicians or engineers. Standard operating procedures are designed by the company and should be followed by the workers to complete the task in a coordinated way. However, human factors such as carelessness and laziness can be another factors that contribute towards the lower production rate. Thus, swarm robotics can be the solution in this case, as swarm robotics are being programmed to work and solve problems in a coordinated way. The algorithms are designed and programmed based on different application and the advantage of using swarm robotics is robots would not suffer from fatigue and they would only follow the algorithms that being programmed into themselves while carrying out the task. The rate of production in this case, will be shorten. However, there is a problem of implementing swarm robotics in the production line as the driverless vehicles or the autonomous guided vehicle used nowadays might not be able to support this need and the process of implementing this swarm robotics might require a lot of prototyping or testing phase before it could be used directly in the manufacturing field. Therefore, the implementation of the swarm intelligence will be tested through this thesis using simple mobile robots to show and prove the possibility of implementing those algorithms in the production line.

1.3 OBJECTIVES

Several objectives are covered throughout this thesis. The objectives are shown below:

1. To implement communication between mobile robots.
2. To design and implement swarm intelligence algorithms on the controller of the mobile robots.
3. To design a position determination method for mobile robot localization and navigation.
4. To show the functionality of the implemented algorithms with the available hardware through experimental setup.

CHAPTER 2

LITERATURE REVIEW

2.1 SWARM INTELLIGENCE

Swarm intelligence is the collective behavior, which exists in a group of animals or insects. Swarm intelligence consists of swarm agents which are homogeneous or almost similar to each other in terms of their characteristics. Swarm intelligence is the ability to act in a coordinated way without the presence of a coordinator or of an external controller. They can be defined as a decentralized and self-organizing system which shows the characteristics of not being controlled by any leader and controller. There is an interaction between the individuals of the swarm agents and also between the swarm agents and the environment itself such as through the use of pheromones in ants, dancing in bees, and proximity in fish and birds (Paschek, 2013). Figure 2.1 below shows the collective behavior of the colony of ants (Paschek, 2013). In the picture labelled with number 1 shows a single ant which found a food source which labelled with alphabet "F"and the food will be brought back to the nest labelled with alphabet "N" and the picture labelled with number 2 shows that other ants are trapped and explored different paths to the destination of the food source and thus, the pheromone released by the ants will cause the track getting stronger with pheromones on the shortest path. The picture labelled with number 3 shows the result at which majority of the ants follow the shortest path due to the strongest pheromones released by the ants. Through Figure 2.1, it can be seen clearly the ants work together in a coordinated way and finally get the optimize way to go to their food source. The pheromones released are the medium of communication used between the ants in order to get the information from each other and finally, solve the problems in a coordinated way. This kind of interaction or behavior can also be seen in other group of insects or animals such as the dancing bees and the flock of fishes.

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