PARKEY: ticket-less parking system using license plate recognition approach

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Abstract. As of recent practice, the majority of current parking systems are still implementing the same traditional method of giving entry to parking visitors which is by giving out a physical ticket. This has caused several problems for mall visitors. Therefore, it is planned to propose a system that can eliminate the problems and provide further improvement to the current systems. Our proposed system named PARKEY is a Ticket-less Parking System that has been designed to provide a new method of parking entry and exiting while implementing new features in the parking system. The objective of the project is to provide a working ticket-less entry and exit system by using a virtual ticket with the help of image recognition technology. With the proposed system being developed, it will help to solve problems that are present in the current systems and give an implementation of a parking system that is up to par with the current standard of technology. Before the system was developed, interviews, observation, and requirement reuse were used as methods to elicit requirements that will provide useful insights for the development of the system. Before the system was developed, interviews, observation, and requirement reuse were used as methods to elicit requirements that will provide useful insights for the development of the system. This includes providing questions to users, making observations to current systems deployed, and studying existing systems ranging from older systems to newer, similar systems. Using the stated elicitation techniques, some findings were gathered and are beneficial to the development of the system. The use of observation to current parking systems helps provides data that will be used as a benchmark for the proposed system to identify how quick the proposed system reaction time should be to provide an on-par performance with the current systems. Interviews with several potential users were done to gather information on their experience from the current parking systems and their opinions on what can be improved and expectations of the proposed system. Other than that, studying the currently available systems gives a better understanding of the drawbacks and limitations of the current systems and provides some functionalities from those systems that can be combined and implemented to benefit the proposed system’s improvement during development. The developed proposed system applies a combined usage of a web application, license plate recognition technology, and an e-wallet based payment system to tackle current parking system problems.

1. Introduction
Parking has become an important component and a necessity in every shopping mall to make it convenient and safe for shoppers to park their car. Many shoppers would prefer to park inside the
shopping mall’s parking lot so that they can avoid walking far just to get into the mall. It also brings revenue to the malls by charging a parking fee to those who park in the parking lot. Most shopping malls in Malaysia currently use the same parking system. The two main components are the parking ticket and payment kiosk. Although this system works perfectly fine most of the time, it does bring quite a few problems. For example, sometimes it would take a lot of time for the ticket dispenser to dispense the ticket to the user upon entry. Other than that, when a user loses their parking ticket, it would cost a lot of money for them to pay for a penalty. To solve this problem, the ticket-less parking system aims to modernize the parking system by eliminating the use of a parking ticket and replacing it with the use of a vehicle license plate. This will help solve the problems that are currently present in the current parking system as well as bring benefits such as reducing the use of paper. Until now, the use of vehicle license plate has not been widely used especially in mall parking.

The common issue faced by numerous shopping malls with regards to parking systems is the lack of fee monitoring. It has been forever since the mall parking system in Malaysia has any changes especially parking fee monitoring. This lack of advancement has caused the user to be uneasy as they will always be guessing how much of the parking fee will they have to pay. The current system’s current system of checking the parking fee is by going to the payment kiosk and insert the ticket to check the amount of the fee. It is not on par with the current standard of technology where everything can be done through the internet. The current system is still using a medium for access to parking which is a ticket. It is small and thin, making them easy to lose. This has been a common problem for several users. As for the consequence of it, users who lost their ticket would have to pay up to RM50 for the penalty.

Although most parking system uses ticket, there are still some out there that still uses magnetic cards as an alternative to a paper ticket. Although this type of card is widely used as a credit/debit card, it is unreliable when it comes close to a magnet as it would cause it to be demagnetized rendering the card to be corrupted as said in the article [1]. This can cause a problem to the user as they will not be able to pay their fee and exit the parking as their card appears to be not readable to the card reader.

Our aim of this project is to study the requirement and limitation of existing parking application, to design a parking application that uses vehicle plate recognition technique at a permit, and as an output, to develop an integrated parking application the combines vehicle plate recognition module with virtual ticket module.

