UNIVERSITI PUTRA MALAYSIA

EMBEDDED SYSTEM FOR INDOOR GUIDANCE PARKING WITH DIJKSTRA'S ALGORITHM AND ANT COLONY OPTIMIZATION

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By

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Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia in Fulfilment of the Requirements for the Degree of Master of Science

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Chairman : Azura Binti Che Soh, PhD
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The population increases rapidly and many parking bays are needed, especially during weekends when shopping malls face heavy traffic congestion. Consequently, during peak hours, finding a vacant parking bay is more of a difficult task. This study proposes a car parking management system which applies Dijkstra's algorithm, Ant Colony Optimization (ACO) and Binary Search Tree (BST) in structuring a guidance system for indoor parking. In this system, the layout was designed under two categories which are the standard bay size and the small bay size to increase the parking bays. Based on the proposed layout of the parking system, the number of parking bays have increased by 21.5% compared with the standard parking design. The proposed embedded system for guidance parking is a system that assigns the nearest available vacant bay to the entrance with the shortest driving path. The system will automatically check for the nearest vacant bay and reserve it for the current user allowing a different bay reservation for the next user. The circuits have been designed by proteus, the microcontrollers have been programmed by micro C, and the Graphical User Interface (GUI) has been implemented in Java. Few by electronic components such as RFID, multiplexer, XBee, and servo motors have been used to realize the system. Dijkstra and ACO with BST are integrated to produce the embedded system for parking guidance for the indoor parking system. BST inserts the nodes in the way that the Dijkstra's can find the empty parking in fastest way. Dijkstra's algorithm initials the paths to finding the shortest path while ACO optimizes the paths. This study is aimed at helping to calculate the shortest path as well as to guide the driver towards the nearest vacant available bay near the entrance by considering both the walking distance and the driving distance. It also presents the real-time simulation of the parking system and validates any information regarding the parking status by dual switches, multiplexers and microcontroller. The proposed embedded system has achieved positive outcomes in comparison to the current system and the traditional algorithm with regards to the shortest path. The results show a range of 8.3% to 26.8% improvement in the proposed path compared to the traditional

Dijkstra's algorithm. The findings also indicate that the proposed embedded system for indoor guidance parking using Dijkstra-ACO algorithm with the proposed layout of parking bay for indoor parking system, will help in reducing the time wasted in searching for a parking bay and will increase the efficiency of the parking system in shopping malls.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

SISTEM TEMPAT LETAK KENDERAAN DALAMAN DENGAN PANDUAN PINTAR BERDASARKAN ALGORITMA DIJKSTRA DAN PENGOPTIMUMAN SEMUT COLONY

Oleh

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Sistem tempat letak kenderaan adalah satu kemudahan penting yang ditemui di dalam mana-mana struktur bangunan, terutamanya di tempat tarikan dan kunjungan orang ramai. Disebabkan populasi yang semakin bertambah, banyak tempat letak kenderaan diperlukan, terutamanya ketika hujung minggu di mana pusat membeli-belah menghadapi kesesakan lalu lintas yang teruk. Kesannya, ketika waktu kemuncak, mencari tempat letak kereta yang kosong adalah satu tugasan yang rumit. Ini membuatkan pemandu berasa kecewa, dan dengan dahsyatnya mengakibatkan kereta diletakkan secara tidak tersusun di dalam pusat membeli-belah. Tambahan lagi, kesesakan lalu lintas yang teruk menyebabkan penggunaan minyak petrol yang tinggi, sementara pemandu sedang menunggu giliran mereka untuk meletakkan kenderaan. Oleh itu, sistem pengurusan tempat letak kenderaan bersama sistem panduan pintar merupakan salah satu kemudahan penting yang diperlukan di pusat membeli-belah. Kajian ini mencadangkan sebuah sistem pengurusan meletakkan kereta yang menggunakan algoritma Dijkstra, pengoptimuman Semut colony (ACO) dan pokok carian Binari dalam menstrukturkan sistem panduan pintar bagi tempat letak kenderaan dalaman. Dalam sistem ini, rekabentuk susun atur pelan tempat letak kenderaan dicadangkan. Susun atur telah direka kepada dua kategori iaitu saiz ruang biasa dan saiz ruang kecil untuk meningkatkan ruang tempat letak kenderaan. Berdasarkan rekaan baru susun atur sistem tempat letak kenderaan tersebut, bilangan ruang tempat letak kenderaan telah meningkat sebanyak 21.5% berbanding dengan rekaan tempat letak kenderaan biasa. Panduan tempat letak kenderaan pintar yang telah dicadangkan itu adalah satu sistem yang memberi ruang tempat letak kenderaan terdekat yang kosong kepada pemandu berserta keperluan arah yang dicetak pada tiket. Oleh itu pemandu dapat mencari ruang yang paling senang dengan jangka masa yang minima. Sistem ini secara automatik akan memeriksa ruang kosong yang terdekat dan menempahnya untuk pengguna semasa dan membenarkan tempahan ruang berbeza bagi pengguna seterusnya.

