MICROPROCESSOR-BASED ON-STREET PARKING NOTIFICATION SYSTEM

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DECLARATION

I declare that this thesis entitled "MICROPROCESSOR-BASED ON-STREET PARKING NOTIFICATION SYSTEM is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :

Name :

Date :

APPROVAL

I hereby declare that I have checked this report entitled "Microprocessor-based On-street Parking Notification System" and in my opinion, this thesis it complies the partial fulfillment for awarding the award of the degree of Bachelor of Mechatronics Engineering with Honours

Signature : .....

Supervisor Name : .....

Date : .....

DEDICATIONS

To my beloved mother and father

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ABSTRACT

Due to the flaw existed in public transportation system in Malaysia, most of the locals will rather use their own transportation to travel to the desired destination. Thus, this causes the number of vehicles in Malaysia to increase, which leads to finding a vacant parking lot is getting tougher especially in a crowded area. Thus, it causes traffic congestion and consumes additional time and fuel. Therefore, an efficient and user-friendly on-street parking system with the implementation of Internet of Things (IoT) and cloud computing was able to meet the deficiency of current parking system in Malaysia. The objectives of this project is to design and develop a smart parking system using computer vision algorithm and the performance of the parking vacancy detection system in terms of accuracy was evaluated. In addition, a mobile application was introduced to enable the drivers to check the status of availability of parking space at anywhere and anytime. The microprocessor-based on-street parking notification system consisted of two parts which are software and hardware. The prototype was made up of an Intel UP Squared board which acted as a server to integrate all the inputs and outputs, also a medium to process the captures video or images. An IP camera with a tripod stand was set up to capture sharper and clearer images or videos. On the other hand, the software used to develop this parking notification system is Android Studio and Firebase. After that, the image that has been captured by the IP camera was being analysed via OpenCV in Intel UP Squared board and then the data was being sent to the Firebase and stored as a real-time database. The evaluations on the performance of data synchronization system between OpenCV, Firebase and mobile application and parking vacancy detection system at 3 different type of parking and at 4 different environments were done. The results has proved that the data in the images were successfully transferred to the Firebase and mobile application. The results obtained also showed that the contour parking vacancy detection system and Haar Cascade parking vacancy detection system has achieved 100% of accuracy when tested at three different types of parking. However, the accuracy of Haar Cascade parking vacancy detection system was dropped from 100% to 25% when it is tested at the different environments.

ABSTRAK

Oleh disebabkan beberapa kekurangan wujud dalam sistem pengangkutan awam di Malaysia, kebanyakan penduduk tempatan lebih suka menggunakan pengangkutan mereka sendiri untuk pergi ke destinasi yang dikehendaki. Oleh itu, ini menyebabkan jumlah kenderaan di Malaysia meningkat and membawa kesan kepada tempat letak kereta kosong semakin sukar dicari terutamanya di kawasan yang sesak. Oleh itu, sistem parkir di jalan raya yang cekap dan mesra dengan konsep Internet Perkara (IoT) dan pengkomputeran awan dapat memenuhi kekurangan sistem letak kereta sedia ada di Malaysia. Objektif projek ini adalah untuk merekabentuk dan membangunkan sistem letak kereta pintar menggunakan algoritma penglihatan komputer dan prestasi sistem pengesanan kekosongan tempat letak kereta dari segi ketepatan. Di samping itu, aplikasi mudah alih diperkenalkan untuk membolehkan pemandu memeriksa status ruang letak kenderaan di mana-mana dan pada bila-bila masa. Sistem notis letak kereta di atas mikropemproses terdiri daripada dua bahagian iaitu perisian dan perkakasan. Prototaip ini terdiri daripada papan Intel Squared UP yang bertindak sebagai pelayan untuk mengintegrasikan semua input dan output, juga medium untuk memproses video atau gambar menangkap. Kamera IP dengan pendirian tripod telah disediakan untuk mengambil imej atau video yang lebih tajam dan jelas. Sebaliknya, perisian yang digunakan untuk membangunkan sistem pemberitahuan parkir ini adalah Android Studio dan Firebase. Selepas itu, imej yang telah ditangkap oleh kamera IP sedang dianalisa melalui OpenCV di papan Intel Squared UP dan kemudian data dihantar ke Firebase dan disimpan sebagai pangkalan data masa nyata. Penilaian mengenai prestasi sistem penyegerakan data antara sistem pengesanan OpenCV, Firebase dan mudah alih dan sistem pengesanan kekosongan tempat letak kereta di 3 jenis tempat letak kereta yang berbeza dan di 4 persekitaran yang berbeza telah dilakukan. Hasilnya telah membuktikan bahawa data dalam imej berjaya dipindahkan ke aplikasi Firebase dan mudah alih. Keputusan yang diperoleh menunjukkan bahawa sistem pengesanan kekosongan tempat letak kenderaan kontemporari dan sistem pengesanan kekosongan tempat letak kereta Haar Cascade telah mencapai 100% ketepatan apabila diuji di tiga jenis tempat letak kereta. Walau bagaimanapun, ketepatan sistem pengesanan kekosongan letak Haar Cascade digugurkan dari 100% ke 25% apabila ia diuji di persekitaran yang berbeza.