2. Literature Review

2.1. Review on Existing Systems

Currently, the parking system that is widely used in Malaysia is using a ticketing system where the ticket acts as a pass for them to go in and out of the parking lot. Other similar systems that make use of vehicle license plate recognition were also included in the review to identify the pros and cons of using text recognition.

2.1.1. MAXPARK Barcode Ticketing System. This type of barcode ticketing system is widely used in many shopping malls parking in Malaysia. As stated on the website [2], The system is divided into three major points which are the entry point, parking facility, and exit point. The entry point provides a ticket dispenser where the machine will dispense the ticket to the user and lift the boom gate upon giving the ticket to the user. The parking facility area provides the user the ability to make payment via autopay kiosk as well as a control monitoring system for the parking administrator to control the parking system. The exit point provides the ticket verifier where it allows the user to feed the ticket to the machine and the machine will verify the ticket.

2.1.2. i-Neighbour TimeTec Smart LPR. TimeTec Smart LPR is a license plate recognition system that is applied to neighborhood parking. To use the system, the user must register their vehicle license plate number into the TimeTec Smart LPR system. After that, the vehicle registered will be able to enter and exit the boom gate by using the system’s camera positioned at the boom gate to recognize the vehicle
license plate. Based on what is stated on its website [3], it claims to have a success rate of recognition of 95%. Based on the finding, Table 1 summarizes the comparison between existing systems that are available in the market and our proposed system.

Table 1. Comparison of existing systems with PARKEY

| Aspect                          | MAXPARK Barcode Ticketing System | i-Neighbour TimeTec Smart LPR | PARKEY  |
|---------------------------------|----------------------------------|-------------------------------|---------|
| Use of ticket                   | Yes                              | No                            | No      |
| Plate recognition               | No                               | Yes                           | Yes     |
| Administration System           | Yes                              | No                            | Yes     |
| Parking fee calculation         | Yes                              | No                            | Yes     |
| Payment system                  | Kiosk                            | Not Applicable                | Online  |
| Connected online                | No                               | Yes                           | Yes     |
| User registration               | No                               | Yes                           | Yes     |

2.2. Review on License Plate Detection

2.2.1. License Plate Detection with Python and OpenCV. There are many methods to achieve license plate recognition with many different algorithms to use. One of the most popular examples is by using already made algorithms that are provided open-source on the internet. One of the examples shown is from the article CVisionDemy [4]. The code provided was an adaptation of Chris Dahms License Plate Recognition code. This code was tested with a European license plate and it is unsure if it would work with a license plate from another region. The method that was used was by morphing the image input.

It first used some preprocessing to the image to remove the change the hue and saturation in the image to provide a non-colored image like shown in Figure 1.

It then morphed the image using a morphological operation called Top Hat and Black Hat to bring out the contour of the image. After that, it performed subtraction of the image by subtracting the values of add value (add of gray and Top Hat) and Black Hat. The output of the image shows that it is much rougher on the edges compared to the original image. It then applied gaussian blur and threshold to produce an output of the image with outlines to objects visible in the image.
With the image produced, it will check the contours of the image. The goal is to check each contour and see if it looks like a character. Any contour that looks like a character will be saved in a list and those who do not will be removed. The algorithm will use this method (filter) two times to get the output shown in Figure 3. A region of interest was constructed around the contours used to crop the license plate detected (Figure 4).

![Figure 3. Contours Detected Into Character List](image)

The detected license plate image will be useful to be used to identify characters present in the image for license plate recognition purposes. However, this method is not good enough to be implemented into a system since it was found that most of the time it cannot detect the license plate correctly even on some easy examples. Furthermore, the method provided in the article only provides the license plate detection and it does not include license plate recognition.

2.2.2. **OpenALPR.** OpenALPR is an open-source automatic license plate recognition library that can be compiled and ran on multiple operating systems such as Linux, Windows, and Mac OS[5]. The library license plate recognition function using images and video stream input. The library support integration to multiple coding languages such as Python, C++, and Java. The library is simple enough to use as it
provides a detailed guide on how to retrieve the source code and compile it. The library supports multiple countries such as the United States and other European countries. Although some countries might not be supported by default, developers can train OpenALPR optical image recognition by themselves given if images and time are available. The OpenALPR provides full documentation [6] to guide developers in training the OpenALPR OCR system.