Pelaksanaan perisian dan perkakasan telah pun dilaksanakan. Beberapa komponen elektronik seperti PIC, RFID, multiplexer, XBee dan motor servo telah pun digunakan untuk menjalankan sistem ini. Pengguna grafik antaramuka (GUI) boleh dipaparkan pada komputer peribadi melalui penggunaan Java. Dijkstra dan ACO disatukan untuk menghasilkan algoritma panduan tempat letak kenderaan pintar bagi sistem tempat letak kenderaan dalaman. Algoritma Dijkstra memulakan laluan untuk mencari jalan yang paling singkat sementara ACO digunakan untuk mengoptimumkan jalan itu. Pokok carian Binari telah digunakan untuk menyimpan ruang-ruang dan dan informasi saiz kereta dan mengambil semula ketika diminta. Teori ini bertujuan untuk membantu mengawal laluan yang paling dekat dan untuk memberi panduan kepada pemandu tentang ruang tempat letak kenderaan kosong yang terdekat dengan pintu masuk. Ia juga menunjukkan simulasi masa sebenar sistem tempat letak kenderaan dan mengesahkan apa sahaja informasi berkenaan status tempat letak kenderaan tersebut. Kaedah baru ini telah mencapai hasil yang positif apabila dibandingkan dengan kerja utama berdasarkan laluan yang paling singkat. Keputusan menunjukkan jarak diantara 8.3% kepada 26.8% penambahbaikan daripada kerja yang dicadangkan berbanding kerja terdahulu. Penemuan ini juga menunjukkan sistem panduan pintar yang dicadangkan menggunakan algoritma Dijkstra-ACO berserta susun atur baru bagi ruang tempat letak kenderaan untuk sistem tempat letak kenderaan dalaman, akan membantu untuk menjimatkan masa mencari ruang tempat letak kenderaan dan meningkatkan kepantasan sistem tempat letak kenderaan di pusat membeli-belah.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

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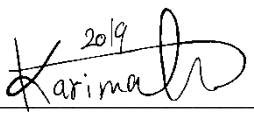
Signature:  Date: _____

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LIST OF ABBREVIATIONS

ACO	Ant Colony Optimization
BST	Binary Search Tree
CPU	Central Processing Unit
DC	Direct Current
DIP	Dual In-line Package
GA	Genetic Algorithm
GUI	Graphical User Interface
I/O	Input/Output
IoT	Internet of Things
LCD	Liquid Crystal Display
LDR	Light-Dependent Resistor
LED	Light Emitting Diode
PC	Personal Computer
PCB	Printed Circuit Board
PIC	Peripheral Interface Controller
RAM	Random Access Memory
RFID	Radio Frequency Identification
ROM	Read Only Memory
TTL	Time to Live
UART	Universal Asynchronous Receiver/Transmitter
USB	Universal Serial Bus
WSN	Wireless Sensor Network

CHAPTER 1

INTRODUCTION

1.1 Background of The Study

Due to the increasing number of vehicles caused by rapid population growth in urban areas, the demand for parking infrastructure for the general public has increased significantly generally, finding an available parking space in shopping malls especially during peak hours is a challenging task. Drivers have to drive around looking for a vacant parking spot, which increases traffic congestion (Han et al., 2017). The driving around not only frustrates drivers but also increases the average consumption of fuel and hence the air pollution that affects the environment (Yujin & Xiaoxue, 2017).

