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Automated Car Plate Detection and Character Recognition with Parking Fee Management using Point Feature Matching

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Abstract: The increase of car ownership every year will also produce a higher demands of parking space especially in office buildings, shopping malls and high-rise residential buildings. The difficulties for car drivers at parking lot are the process of taking, keeping and paying parking ticket as well as searching for available parking lot during peak hours. The conventional methods of finding parking space is time consuming and do not detect the car plate number. This study presents a solution in car plate detection and character recognition and also notifying the drivers on the availability of parking space in real-time. In this study, an image processing technique of point feature matching has been used to detect the car plate number upon the car entering the building, store the time of entry and the time of exit to automatically calculate the parking fee as well as notifying the available parking spot in real-time. The testing results on the car plate detection shows an increase on 14.8% recognition rate from the previous work. This solution is suitable for huge parking space in commercial site, government building, airports and shopping complex.

INTRODUCTION

Car production never stops. For example, in Malaysia, the car production keeps increasing and averaged at 25,064.76 units from 1984 until 2017, reaching the highest production of 56,745 units in April 2015[1].

With the constant production of cars, car ownership has been increasing exponentially and will continue to rise indefinitely. A survey by Nielsen Global Survey of Automotive Demand in 2014 shows that, Malaysia placed third in the world for car ownership with 93% with highest incidence of multiple car ownership globally. In comparison of few other Southeast Asia countries, 47% of Filipino and 46% of Indonesia households does not own a car[2].

With the arising of car ownership, it will also be followed by the demand of parking space. Hence, more and more parking space are needed. Although, Malaysia has been promoting the use of public transportation to cater this need, it still unsuccessful to avoid the increase of car ownershi[1].

Nevertheless, more cars will be bought which resulting more parking space and parking garage will be built to cater this. The weakness of existing parking system is the usage of parking ticket/token where it could be replaced with a better approach to avoid the loss of the ticket/token where the drivers will have to pay a high amount of penalty. There is also no display of parking availability before the entrance which can saves a large amount of time and fuel if drivers can avoid entering filled parking space.

By introducing car plate detection and character recognition approach, this could help eliminate the use of parking ticket/token and implement automated calculation of parking charge. The parking vacancy number also could be introduced to help drivers before entering the parking lot.

Current parking management implementation: Most parking system in Malaysia use the old system where drivers need to take parking ticket/token during entry which signify their time of entry. To exit the parking space, they need to go to the nearest parking payment machine to pay for the parking fee. The paid ticket/token then will be used when exiting the parking area.

Drivers also has no way of knowing whether vacant parking space are available before entering the parking area. Without automated intelligent system, drivers will need to enter a fully filled parking garage unaware, to search for vacant parking space and end up wasting a lot of time and gas with no finding.

Another usual problem is drivers lost their parking ticket/token. Parking tokens are usually small and looks no different to ordinary coins. Furthermore, its sleek design contributed to the loss of it while taking things out of your pocket.

The proposed system will calculate vacant parking space and display it at the entrance, so that, user can choose to enter the parking area or not. The use of ticket/token will no longer be needed with the introduction of the proposed system as it will store the car plate number and the entrance time when the car entered the parking area with motion detection and image processing. When the car passes through the beginning of the exit lane, the system once again captures the car plate number with the exit time and automatically calculate the parking fee based on the comparison of entrance time and exit time.

Significance of the proposed system: The proposed system includes the following modules that will improves time and less hassle to the user.

Number plate recognition: This module will consist of capturing the number plate of the cars in the form of picture and the process required to interpret the picture into digits that represent the number plate to be stored. This module will be used during entrance, exit and monitoring the parked location.

Parking fee payment: Instead of using parking ticket, this module will use the stored number plate to accurately calculate parking fees. Drivers only need to drive to the exit to invoke this module.

Admin: This module will involve admin related works for this system. The system should be able to capture the car number plate when drivers first entered the parking garage. The captured picture will be successfully converted into the form of data that can be stored into the database. The time of entrance will also be recorded to calculate the parking fee in accordance to the required rate.

During the exits, the system will capture the number plate and cross check with database to calculate parking fee based on the duration of stay. At the end of this process, the system should produce the parking printable receipt.

This system should also allow the admin to add new admin to accommodate other qualified users. Admin should also be allowed to edit their own information. The data of parking transaction should be saved into the database and can be viewed by the admin.