The usage of the library is simple. It will just need an image input that has a license plate to be recognized and it will produce an output with the top 10 results sorted by the confidence level. The output can be in a JSON format making it accessible as a data input to any existing system. This library will be useful to be used by any project that requires license plate recognition as it can be integrated easily into any system. Furthermore, having it as an open-source program would make it easier for developers to find support on the internet during development in the event of having problems while using the library.

3. Requirement Analysis

3.1. Requirement Elicitation
The first and important step in software development is requirement engineering and the main goal of the process of requirements engineering is requirements selection. There are various methods to collect the needs and software developers use them to compile the specifications.

3.1.1. Observation. Observation is a technique to elicit information out of existing systems that are currently being used by closely observing the system and analyze the use cases to decipher how a user uses the system. Observation with the systems is done by going on-site and observe the usage of the current system available to gather existing requirements to be implemented in the system to be proposed. For this method, two different similar systems will be observed to understand the existing requirements of the system.

The observation was done in a nearby shopping mall that has a parking system. The shopping mall chosen to perform observation were IOI City Mall Putrajaya and De Centrum Mall. The observation was conducted by observing and assessing user action without any interference from the observer. Both systems use barcode scan parking tickets and 3 stations are needed for the parking system to work properly. Those stations are:
• Parking entry where it dispenses parking ticket to the user.
• Parking kiosk payment is located near the elevator or stairs for users to pay for their ticket.
• Parking exit where it accepts the ticket from the user and scans the ticket.

On the first observation, a total of 20 data were recorded with each parking system with 10 data. Both parking showed a similar result for the time taken to dispense the ticket and lift the boom gate with a difference of 0.2 seconds on average between the first and the second system. De Centrum Mall parking entry gate shows an average time of 6 seconds for the system dispense and lifts the gate at the entry point with the longest time taken is 7 seconds and the lowest time has taken is 5 seconds (Figure 5).
Figure 5. De Centrum Mall Parking Entry Gate Time Taken

IOI City Mall parking entry gate shows a faster average time with an average of 5.8 seconds for the whole process to complete (Figure 6). Although the average time is faster, the highest and the lowest time show the same result with the highest and lowest was 7 seconds and 5 seconds respectively. This shows that the average time to be achieved for the proposed system to scan the vehicle license plate and lift the boom gate should be around at least 5 to 7 seconds. The system, however, will need good processing power to achieve the time stated due to the difference in how a barcode scanner and a license plate recognition system works. The proposed system will expectedly take 2 to 5 seconds longer than the systems observed. The second observation showed an interesting result with both systems shows a different result. The first parking system showed a shorter time taken due to all the attempts recorded were without the need to insert or pay money to the machine because of the parking rate to be free for the first two hours. However, the data can be used to expect the difference that a barcode scanner system will be compared to letters and numbers input for the proposed system.

Figure 6. IOI City Mall Parking Entry Gate Time Taken

3.1.2. Requirement Reuse. Requirement reuse is a recognized and frequently used method in eliciting information when it comes to developing a project in the software engineering field. It is also useful to validate the requirements in the proposed system. Requirement reuse can be implemented in a project by observing and studying requirements that are implemented in the current working system. It is a method to avoid consuming a lot of time and cost.

To implement requirement reuse on this project, multiple similar existing systems were referred to identify requirements that are useful and suitable to be applied to the proposed system. To make sure the requirements to be observed do not deviate from the area of the proposed system, only systems that are related to the field of the project will be reviewed in which this case would be the parking system.
The systems that were reviewed to elicit requirements were nearby parking system as follows:

- IOI City Mall Parking System
- De Centrum Mall Parking System
- MAXPARK Barcode Ticketing System
- i-Neighbour TimeTec Smart LPR

The systems listed will be used as a guide in obtaining requirements and use cases for the proposed system.