Since technology is improving rapidly, most people have started looking for the most creative innovation for their lives. Industries also have been motivated to find solutions to facilitate car parking for the public in a convenient way. One of these solutions is a smart parking system. The main idea of the Embedded Parking System is to ease the way for people to park their cars easily. Smart parking systems can give a good solution to parking issues. Smart parking systems are still not very common despite the prevalence of embedded systems in the automation of many aspects of everyday life. Smart parking is a vehicle parking system that aid drivers to identify empty parking bays (Sadhukhan, 2017).

However, although there is an increase in the number of vehicles, the major problem that needs to be overcome is the limited area designed for parking especially in indoor parking such as shopping malls. The current management system shows only the number of available parking bays. It does not guide the driver to determine the exact location of these bays. Besides that, in the large parking area, the system needs to take some time to recognize the parking bay that has become empty when the driver exits from the building. What makes it more complicated, the competition over the vacant bay which leads to the frustration of drivers who failed to reach the bay before the others. This is because it is a difficult task for drivers entering the large indoor parking facility to know where the empty parking bays are located. If there is a traffic congestion in an indoor parking facility, cars will be jammed, and this consumes more time and fuel which may lead to air pollution.

This thesis focuses on the Smart Indoor Guidance Parking System and the technologies involved to build smart parking systems that help to guide people to a fast and an easy way to get a parking bay. This Smart Indoor Parking System increases efficiency for the parking bay management. Most of the current parking system has been used IR sensors

to detect the availability of the bays which is costly high. Thus, this parking system is full of low-cost Dual switches to detect the parking bay status. If all the parking bays are occupied, the system will give an unavailable message on the GUI (GUI). The microcontroller is the main component in the circuit as it needs to acquire the data input from each of the multiplexers to keep updating the availability of the parking system.

1.2 Problem Statement

The demand for parking systems is increasing since the cities are developing rapidly. The technology also is improving rapidly especially in transportation and construction industries. Moreover, some people afford to have private vehicles and hence the number of vehicles is rising. On the other hand, many skyscrapers and shopping malls have been built. Most large cities have many shopping malls which are considered as the most attractive places for entertainment and spare time.

Shopping malls have many facilities such as libraries, pharmacies, store department, restaurants, and offices. Many people like to go to shopping malls continuously which indicates that several cars enter the shopping malls especially during peak hours. A study about evaluating public transit benefits and costs confirmed that shopping trips account for 75% of all trips (Litman, 2015). However, these shopping malls suffer from such a serious traffic jam due to the huge number of cars that seek parking bays. Therefore, the driver has to move around to find an available parking space which leads to waste their time and fuel consumption and also leads to traffic jam(Won et al., 2018).

Moreover, a driver will get frustrated easily which could increase the probability of an accident. The technology has involved with many different techniques to provide smart parking systems such as automatic parking, E payment, and guidance parking system (Lin et al., 2017). These parking systems can provide a solution to the drivers to find a parking ba y which helps them parking their cars. However, these parking systems still are not efficient and suffer from a high level of traffic and congestion in the parking, poor performance, high cost, and not user friendly (Lalitha et al., 2018), (Giri & Mhetre, 2018).On another hand, the embedded system is an important part of any parking system. Different components are used to build an embedded system such as sensors, microcontrollers. Moreover, wireless devices are used to transfer data from the parking lot to the control system. These wireless devices could be Wi-Fi, ZigBee or Bluetooth. Each component has different characteristics. the most suitable system should avoid cost and high-power consumption (Netalkar, 2014). Most of the current systems use Wi-Fi or Bluetooth to transfer data to the control. However, these components suffer from short battery life or the transmission range which can affect the performance of the system. Moreover, The modern parking garage is structured for a maximum capacity rather than being structured for a maximum efficiency (Mirunalini et al., 2018). So that, many researchers tried to propose a guidance system to guide the driver to the empty parking bay. They proposed several algorithms to generate the path planning to access to the empty parking bay in the least possible amount of time. Many algorithms have been used

to calculate the nearest vacant parking bay; for example, Dijkstra's algorithm is very known in this field. Moreover, genetic algorithm, A* algorithm, and ACO have been applied on the shortest path problems. All these algorithms demonstrated its ability to find the shortest path in the guidance system. However, some of them are not accurate enough to find the shortest and the optimist path(Shiv et al., 2017). Hence, these algorithms need to be modified or optimized by other optimization algorithms. In this study, the efficiency of the path length is very significance.