MATERIALS AND METHODS

Study design: Agile development model has been selected to implement this project for reasons. The proposed system consists of individual modules that can be tested individually and integration testing will be done after next module have been completed. Modules were developed one by one, and system integration was done every time a module completed[3, 4]. This conforms with the structure of Agile development model as depicted in Fig. 1.

Start: Problem statement will be identified and analyzed and requirement elicitation will be done during this phase. All confirmed requirement will be documented in formatted document, software requirement specification.

Development cycle: During this phase each module will be implemented sequentially and tested. Next module completed will also be tested and integrated to the previous module and integration testing will be done.

Review: System functionality of completed system will be reviewed and cross checked with requirements documented to ensure all the requirements has been implemented.

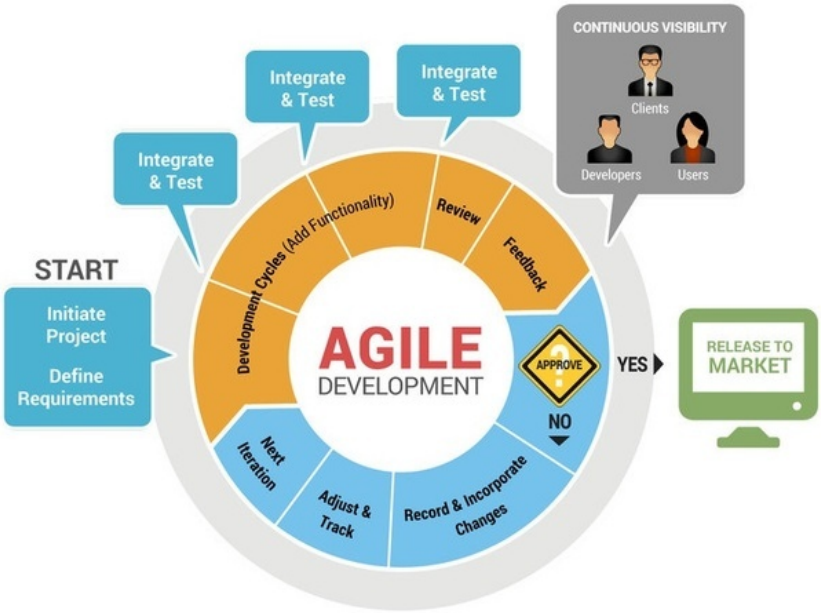

Fig. 1: Agile development model

Table 1: Overview of development activities and their output

Phase	Task	Output
Start	Identify and analyze the stakeholder's needs and wants. Questionnaire, interview and review of existing system can be done to further refine the requirement during this phase	Documented problem statement, objective, scope and limitations that define system features to be implemented in form of modules or components
Development cycle	Each module will be developed one by one sequentially and tested individually.	Working codes of each module
	After integration, further testing for the interface will be done	Integrated modules Component and integration testing results
Review	After completion of all modules and integration, a working program will be produced at the end of cycle that will be reviewed. All requirements will be compared with the completed system to check for completion	Working program System testing results
Feedback	Gain feedback from stakeholder and confirm all requirements have been met	Change request
Approve	The completed system that have been reviewed by developer team and stakeholder will be evaluate if it is ready to be deployed. Stakeholder's feedback may need to be implemented before deployment, hence enter new cycle	Deployable system Approval results
Record and incorporate changes	Preparation for next cycle's development including items to be implemented are prepared and designed	Minor component or whole module design

Feedback: Feedback from stakeholders will be acquired during this phase.

Approve: During approval, the system will be evaluated in accord to review and feedback. If the system is evaluated to be completed, it can be deployed to the market, if not, next phase will be started.

Record and incorporate changes: Changes or correction that need to be implemented need to be documented and next iteration will start.

System development workflow: As shown in Table 1, Agile development model is an iterative process with its development cycles depend on the functionality to be developed in the project[5, 6].

Point feature matching: In this study, point feature matching method is used for the car plate detection and character recognition. Point feature matching is a method involves tracking a few feature points which may include edges, corners/interest points, blobs/regions of interest or interest points or ridges from a video stream data[7]. The tracked feature points will be compared to the trained feature points which already stored in database. The algorithm will calculate whether there is enough evidence that the tracked features have to be detected as the alphabet/number stored in the database. Figure 2 shows the outline of the proposed algorithm.

