VIETNAM NATIONAL UNIVERSITY - HO CHI MINH CITY

INTERNATIONAL UNIVERSITY

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INTERNET OF THINGS

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iSP - IOT-BASED PARKING SOLUTION FOR COMPANY

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IOT-BASED PARKING SOLUTION FOR COMPANY

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Github Link:

GitHub - namanh2310/IoT_Project

ABSTRACT

Parking has been one of the twenty-first century's most pressing concerns; as the population grows, so does the number of automobiles, resulting in a surge in demand for a more secure and effective parking solution to replace previous methods, which was still implementing the use of human resource as the focal point of the project[1]. This study offers an Internet of Things-based License Plate Monitor and Surveillance System that detects and recognizes license plates and human faces as well as minimizes the use of human resources in the system by automation. With an Arduino UNO R3 and a variety of low-cost actuators and sensors, our IoT system can replace the guard's typical duties in the parking lot, such as recording the license plate and their individual faces, discriminating and controlling the barrier, and guiding the vehicle to a vacant spot. To accentuate the low-cost stability of the system in the duty of surveillance, numerous Machine Learning(ML) and Computer Vision algorithms, such as the OpenCV library have been introduced for the use of License plate detection and recognition. The results show that our system can recognize and detect a wide range of license plates with excellent accuracy. Finally, a web interface and a mobile client application have been developed, with the former utilized to monitor license plates and faces.

1.PROJECT OVERVIEW

1.1. Introduction

The Internet of Things (IoT) is a network of physical and virtual devices connected via the Internet that has developed considerably in recent years as a result of advances in hardware, software, and networking technologies. Sensors can accurately describe their surroundings, relay data, and communicate with one another with proper deployment. Furthermore, AIoT system helps make responding and interacting with the environment possible. Home monitoring and security systems, indoor and outdoor air quality monitoring and management, energy grid management, healthcare systems, and weather monitoring are some examples with which IoT can provide improvements[2].

Among the many practical obstacles in IoT systems, one new issue that has recently emerged is the growing need for efficient and safe parking lots, which has an indirect impact on traffic, housing, and pollution. Moreover, the rapid urbanization of Ho Chi Minh City has resulted in a huge increase in the number of automobiles. Many parking solutions have been developed, but many more continue to fall short of expectations, as most parking lots continue to suffer from burglary and congestion.

1.2. Problem Statement

Although the car industry has rapidly progressed, the improvement of parking amenities has not kept pace with it. Ensuring efficient management of parking areas requires a considerable number of staff members.

Currently, a vast array of parking amenities are actively incorporating cutting-edge technological advancements to optimize parking administration. It is important to note that there are some aspects of the parking management process that have not been automated yet. Due to the absence of automated transaction systems, human operators are required to issue tickets. Continuously, the human workforce is heavily relied upon for implementing security measures. The lack of a system for identifying available parking spots using automation could present a major hurdle that might make the parking system ineffective.

Given the current obstacles, it has been determined that the integration of artificial intelligence and web services into a modern parking system would aptly tackle these hindrances. The objective is to achieve complete mechanization of the system through the integration of artificial intelligence (AI) techniques, thereby improving its overall efficiency and security. The mentioned goals are expected to be attained at the end of the undertaking.

1.3. Scope and Objectives

The scope for implementing AIoT into a parking solution is the prototype and can be first used for testing in parking schools with specific continuous time to evaluate the work efficiency of the system then if the conditions allow, we can upgrade and develop more functions in the system and towards applying the system to various parking slots around Ho Chi Minh City. AIoT can be utilized to optimize parking management systems by using data collected from various sources such as parking sensors and cameras. This data can be analyzed and processed by deep learning algorithms to provide real-time insights and predictions. AIoT can also help in reducing traffic congestion by guiding drivers to available parking spots and reducing the time spent searching for parking.

The main objectives of our research are:

- Design and develop system that can automatically manage parking
- Analyze the vehicle's license plates and the driver's face recognition with good accuracy
- Design and build website to present the real time images of plates
- Design and build mobile app to present the availability of parking slots, price of parking and also the sign in/out account functions

- Implementing Deep Learning by using library OpenCV with pre-trained deep learning model and perform task such as image classification for example in this research to analyze correctly plates when vehicle come in/out

1.4. Structure of the report

As we conclude the first part of the report, we have already gone through the background, problems and proposal of the project. The remaining part of this work is organized as follows. Section 2 provides an overview of essential and related research in the problem of parking solutions. Section 3 discusses the methodology and the basic design of the system. Section 4 outlines the results of the implementations made in the project. Section 5 gives evaluations and discussion on the system thus drawing comparison between our system and the existing parking solutions. Section 6 makes conclusions and discusses possible future approaches.

