

Creating Smart Parking System to Support Smart City Concept

MUSLIMAH. SEKAR LARASATI¹, IBNAZHIFI. NEVINDRA², BLESSINDA. KIMBERLEY³,
DARMAYANTIE. ASTIE⁴, WATI. SUTRESNA⁵

¹*School of Electrical Engineering and Informatics, Bandung Institute of Technology, Bandung-Indonesia*

²*Faculty of Computer Science and Information System, Gunadarma University, Jakarta-Indonesia*

³*Faculty of Technology Information and Science, Parahyangan Catholic University, Bandung-Indonesia*

⁴*Magister Program of Information System Management, Gunadarma University, Jakarta-Indonesia*

⁵*Department of Computer Science, Gunadarma University, Jakarta-Indonesia*

Abstract- *This paper discusses the automatic parking system and the collection of parking rates. The purpose of this paper is to be able to overcome the problem of increasing vehicle size and limited parking spaces in urban cities. By using the Internet of Things (IoT), we make a system to read vehicle license plates and detect empty parking slots. We then send any information on the mobile application as a liaison between users (people who will park) with the parking system. Our whole system will help people to park their vehicle and pay the parking fare in no time. This paper provides algorithms as paths, methods and solutions to parking systems with effective and efficient solutions using computer vision.*

Indexed Terms- *Smart Parking System, License Plate Recognition, Mobile Application*

I. INTRODUCTION

Increasing vehicle size and limited parking spaces in urban cities are major contributors to parking problems. This problem is exacerbated by the low intensity of mobility in parking conditions. It's really visible from the start of the parking lot. Usually, when entering the parking area there is always a queue point needed to enter the parking area. Therefore, each driver needs to allocate a few minutes to get a parking ticket.

The time required will be even longer if ticketing is done traditionally through a manual recording by ticketing officers. After passing through the entrance gate, we have to find a parking space. This is a routine

(and often frustrating) activity for many people. So much time will be spent looking for a parking slot.

This is because, when drivers are looking for a parking space, they tend to slow down while looking around to find an empty parking slot. Engine deceleration will have no effect if there is only one car. But according to the initial problem that has been described, with the increase in the size of the vehicle, it is rare for a situation where there is no vehicle queuing behind the car in search of a parking slot who also wants to find an empty parking space. Therefore, a domino effect occurs, with one car slowing down, the car behind it will adjust its speed to the car in front and cause traffic congestion, even in the parking area.

Along with technological developments, innovations emerged to increase the effectiveness of the parking system. To tackle this problem, one of the solutions can be done with deep learning. The effectiveness of the parking system can be improved. Starting from the beginning of the parking entrance, recording and retrieval of tickets can be eliminated by using the help of a system to automate the recognition, detection, and registration of car license plates through the camera. After entering the parking area, the driver can get information about the number of vacant parking lots and the location of the vacant land. With the use of machine learning, through automatic data collection every parking slot is filled or with the help of sensors and edge computing can detect the availability of parking spaces. Then to be able to get out of the parking lot, the driver needs to make a payment. There are so many ways of payment that can be made to increase the effectiveness of the parking system, but

here are two ways provided that can be done using vehicle plate detection that can be done to automate the payments every time a car plate is detected at the exit or can also do a subscription program for the area the parking lot then the system will automatically record the cars that come out and reduce the opportunity to park with a subscription. Reducing time with the help of technology can greatly simplify, increase the efficiency of the parking system and especially avoid congestion in the parking lot.