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IoT	-	Internet of Things
OS	-	Operating System
PC	-	Personal Computer
UI	-	User Interface

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CHAPTER 1

INTRODUCTION

1.1 Introduction

The current parking systems are mainly focused on the indoor parking system. However, the on-street parking system should be highlighted because most of the traffic issues such as traffic jam and double-parked are happened at outdoor. Therefore, this chapter highpoints the background of study, problem statement, objectives and scopes of the project. Background studies depicts the important of an effective parking system and the technologies used to be implemented in parking system. The issues and problems that are aroused due to the ineffective parking system in Malaysia are stated. Besides, the flaws of the current on-street parking system in Malaysia are also discussed as the problem statement of this project. To improve the existing on-street parking system, 2 objectives are suggested as a benchmark. Lastly, several scopes is mentioned to define the limits and boundaries of the project in overseeing the project upon completion.

1.2 Background of Study

Due to the increasing in population in the industrialization of the world, the mismanagement of the parking system to the available parking space leads in parking related problems. An effective parking system is needed to be developed in order to manage the available the parking lots and satisfy the parking lots demand. The word "effectiveness" provides different ideas and meanings based on the requirements that are needed in a system. There are many parking systems with different technologies are proposed by the researches from different countries in order to developed an effective parking system.

In [1], a survey about the various technologies and techniques for an intelligent car parking system is done by Faheem and his teams. The technologies and techniques that are commonly implemented in the parking system are wireless sensor based system, vision based system, expert system, GPS based system and so on. These

systems are used to detect the parking availability at a parking area. In order to make the parking system more effective, the system always uses the concept of Internet of Things (IoT). IoT is introduced by Kevin Ashton in 1998 [2]. It is becoming so important to integrate with cloud computing because it provides a platform to store more data and develops smart applications for the users.

1.3 Motivation

Due to the ineffective parking system, the drivers need to spend more time and costs in searching a parking lot to park their vehicles. The ineffective parking system leads the double-parked problem and it causes the traffic congestion in the crowded area. This double-parked problem also causes the incidents happened due to conflict and misunderstanding between two parties. A real incident is happened at a restaurant in Bentong, Pahang. According to the article reported by China Press, the Toyota truck owner got angry and knocked the double-parked Honda City after he honked it for half an hour [3]. Besides, the double-parked problem also leads traffic congestion occurred at SS 15 Subang Jaya because the drivers do not want to waste their time in searching a vacant parking to park their car properly [4]. According to the survey done by Uber, a Malaysian spends average 25 minutes each day in looking for a parking spot and this causes 74% of them have missed or been late to work [5].

In addition, this ineffective parking system causes the burning of addition fuel in searching a parking space in crowded area causes the environment impacts. The carbon dioxide, CO_2 that is released when the burning of petrol causes the global warming problem. The global warming problem leads the temperature of the world changing dramatically and unexpectedly [6]. The burning of the petrol leads the problem of air pollution. Air pollution affects quality of air and causes the accidents occurred due to the thick fog formed by the burning of fuel. The air pollution also will harm the human's health such as asthma problem and eye disease.

The development of the advanced technologies is one of the motivation for developing an effective parking system. Director Chong Kai Wooi explained that Malaysia is on the track of smart cities, paying parking using application via smartphone is a possible way to improve the quality of life of the peoples [7]. From the statistic collected by statcounter, there is 78.46% Malaysians use android smartphones [8]. Hence, the Android Studio software is the best platform to develop a

mobile application for the parking system [9]. Lastly, Internet of Things (IoT), a system of interrelated computing devices, mechanical and electrical devices that are provided with unique identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction [2].