2. LITERATURE REVIEW/RELATED WORK

2.1. Researches on the IoT-based parking system

Various research papers about an automatic parking system have been published. Pham Thanh Nam provided an IoT smart parking system (Study 1)[8], a web portal, and a mobile application to allow users to interact, and check for the available parking lots in the nearby area. The system uses the RFID and QR technologies as its main focal point for lowering the deployment cost. Likewise, the IOT based Smart Parking Management System (Study 2) of J. Cynthia[9] also utilizes the RFID technologies for the task of validation. However, its mobile application provides much more functions for the user such as an account system, a booking and history interface. Besides, Hasan Mahmud contributed an automatic parking system (Study 3)[10] - this paper gave us a much more streamlined web page interface with dashboards to visualize the flow of vehicles in the system, as well as provide a method of monitoring and validation. Moreover, this system also implements the use of ultrasonic sensors as a switch to further the automation process in the IoT system.

The existing research on IoT based parking solutions have provided valuable design for implementing efficient and low cost systems. These designs are based on 3 main components: the IoT parking lot, the Web server and database, and the client side mobile application. The system uses the RFID and QR technologies as its main focal point for lowering the deployment cost. Some studies also implement the use of ultrasonic sensors as a switch to further the automation process in the IoT system. They all utilized the Arduino and numerous sensors, modules to further decrease the overall deployment cost of the system, established the communication between the arduino and the database through an external wifi module which is compatible with the arduino. Database is a cloud server which can receive the post request directly from the arduino.

The web server and database serve the purpose of visualizing and help the task of monitoring become easier through the use of a dashboard interface. They provided a user-friendly dashboard to track the flow of vehicles, manage reservations and validation tasks. Its mobile application provides much more functions for the user such as an account system, a booking and history interface.

However, these works lack implementation of AI into parking systems. So the integration of AI technologies like machine learning can enhance the overall performance and efficiency of IoT-based parking solutions.

2.2. Researches on the AI implemented in this project

Automatic license plate detection python[11] .This provides object detection using Yolov3 from OpenCV, captures the car license plate and two boxes will display the car and the license plate separately.

This tutorial on github provides us with a basic knowledge and introduction of the EasyOCR and OpenCV library in python, in which the author goes through the specifics of object detection and how to translate it into license plate detection and recognition.

OCR for Text Detection and License Plate Recognition with EasyOCR in Python and OpenCV [12] like the tutorial above the video heavily emphasis on the use of EasyOCR and OpenCV to detect the license plate. Furthermore, it is also worth mentioning that while the first tutorial fails to read in the license plate if there are too many of them or there are 2 lines of characters on the license plate, the second tutorial helps solve this problem.

Face recognition algorithm[13] To further enhance the security aspect of our project, we also refer to this Face recognition algorithm documentation. In this github link, the authors have given a clear guide on the overall basics of this AI and how we can use it as well as given many results on the accuracy of the model based on the example they have provided.

Overall, our project focuses solely on the AI implementation, which is described in the aforementioned tutorial. Furthermore, because these tutorials all utilize the same language (Python), we can easily refer to them and incorporate them into our system. However, because we want to develop a parking system that satisfies automation criteria, we are working to improve the License Plate detection and identification procedure as effectively as possible.

3. METHODOLOGY

3.1. Overview

Our proposed parking system model involves connecting various local parking lots to create a network that offers parking information. The information gathered from these lots is sent to a cloud server (Google Cloud Firebase and Cloudinary) to ensure that users who have an internet connection can access it. By creating a network of parking lots, drivers will have a better understanding of their parking options, enabling them to make informed decisions instead of relying on information from a single lot. Moreover, our proposed network model of the system can be developed in the near future if we can officially apply to various parking slots in HCM.

The main components of our project are include: Local IoT parkings, Database server(Firebase Google Cloud Server and Cloudinary), Application Software that can run on user's smart devices(smartphone) and we also design a website for administrator with the function to manage the quantity of vehicles/drivers, parking slots available and announce the valid data that match the vehicle's plate and driver's face after scanning.