3.1.3. *Interview.* Interviews are one of the most popular and widely used requirement elicitation techniques. An interview can be used to verify facts, clarify ambiguity, and engage end-users to identify requirements and grab their opinions and ideas [7]. Interview with each interviewee was done to gather requirements that are crucial for the development of the system and acquire their opinion on the system. The interviewee selected to be interviewed were end-users who drive to shopping malls.

A total of five interviewees were interviewed to ask them questions about their experience with the parking system that they use when they go to shopping malls. The interview was conducted face to face and through an online voice communication platform. The interviewee’s answers, opinions, and thoughts were recorded during the interview and documented. The interview was conducted by asking the interviewee six questions related to the development of the proposed system to identify the problems of the current system and to pinpoint the requirements that need to be implemented into the system.

The first question was asked to ask the user to briefly explain the implementation of the parking system in shopping malls that they usually go to. Almost all the interviewees answered a similarly explaining that the parking system uses barcode ticket to enter and exit the parking lot and the system provides a parking payment kiosk where the user will use it to insert the parking ticket, view the parking fee, and insert banknotes as a way of payment. It is noted that the parking system will tell the user that they will have a 15 minutes window to exit the parking before the system charge a parking fee to the users again.

The second question was asked to see the interviewees’ opinion on the efficiency of the parking ticket kiosk. The answer received were different and mixed opinions between the interviewees. One of the interviewees said that they have no problem with the parking ticket kiosk. Four interviewees do not like that the parking ticket kiosk sometimes does not accept some banknotes even though the banknotes they give to the machine is fine. One interviewee specifically stated something that grinds their gears was when they went to a shopping mall during a public holiday and the line to the parking ticket kiosk was so long it took them around 10 minutes for their turn to pay their parking fee. This proves that the parking ticket kiosk is not efficient and fast enough during peak time to serve more users than the usual time.

The third question was asked to identify the current method for users to check their parking fees. All the interviewees specified that the parking fee is usually shown at the payment kiosk where it will be displayed on the kiosk screen during payment. Other shopping parking such as The Gardens Mall located at Bangsar uses a toll booth instead of an automatic payment kiosk where it will display the fee at the kiosk upon giving the parking ticket to the worker. This is frustrating to some of the interviewees as they are not able to manage their cash before making payment at the kiosk resulting in them not having enough change to make payment.

The fourth question is asked to know if the interviewee ever lost or damaged the parking ticket. Two out of five interviewees stated that they have experienced losing the ticket and the rest of the interviewees acknowledge the consequence of losing or damaging the ticket. The two interviewees stated that did lose the parking ticket once for each of them and it costed them RM50 for the penalty of losing the ticket. The procedure for when losing the ticket is lengthy as they will need to use the intercom function on the kiosk to contact the parking management. They are then asked to go to the parking management office to report the situation. The rest of the interviewees answered that if the parking ticket is lost or damaged, they will have to pay a penalty.

The last two questions were asked to get their opinion on a new parking system based on the proposed project and their ideas to improve the parking system. Most of the interviewees give positive feedback
on the proposed system. One of the interviewees disagrees with the proposed project with the reason stating that the current parking system is fine as it is. The feedback for the ideas to be implemented is to provide a method for parking users to check their current parking fees as well as a different payment method to avoid a long queue on the payment kiosk.

4. Proposed Solution

4.1. System Architecture
The system will have two different servers, one server is the boom gate server that will perform the license plate recognition from a live feed that is sent by the camera attached to it. The boom gate server then will send a signal to the boom gate to open and close the gate. The license plate that is recognized by the server will be sent and recorded into the database. The second server will act as a web server that hosts a web application for both the user and system administrator to access the system. Any data that is sent or written into the database from the user and administrator perspective will be gone through the webserver. The web server will be accessible from the internet.

From the user’s perspective, the web application will provide an interface for the user to access their parking time and fee, e-wallet balance, and adding their e-wallet funds. From the administrator’s perspective, on the other hand, the web application will provide an interface for them to manage their system and retrieve statistical info for management purposes.