The pilot basis for this project was Amazon-Go. With enormous and impressive technology, Amazon-Go made a huge impact on the retail operations, the community even with the whole industry. With their program, they track the motion of the purchaser, list down the items taken by the buyer, and take out the items returned to the shopping list. This project heavily relies on technology with the help of deep learning. Upon reviewing this project, we conclude that technology will be adopted in different sectors and would take the industry to another new level from this perspective. This all will work from the advantage that can degrade the labor cost and insufficient time from our daily basis in the traditional way. So that in the future, we can adapt the way the Amazon-Go environment works in the vehicle industry by combining two different concepts such as checkout-free and drive-thru. A highly efficient parking system can lead people to do their grocery shopping and another errand only by entering the parking lot, picking up the groceries, and then leaving without realizing that you have already paid for the groceries. In the process of exiting the drive-thru shopping area, your license plate will be detected automatically and your payment account will be automatically deducted as well. This is an example of implementing the Amazon-Go system as a free checkout plan with a drive-thru plan using a license plate detector. In the next section, we will discuss some of the deep learning implementations that have been researched and even developed by several people to help improve parking systems as described above.

II. RELATED WORKS

In this section, we will discuss some related works that have been done previously by other researchers. Existing work can help to develop and improve the

parking system in this paper. Sieck et al. [1] utilize the implementation of a smart parking system in a midsize university parking lot with the help of IoT focus on the parking slot. Their goal is to solve the problem of insufficient parking slots. The mobile application has a map to search for a parking slot. By this works, their system can minimize time, money and even have a major impact on the environment in terms of reducing the use of gasoline when searching for parking slots.

Another approach was coming from Ajcharyavanich et al. [2], that presented a smart parking system on a smaller scale for a parking slot reservation. The system can monitor and control all over the parking slot. They first implemented this system on the university campus. In replacement of the traditional parking paper with the electronic QR code for the payment.

With the same vision to make a smart parking system, Rashid et al. [3], suggest using number plate recognition for the payment to implement an automatic parking system that will increase the efficiency and security of public parking spaces. They use a magnetic card or even a QR code to collect parking payments without causing any inconvenience. The automated parking system will be able to eliminate the need for human interaction by relying just on the license plate.

Prem et al. [4], proposed a parking system with the blends of hardware and software capabilities into a single automated system. The works employed digital image processing software to find the license plate utilized to determine whether the car is allowed to enter the parking lot. The system sends and receives signals for processing using a variety of sensors.

Our team plans to design and prototype an IoT-based smart parking system for parking space reservations on a university campus based on the examples above. The integration of IoT devices and a cloud-based server in front of the entrance parking to detect license plates and to monitor and manage the complete parking system at a university campus. We also have an actual count for the parking slot after the entrance of a vehicle. Although, on the midsize parking lot, we also can implement IoT on parking slots. The standard parking paper/sticker can be replaced with a cashless payment utilizing a sensor on the exit gate after

detecting the license plate. In addition, the smart parking system that has been prototyped is in accordance with the smart campus plan and the cashless society that is being implemented on a regular basis with the aim of a smart city.

III. SMART PARKING SYSTEM

In this section, we will discuss about our system architecture, license plate recognition-based system, and mobile application.

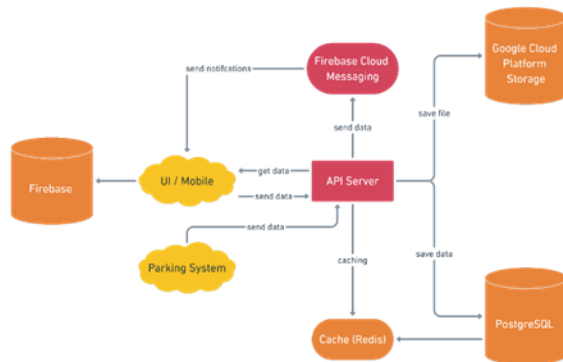


Figure 1. High Level Architecture for Smart Parking System

A. System Architecture

The system to be implemented is in accordance with Figure 1. There will be two running services, namely a mobile application system that will be used by users to perform all transactions. In this mobile system, users will be able to do several things, such as:

1. Create user account
2. Register user vehicle
3. Book parking slot
4. Parking fare payment

While the service parking system will focus on parking services to provide information to users. Parking System will use the IoT system to send real-time information to the API server. Some of the features that exist in this parking system such as:

1. License plate number recognition (LPR)
2. Empty parking slot detection

The API will be built using NodeJS version 16.13.1 which will be stored and deployed on Google Cloud

Platform (GCP) using the Compute Engine platform. This API will later be shared for mobile needs and Parking System needs.