Use case diagrams are often applied in the business model for determining the interactions between user and system. The figure 1, which is shown below displaying the relationship of customer and the parking administrator with many specific functions

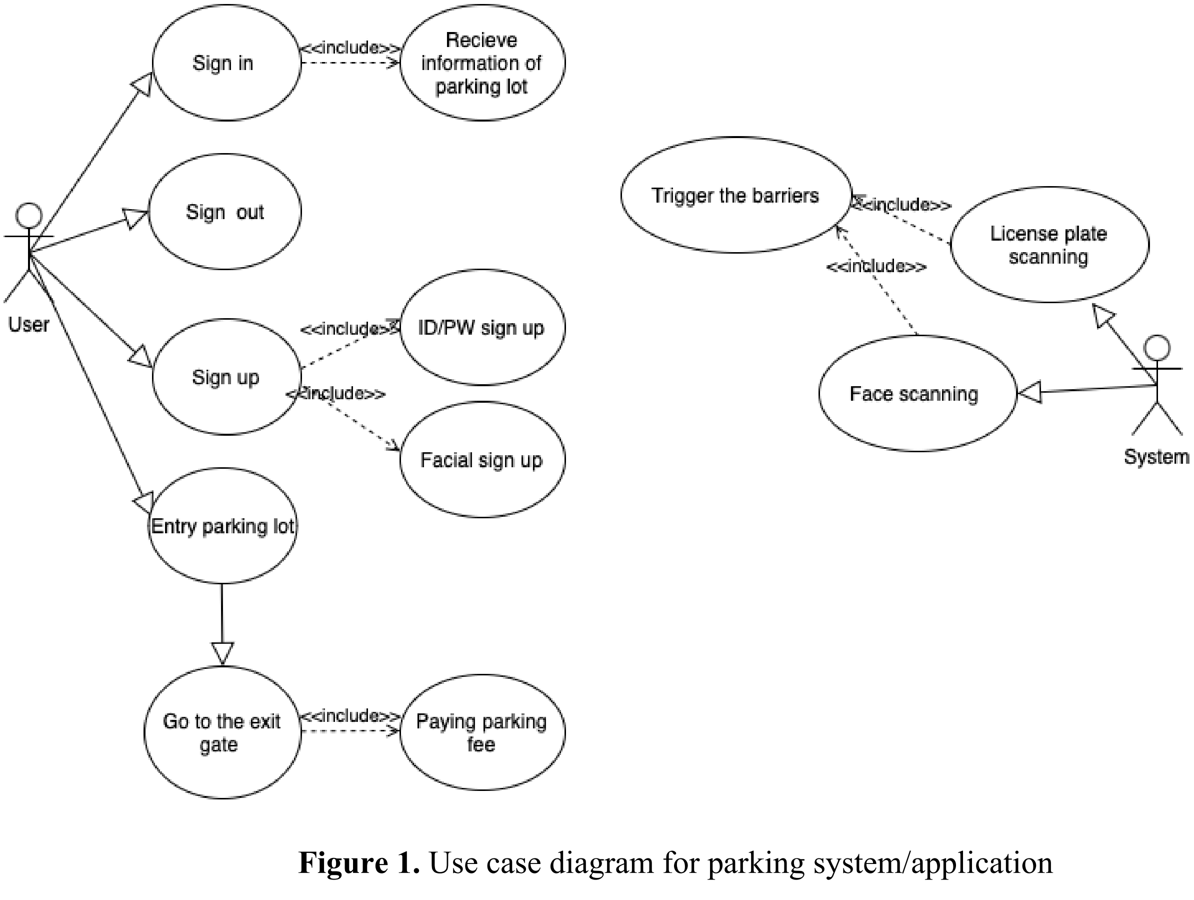


Figure 1. Use case diagram for parking system/application

3.2. Use Case Descriptions

3.2.1. User

a) Use case 1

Name: Sign in

System Identifier: Sign in function

Inputs: User information

Outputs:

The user personal dashboard

If failed, “ try again ” appear to notify the user

Basic course:

Actor: Visitor	**System**
1. Open the login page	1. Display the login page
2. Enter username and password	
3. Submit	3.1. Success login 3.2. If fail, “incorrect username or password” appear 3.3 Return to login page