Due to the motivations that are mentioned in the above, an effective parking system with high performance and the low installation cost which is suitable to open space parking area is needed to be developed to improve the current parking system in Malaysia. The proposed parking system applies the concept of Internet of Things (IoT).

1.4 Problem Statement

Although there are various parking system developed in Malaysia, the development of on-street parking system is always be neglected due to limited resources. Traffic congestion and double-parked issues are always occurred at the crowded area especially at office area or at food court area. This is because the current on-street parking does not install any sensing devices to detect the status of vacancy of parking spaces. In Malaysia, there are no security camera installed on the street. Without the vision based sensor, the availability of the on-street car parks is unknown. No one will know the car parks' availability status at the desired location unless the drivers reach there. This leads the drivers spending more time in searching the parking space lot by lot.

Another problem that is encountered by on-street parking system in Malaysia is that there are no any platform provided to the users to get real-time information of the availability of car parks. Government does not provide any web application or mobile application to the users for checking the parking availability. Most of the parking vacancy display are just showing the number of the available parking but not the exact position of the car park. Furthermore, although there are some parking payment applications provided by state government such as Malacca and Kuala Lumpur, those payment systems can only to be used in town area. For most of the areas such as Puchong, Subang and Ayeh Keroh, the parking payment system still requires the purchase of coupon. The coupon system is not a convenient system for drivers and motorists, especially for those who seldom visit the area. Besides, it is difficult to

purchase the coupons since there are very less coupon sellers. There is a possibility that the driver may get fine at the moment he or she are searching for parking coupon.

To improve the current on-street parking system, an application should be developed to deliver the real-time information about the status of availability of car parks at the desired location. In addition, sensors should be installed at the on-street parking area to monitoring the car parks. Lastly, a reliable detection system should be developed to identify the availability of parking so that the users can obtain the most accurate information.

1.5 Objectives of Project

This project embarks to achieve the following objectives upon its completion:-

i. To design and develop an on street parking system with the integration of mobile application for providing real-time information to the users.
ii. To evaluate the performance of both contour parking vacancy detection system and Haar Cascade parking vacancy detection system in terms of accuracy in detecting the status of availability of car parks.

1.6 Scope of Project

In accomplishing the intended goals of the project, several limitations were defined as follows:

i. The parking system is focused on on-street parking area. The prototype is built with three different types of parking which are parallel parking, angle parking and perpendicular parking. Each type of parking has 4 parking lots.
ii. The size of the parking lots are designed for the toy cars. The size of the parking lots at the prototype hardware is smaller than the size of actual parking lots.
iii. A yellow circle with number label is placed at the center of the parking lot. When an IP camera detects the number along with its yellow background, it shows the parking lot is available.

iv. The evaluation of the system is done at daytime. The experiment setup is carried out at the bright condition which has sufficient lighting condition.

v. Huawei smartphone is used as an IP camera for monitoring the parking area.

vi. Camera tripod is embedded with the camera to provide stability and prevent the camera from capturing an obstructed image.

vii. A mobile application is developed using Android Studio. The mobile application can be used by android users with the internet connection.

viii. Intel Up Squared board is used as a server and a processor for computer vision algorithms. The Ubuntu OS and OpenCV software are installed in it.

ix. OpenCV python is used as a medium of processing the videos or images that are captured by the IP camera.

x. Firebase is used as a cloud system to store data obtained from OpenCV and transfer the data to the mobile applications.

1.7 Thesis Outline

This research project is documented and structured as follows. Chapter 2 provides the literatures review based on the previous findings and researches. Chapter 3 highlights the methods used in this project in order to achieve the objectives of the research. The analysis and discussion on the results of the experiments are stated in Chapter 4. Lastly, the conclusion and recommendations about the research is emphasized in Chapter 5. All the references and appendices related to the research is attached at the end of the report.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter, literature review related to the on-street parking system are done by referring the trusted resources such as articles and journals. First of all, the concepts and requirements of an effective parking management system. Next, the background of various existing parking system are described. Reviews on related works are studied and compared. The evaluation and comparison are done based on limitations of the system, method of detection and method of analysis.