Thus, an alternative should be considered to provide an effective guidance system for drivers. Recently, researchers have been working to present some solutions to provide a parking system that can give drivers a smooth path to the nearest parking bay that leads to reducing time and fuel which most shopping malls suffer from.

1.3 Research Objectives

The main objective of this thesis is to build an Embedded System for Indoor Guidance Parking which has 4 attributes, manageable, adaptable, fast processing time and user-friendly. This thesis has 3 sub-objectives which are:

i. To design the GUI with the new proposed layout that can differentiate the parking bays according to the size of the car.
ii. To evaluate the parking system in allocating the nearest parking bay to the entrance based on Dijkstra, ACOs and BST.
iii. To design an effective embedded system with a low-cost hardware component and integrated with the software by Java.

1.4 Research Contribution

The Embedded system for Indoor Guidance Parking System with Dijkstra's algorithm and ACO by BST is proven to achieve the objective of finding the optimal parking bay to the intentional entrance in the indoor parking. In which, the proposed solution contributes to the shortest path according to the optimization by ACO on Dijkstra's algorithm and fast performance according to BST. This system will help to lower the consumption of fuel and time.

This system presents a low-cost circuit in which that all the components has been used is low power consumption. Therefore, this circuited is integrated with the software by special class in Java.

Moreover, the system presents a new classification of the car sizes which maximise the parking area. This layout is designed in order to achieve the accuracy by adding a big number of nodes, more than one gate and entrances and to show the distance of walking and driving.

1.5 Research Scop

The scope of this research includes the following

i. The Embedded System for Indoor Guidance Parking which is integrating between the hardware and software using Java GUI.
ii. In this research, the system development applied for the indoor area (shopping mall complex) in a layout of 3944 m^2 (58 meters × 68 meters). Sixty small parking bays and 104 standard parking bays.
iii. Two types of users use this system: the employee and the visitor. The employee will use Radio Frequency Identification (RFID) system and the specific parking will be provided to them. Meanwhile, for the visitor, the guidance system will help them to find the nearest parking system to the entrance.

1.6 Thesis Organization

The content of the thesis is organized into 5 main chapters which are: introduction, literature review, research methodology, results and discussion, and conclusion and recommendations.

Chapter 1 is the introduction that sets the foundations of this project. It starts with a brief background on the topic in general. It then states the problem statement that is determined to be analyzed. Drawing on the research problem, the chapter presents the research objectives which are set in order to solve the stated problems with the appropriate solution by designing the desired system for the convenience of users. The thesis layout and scope of work is also explained in this chapter to ensure consistency.

Chapter 2 explains the literature review on related topics from several journals and papers in order to obtain information about current smart parking systems. Firstly, the types of smart parking system using different technologies are explained. Then an overview of shortest path algorithms is presented. Moreover, the Dijkstra's algorithm application in the shortest path is discussed. After that, a general view about artificial intelligence and its application in the parking system is reviewed. Similarly, experimental search algorithm is stated with some applications. After that an optimization algorithm including ant colony and genetic algorithm and their applications

in the shortest path is presented. Data structure and some application are demonstrated. An introduction on the embedded system is added.

Chapter 3 explains the research methodology of the system on how to design the system. The procedures are provided with clear step by step configuration and informative diagram. The procedures explain the software programming in Java and circuit design in Proteus 8 Professional. The description on the layout construction is also included in this chapter.

Chapter 4 discusses the research results that are obtained from the proposed parking system. The circuit design result is analyzed and tested based on real-time. The limitations of this system are also discussed in this chapter.

Chapter 5 provides a conclusion for this project and a set of recommendations for future research. In other words, this chapter summarizes the previous chapters and discusses the research findings allowing for suggestions for the further studies in order to overcome the limitation of this project which in turn leads to an improve of the parking systems.

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LIST OF PUBLICATIONS

Ata, K., Soh, A., Ishak, J., Jaafar, H. (2019). Shortest Path Algorithm for Guidance System Based on Dijkstra's Algorithm and ACO. *Symposium on Control System and Signal Processing*. (Submitted).

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