For data storage, PostgreSQL will be used as a database while Google Cloud Platform Storage will be a place to store files in the form of images or documents. For API endpoint security, JWT is used to check whether the person accessing the endpoint is someone who has data (already registered) so that it is guaranteed. The system will also use Redis as a temporary database to speed up transactions.

B. License Plate Recognition System

Figure 2 shows the process flow for an LPR system that is integrated with IoT devices and android applications. This LPR-based Parking System has several capabilities that can assist users to easily park their vehicle. When a vehicle approaches the parking gate, the ultrasonic sensor will send a signal to the microcontroller (Raspberry Pi) to activate CCTV and capture the front side image of the vehicle. Then, the image sent to the API server and the API will read the digits of the license plate number using a computer vision model. The computer vision model that has been trained beforehand deployed in the form of a REST API on the API Server. After reading the license plate, the API Server records the parking transactions for users related to the license plate. The transaction record will be inserted or updated to the database (PostgreSQL) and sent as notification messages to the user's android device. The same thing also happens when the user's vehicle approaches the exit parking gate. When the user is at the exit parking gate, the notification will contain a transaction summary and a request to pay the parking fare.

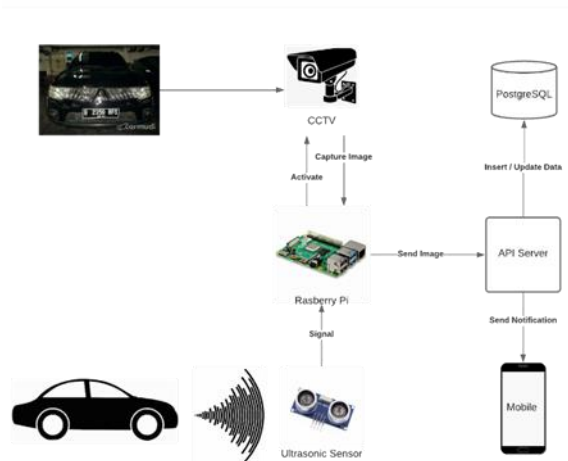


Figure 2. License Plate Recognition System

This LPR-based system helps record user transactions which were originally done manually by parking guards in conventional parking systems. It can help to prevent mistakes in recording parking transactions. Transaction records are directly integrated with the related user account in the android application based on the results of the license plate recognition. This will certainly make it easier for users to directly pay the parking fare based on an integrated transaction record. With automatic transaction recording assisted by the LPR system and integrated with user accounts, it will save users time to park and pay for parking fare.

C. Mobile Application

Based on Figure 3, this mobile application will be a liaison between the user (people who will park) and the parking system. Users are required to create an account first before using the application further, this is done so that the system can track anyone who enters and leaves the parking lot that has the parking system. After registering, the user can register the vehicle they have, the data needed is as follows:

1. Vehicle type (car, truck, motorcycle)
2. License plate number
3. Vehicle name (as a marker)
4. Vehicle brand

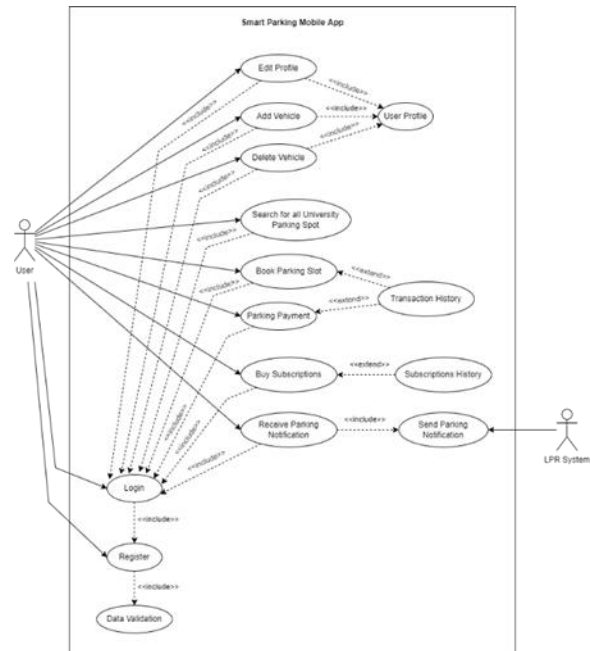


Figure 3. Mobile Application Use Case

After registering the vehicle, the user can book the desired slot and parking spot. The Smart Parking System based on the LPR will work as a marker for every user entering and leaving. As well as being a tool for making payments. The LPR system will read the number plate and send the resulting string to the backend system to see if there is a registered number plate. If so, from there the system will see whether there is a registered parking record or not. If it is there, the system will read that the user will leave, but if not, the system will mark that the user will enter the parking lot.

IV. RESULT

In this work, we have succeeded in developing a smart parking system consisting of an android application and an LPR-based system. The developed application has features such as user account creation, user vehicle management, booking parking slots and parking payments. The LPR-based system was developed to facilitate the recording of parking transactions based on the recognition of the user's license plate which is integrated with the user account in the android application. Figures X and Y show the results of the android application and the process flow of the LPR-based system.

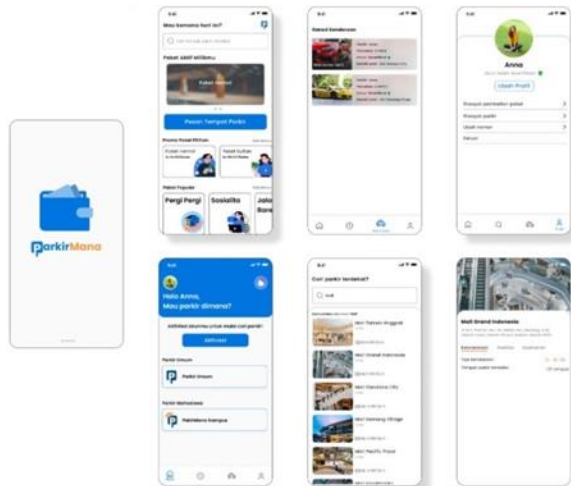


Figure 4. Mobile Application

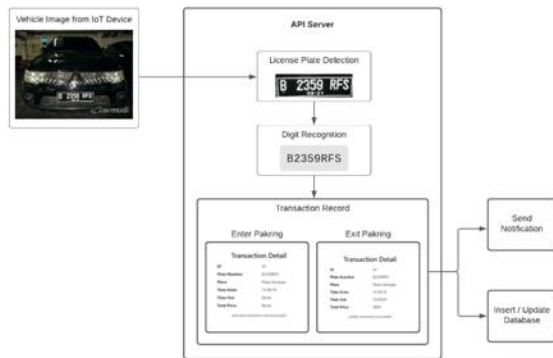


Figure 5. License Plate Recognition

Our smart parking system only takes less than 4 seconds to recognize the license plate and record transactions, 1 minute for the user to go to the parking slot location, and less than 10 seconds to confirm and pay the parking fee. This time is a very short time when compared to conventional parking systems. Most conventional parking systems take about 20 seconds at the entrance gate to collect a parking ticket, 1 minute for the user to go to the parking slot location, and 5 minutes to check the ticket and pay the parking fare.

In addition, we also perform a comparative analysis of the system we developed with the existing system, especially in Indonesia. The following is a comparative analysis between our application and similar applications that have been copyrighted by the Directorate General of Intellectual Property. After conducting a market analysis, the developer benchmarks products and technology against four similar competitors in the market, namely Paparkir, Android-based Smart Parking Application, Smart Parking System FPMIPA UPI, Smart Parking System Simulation Model with Rockwell arena. The benchmarking results are attached in Table 1.