2.2 Effective Parking Management System

Generally, an effective parking management system needs a server or a gateway that are used to be a bridge to interface hardware (sensors) and software (cloud, mobile application and website). Once a car enters or leaves the parking area, the server will send the real-time information to the database via the internet. When a car parks over the sensor, the information will be transmitted wirelessly to the gateway and the occupancy will be reported instantly to the users via application. When the car leaves the parking lot, the application will be automatically connected to the payment method system. Hence, it is more convenient for the users to get the real-time information of the parking area and also save their time to search the payment machine. For the authority, he can identify non-paying cars with the use of mobile application. This method makes the parking workers can work effectively. Figure 2.1 shows the basic concept of an effective parking management system.

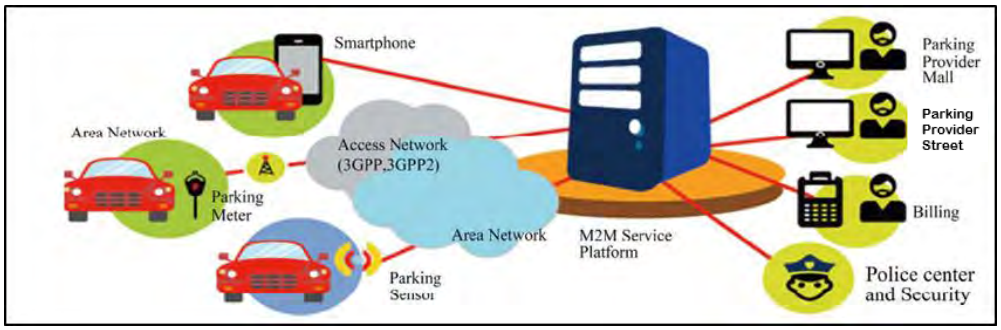

Figure 2.1: The Basic Concept of An Effective Parking Managemnet System

An effective parking management system should consists of the following specifications [10]:

a) Able to optimize the usage of parking spaces.
b) Able to minimize the traffic congestion in the city.
c) Able to guide the users or drivers to the available parking lot.
d) Able to detect the vehicle occupancy in real-time accurately.
e) Able to provide the real-time information of parking availability to the users.
f) Able to provide a media for the users to pay parking fee.

2.3 Comparison of Existing Open Space Parking System

Table 2.1: The Comparison Table Between The Existing Open Space Parking Systems

Articles	Sensing Method	Sensors/Spots	Accuracy	Limitations
[11],[12]	Mobile Sensing Unit	Not Necessary	>= 90%	The performance of the system relies the accuracy of GPS information, sensing unit need to be mounted in a car.
[13]	Camera	Not Necessary	> 96%	The performance of the system is affected by the shadows produced on the parking lots, the solar reflection from the vehicles.
[14],[15]	Magnetic Sensor Node	1	> 98%	Sensor nodes have limited computing power and memory

[16]	Ultrasonic Sensor	1	No mentioned	Require wiring works to install ultrasonic sensor.
[17]	GPS/ accelerometer sensors	Not Necessary	> 97%	No external sensors such as camera, wireless sensor and ultrasonic sensor, everyone must have smartphone with bluetooth sensor.
[18]	Video camera	Not Necessary	No mentioned	Require large amount of storage memory.
[19]	Ultrasonic sensor	2	>= 90%	Require more than 1 ultrasonic sensor to reach high accuracy of detection of parking availability.
[20]	Photoelectric Sensor	2 at the speed bump	> 98%	The maximum speed allowed at the parking area is 20km/hr and the information provided is for whole parking area but not specific for a parking lot.
[21],[22]	Web camera /Camera	Not Necessary	> 90%	Images will have shadow when there are no sufficient lighting condition.

In this research, the discussions and justification of existing parking system are focused on the on-street parking area. There are various methods of detection used in existing parking system to identify the status of the parking availability. Vladimir Coric and Marco Gruteser [12] proposed that the preinstalled parking sensors that are mounted on the passenger side of a vehicle are able to detect the presence of parked vehicles on the street by measuring the distance from the nearest obstacles beside the street. The mobile sensing unit helps to collect data about the status of parking availability. In addition, in this system, the mobile sensing unit is not required to be implemented at each of the parking lot. The experiments that are done in article [11, 12] proved that the performance of the parking system that uses mobile sensing unit hits the accuracy more than 90%. The accuracy of the parking system is affected by the stability of the GPS. However, this sensing method is not recommended to be used in Malaysia because most of the Malaysians do not want to spend money on installing the mobile sensing unit in their own cars.