Experiments: The training dataset for this study comes from UFPR-ALPR Dataset[8]. This dataset, includes 4500 fully annotated images from 150 vehicles

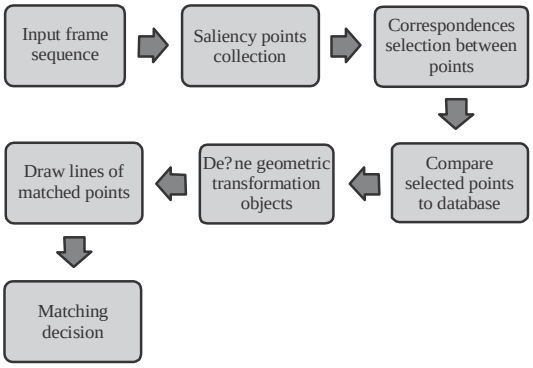

Fig. 2: Block diagram of the proposed algorithm using point feature matching

in real-world scenarios where both vehicle and camera (inside another vehicle) are moving. The dataset images were acquired with three different cameras and are available in the Portable Network Graphics (PNG) format with the size of 1920×1080 pixels.

To test the proposed algorithm, 500 testing data has been used which consist of a combination of ALPR dataset and dataset from Malaysian car plate number collected by the researchers.

Figure 3 shows our proposed next parking system capturing the car plate number at the entrance of the parking lot. Meanwhile, Fig. 4 shows the next parking system capture at exit of the parking lot. Figure 5 shows the next parking system receipt.

Fig. 3: The proposed next parking system with car plate number capture at entrance of the parking

Fig. 4: Next parking system with capture at exit of the parking with the total parking charge

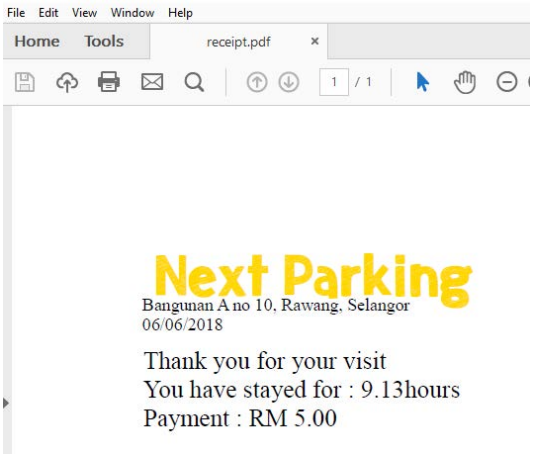

Fig. 5: Receipt for parking fee

Table 2: Results obtained and the computational time required in each stage in the testing dataset

Stage	Recall/Accuracy (%)	Time (m sec)
Car plate detection	100.0	3.287
Character segmentation	99.6	1.572
Character recognition	94.9	1.442

Table 3: Comparison of recognition rates between the previous work and the proposed method

Method	Recognition rate (%)
Sight hound	58.6
Open ALPR	57.8
Proposed	73.4

RESULTS AND DISCUSSION

To demonstrate the significance of the proposed method, the proposed method is compared with two different existing methods: Sight hound[9] and OpenALPR[10]. The experimental results prove the effectiveness of the proposed method as explained below. Table 2 shows the results obtained and the computational time required in each stage from the testing dataset. The stages are divided in three: Car plate detection, character segmentation and character recognition. Car plate detection is where the car plate of the cars is correctly detected. The result shows that all 100% of the car plate were correctly detected by the proposed method. Meanwhile, character segmentation is when every character in the detected car plate are successfully separated. The result shows that 99.6% of the characters from the car plate were correctly segmented. Lastly, character recognition is when the individual characters in the car plate number are recognized by the system. The result shows that 94.9% of the whole characters from all car plates in the testing dataset were correctly recognized by the proposed method. Recall is for detection and segmentation and accuracy is for recognition.

Table 3 shows the comparison of recognition rates between the previous work and the proposed method. The recognition rate is calculated by taking the frequency of the respective systems correctly recognizing all letters and digits from the car plate number over the total testing dataset. The recognition rate of the proposed method is 73.4% where it is superior than the previous work by 14.8%.

CONCLUSION

In this study, the car plate detection and character recognition with streaming video input and parking fee management system have been investigated. Through developing an algorithm using point feature matching method, the proposed method has been proven to be effective in detecting and recognizing car plate number. There is still room for improvement which future work could take place where the proposed method currently focused only on one public dataset in the training process, more dataset could be used to train the algorithm to suits the nature of the Malaysian car plate number scenario.

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