4.2. System Development
The ticket-less parking system has two different parts that will work together to become one system. The web-based application was developed using Laravel 6.0 Framework. The license plate recognition application for this system was developed and built for Raspberry Pi 3B+ and above. A raspberry pi camera (Figure 8(a)) will be used as an input image for the license plate recognition and a 5V DC stepper motor with a ULN2003 driver board (Figure 8(b)) to control the stepper motor and simulate the movement of a boom gate for entry and exit of parking.

![Figure 7. System Architecture](image)

![Figure 8(a) and 8(b). License Plate Recognition Application](image)
The web-based application has the regular register and login function, search the vehicle to view the parking information, update information function for the users to manage their information and vehicle, view parking and payment history function, and lastly admin dashboard that allows admin to view parking logs, payment logs and search vehicles and users in the system as well as view the overview of the system.

The license plate recognition application will use a raspberry pi camera and a stepper motor with a driver. The camera will act as an input for the license plate recognition and the stepper motor is to simulate the boom gate for the entrance and exit of the parking.

### 4.2.1. Web Application Landing Page

Figure 9 shows the landing page of the web application that is accessible to users. The landing page will provide an interface for users to search for their vehicle license plate and links for the user to login and register on the top right of the website. For users who do not have an account and planning to create one, they will be able to click the Register button located at the top right and bottom of the page to redirect to the registration page.

![Figure 9. Web Application Home Page](image)

### 4.2.2. User Registration Page

Figure 10 shows the registration page for the user to register an account to manage their vehicle license plate and e-wallet balance. The registration page provides a form for the user to enter their info for their account and a signup button to send the form into the database.

![Figure 10. User Registration Page](image)
4.2.3. Parking Info Page. Figure 11 shows the parking info page. After searching for the user’s vehicle license plate on the landing page, the web application will redirect the user to the parking info page where it will show the specific vehicle's current parking info such as parking time and current fee based on the parking rate. For users who want to register or login into the system, both links for the actions are located at the bottom of the page to guide the user to pages that they wish to use.

![Figure 11. Profile Customization Page](image)

4.2.4. User Home Page. Figure 12 shows the user's home page. The page will be accessible to users after they log into the system. The page will provide information about their vehicle and show the balance that their vehicles have. This page will also provide a button for users who want to add balance to their e-wallet, remove a vehicle, and a button to add a vehicle to their account. To successfully add a vehicle license plate, the license plate must not be linked to other accounts in the system. The top right of the page will the user’s name and a drop-down button for users to use to log out of the system. Every user will be able to view their parking history by choosing the “Parking History” function as shown in Figure 13.

![Figure 12. User Home Page](image)
4.2.5. Admin Dashboard Page. Figure 14 shows the admin dashboard. The dashboard page will be used by the management to configure their parking system and provide them the interface to show the statistical info of their parking system. To make it simple for the admin to get information on the system easily, a parking overview was created. This page consists of 3 cards that show the total of today’s fee, a total of this month’s fee, and parking visitor for today as well as a two-line chart that shows the total parking visitor and total fee by month. This page will only be accessible through a special admin account.

4.2.6. Boom Gate User Interface. Figure 15 and Figure 16 shows the interface screen on the boom gate for entry and exit. The interface will display the user’s vehicle license plate, entry time, gate name, and the message for what it is currently doing.
5. Conclusion
In the 21st century where technology is rapidly changing, the internet of things and virtualization of physical stuff should be a norm today. Implementation of those should differentiate today’s technology against yesterdays. With the realization of the current system, it is a solid upgrade and is on par with the current technology standard compared to the old outdated system. On top of that, the proposed system should also be able to provide features that are not implemented wildly in a car parking sector that can ease users by having all the information the users need in the cloud for easy access. This will also avoid the problems that are unsolvable due to the technological limitation of the current system.

In conclusion, the project is meant to help to reduce and solve the problems present in the current system with the help of today’s technology while also providing new features that will benefit the users.

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