The other sensing method that are used in existing parking system is ultrasonic sensor. Ultrasonic sensor emits the sound wave of specific frequency to detect the presence of a vehicle. The ultrasonic sensor needs to be installed in each of the parking lot. In [19], it mentioned that each parking lot requires 2 units of ultrasonic sensors to increase the accuracy of detection of parking availability. The accuracy of the system that are proposed by Dr.V.Kepuska and Humaid Alshamsi [19] reaches the accuracy above 90%. However, the use of ultrasonic sensor as the sensing tool to be used to monitor the status of open space parking availability is not suitable. This is because the ultrasonic sensor is impossible to place on the ground of open space parking area. The ultrasonic sensors will be damaged or broken when the car runs over the sensors and crush them. In addition, the implementation of ultrasonic sensors to the open space parking area needs the wiring works which lead to the increasing of cost. The accuracy of the parking availability detection using ultrasonic sensors is affected by the environmental factors such as the surrounding temperature, the types of the surfaces used and so on. Due to the cost and unsuitability, the ultrasonic sensor is not be recommended to be chosen as the sensing method.

The magnetic sensor node is also be used to be installed in parking lots to detect the status of the vacancy of parking spaces. Zusheng Zhang [14] proposed a on street parking system based on wireless sensor networks (WSNs). To evaluate the performance of this system, 82 of magnetic sensor nodes are installed on the open space parking area and the system is ran for one year. This system requires few components which are base station, routers, server and sensor nodes. The evaluation of the accuracy of the system is done with two types of algorithm which is the algorithm that is developed by Zuzheng Zhang and his team and Adaptive Threshold Detection Algorithm (ATDA). After the experiments, it proved that the algorithm that are developed by them has a higher accuracy than the ATDA which is more than 98%. The problem encountered by the on-street parking is the strong noise disturbance. To solve this problem, Hongmei zhu and Fengqi Yu [15] use the normalized cross-correlation (NCC) method. By using this method, the accuracy of detection can reach an accuracy of 99.33% for arrival and 99.63% for departure. However, there is a tradeoff between sensitivity of magnetic signal that will result in the detection of vehicles in adjacent parking place. Due to the weakness of the magnetic sensor, the magnetic sensor is not suitable to be implemented in on street parking area in Malaysia

because the noise of surrounding environment such as construction works, motorcycle noise and other source of noise.

In [17], a system that is named PhonePark was developed by Bo Xu and his team members. They proposed to use the GPS or the accelerometer sensor that is built-in in the drivers' mobile phone to detect the locations that the drivers parked their car. In this system, there are no extra external sensors such as camera, ultrasonic sensor and photoelectric sensor to detect the parking availability. Besides, to estimate the parking availability in real-time, they compute the historical parking availability profile for an arbitrary street block using an algorithm. The accuracy of detection of parking availability reached more than 98%. However, this method is not a good solution because not all the drivers carry a mobile phone and they may not install the PhonePark system in their phone. In addition, false information may be produced due to the GPS errors, transportation mode detection error and Bluetooth pairing errors. Therefore, this method is not suitable to be used.

Photoelectric sensors are also be used to deploy on the access roads into and out of the parking area. In [20], the wireless sensor node (WSNs) concept is used in this system. The sensor node is connected to two sensors to detect the passage of vehicles. The two photoelectric sensors was place in a speed bump to monitor the exit and entry process at the parking area. The data obtained will be sent to the data centre. This proposed system is tested at the Tafira Campus of University of Las Palmas de Gran Canaria. The result shows that the accuracy of this system in detecting the passage of vehicles is quite high, which reaches more than 98%. However, this system has some limitations such as this system can only detect the number of cars in and out the parking area but it cannot give the specific parking lot that are available to be parked. Moreover, the speed limit that the car can cross over is 20km/h only. This means that if the car's speed is more than 20km/h, the accuracy may be decreased. This method is not suitable to be implemented in Malaysia because the bump speed in Malaysia is different with other Europe country and it is very difficult to install photoelectric sensor inside the bump speed.

Next, the camera is also used to capture the images at the parking lots. The camera is installed at a fixed position such as at the street lamp to monitor the parking area. Articles [13, 22, 23] support that the vison based system is the best solution for monitoring and identifying the parking availability at the on-street parking area. There are two analysis method that are provided to analyse the captured images from camera