Table 1. Smart Parking System Comparison

Product	Intellectual Property Right Owner	Release Date	Features
Paparkir	Frisco Kharisma Edy Prayoga dkk.	2018-09-01	Used a web-based system. Provided the information of available parking slots. Equipped with a database integrated to IoT devices.
Smart Parking Android-based Application	Telkom University	2017-12-22	Used an android-based system. Provided the information of available parking slots.
System Smart Parking - FPMIPA UPI	Eki Nugraha, M.Kom. dkk.	2020-11-09	Used an android-based system. Provided the information of available parking slots. Map to navigate users to the related parking spot.

Smart Parking System Simulation Model with arena Rockwell	Majapahit Islamic University	2019-09-02	Parking system design through simulation model using Arena software. Used RFID and e-money as a parking transaction system.
Our Smart Parking System	ParkirMana	-	Integrated parking system using Android and cloud computing. Balance top up system using e-wallet service. License plate recognition using object detection and computer vision models. User parking location reminder. Promotion / advertisement service.

Unlike the smart parking systems listed above, our smart parking system provides an effective and efficient parking management system using computer vision technology which is object detection. Not limited to that, our system also provides an environmentally friendly parking ecosystem by not using paper for every transaction. Some of the uniqueness of the product will be explained in table 2. Based on the description above, compared to other systems, the parking system that we have developed has advantages such as:

1. More environmentally friendly because it is paperless.
2. More cost-effective in terms of monthly expenses because parking lot owners can reduce expenses for hiring human labor.
3. Reducing the time needed to check and pay for parking services (efficiency improvement).
4. There is a feature that can help users to track the location of their parked vehicles.
5. Improve the accuracy of recording user parking transactions.

CONCLUSION

Our smart parking system consists of an android application that is integrated with the LPR system. The android application has features for creating user accounts, user vehicle management, booking parking slots and parking payments. The LPR system aims to help record automatic transactions based on the results of number plate recognition that is integrated with the account on the user's android application.

Based on the analysis carried out, there are still shortcomings in our system. There is a possibility that the result of the vehicle number plate recognition is not accurate. This can cause the recording of parking transactions to be invalid. For further development, it is necessary to optimize the LPR system so that there are no vehicle number plate recognition errors. In addition, additional features can be added to improve user user experience, such as navigation features to reserved parking slots and so on.

ACKNOWLEDGMENT

This work was carried under the financial assistance of Bangkit 2021 program funded by Google and Kedaireka (Indonesian Directorate General of Higher Education, Ministry of Education, Culture, Research, and Technology). Also, this work was carried out under the supervision and incubation program of Gunadarma University.

REFERENCES

- [1] N. Sieck, C. Calpin and M. Almalag, "Machine Vision Smart Parking Using Internet of Things (IoTs) In A Smart University," 2020 IEEE International Conference on Pervasive Computing and Communications Workshops (PerCom Workshops), 2020, pp. 1-6, doi: 10.1109/PerComWorkshops48775.2020.9156121.
- [2] C. Ajcharyavanich et al., "Park King: An IoT-based Smart Parking System," 2019 IEEE International Smart Cities Conference (ISC2),

2019, pp. 729-734, doi:
10.1109/ISC246665.2019.9071721.

- [3] Rashid, M.M., Musa, A., Rahman, M.A., Farahana, N., & Farhana, A. (2012). Automatic Parking Management System and Parking Fee Collection Based on Number Plate Recognition. *International Journal of Machine Learning and Computing*, 93-98.
- [4] Prem, Er & Roy, Chandra & Thapa, Arjun & Shrestha, Kumar & Karmacharya, Prasanna & Karna, Rajan. (2018). Vehicle Number Plate Recognition and Parking System.