Table 1. Description of use case 1 (user)

Preconditions: User already sign up account

Post-conditions: User dashboard appear

b) Use case 2

Name: Sign out

System Identifier: Sign out function

Inputs: None

Outputs: System log out the user

Basic course:

Actor: Visitor	**System**
1. Submit the log out button	1. System logging out the user
	2. Login page reappear

Table 2. Description of use case 2 (user)

Preconditions: User already sign in

Post-conditions: User is sign out

b) Use case 3

Name: Sign up

System Identifier: Sign up function

Inputs: Personal information

Outputs: Sign up successful

Basic course:

Actor: Visitor	**System**
1. Open the sign up page	1. Display the sign up board
2. User enter personal information (facial, username/password, license plate)	
3. Submit	3. System will register a new account for users to the database for future work.

Table 3. Description of use case 3 (user)

Preconditions: Users have not registered any account yet

Post-conditions: Successfully creating account

b) Use case 4

Name: Entry the parking lot

System Identifier: Arduino system

Inputs: License plate and user face

Outputs:

If true: The barrier is lift up

If false: The barrier stays still

Basic course:

Actor: Visitor	**System**
1.Enter the parking checking system	1.1. The ultrasonic sensor will change if car approaches 1.2. When the ultrasonic sensor is triggered, the license plate and face recognition algorithm are applied.
2. The car stabilized itself for the next step	2.1. The function triggers the 2 cameras that have been set up inside the booth. 2.2. When the function finishes scanning the barrier is triggered ON. 2.2. When the function finishes scanning the barrier is not triggered ON if the user information is false .

Table 4. Description of use case 4 (user)

Preconditions: The User’s account existed

Post-conditions: The user can access the parking lot

The user can’t access the parking lot

b) Use case 5

Name: Exiting the parking lot

System Identifier: Arduino system

Inputs: License plate and user face

Outputs:

If true: The barrier is lift up

If false: The barrier stays still

Basic course:

Actor: Visitor	**System**
1. Enter the parking checking system	1.1. The ultrasonic sensor will change if car approaches 1.2. When the ultrasonic sensor is triggered, the license plate and face recognition algorithms are applied.

2. The car stabilized itself for the next step	2.1. The function triggers the 2 cameras that have been set up inside the booth. 2.2. When the function finishes scanning the barrier is triggered ON. 2.2. When the function finishes scanning the barrier is not triggered ON if the user information is false .
	3.1. The barrier will open if the driver pays enough fee. 3.2. The barrier is still closed due to insufficient fees.

Table 5. Description of use case 5 (user)

Preconditions: The User already has car in the parking lot

Post-conditions: The user can leave parking place

The user can't leave the parking place

3.2.2. System

a) Use case 1

Name: Face scanning

System Identifier: Face algorithm for face recognition

Inputs: User's face

Outputs: System announce face is correct

Basic course:

Actor: User	System
1. User showing their face to the system	1. Scanning user's face
	2.1 Access to database 2.2 Check if user's face is correct
	3.1 If user's face is correct, continue checking for license plate 3.2 If user's face is incorrect, give warning

Table 6. Description of use case 1 (system)

Preconditions: User's face is existed

Post-conditions: Continue to check for license plate

b) Use case 2

Name: License scanning

System Identifier: AI algorithm for license plate

Inputs: License plate

Outputs: System notice the user that license is correct and captured

System notice the user that license is incorrect

Basic course:

Actor: User	System
	1. Scanning for license plate
	2.1 Access to database 2.2 Check if user's license plate is correct
	3.1 If user's license plate is correct, the barrier is open 3.2 If user's license plate is incorrect, the barrier stay still

Table 7. Description of use case 2 (system)

Preconditions: User's license is existed and face detection is correct

Post-conditions: 1.User can leave of parking place

2. User can't leave of parking place

3.3. System Design

a. Database design

Our term project uses the Firebase[3]platform provided by Google Cloud and Cloudinary as a database with the function to store data of the user's including driver's face data and the images of vehicle's plates. Real-time syncing, automatic scaling and simple connection with other Google services are all features of the cloud-based database Firebase. Firebase is a cloud-hosted NoSQL database that uses a data structure called JSON tree (can be also known as Realtime Database), where data is organized into JSON tree[4].The nodes of JSON tree can contain "key value pairs" that is similar to tables and rows relational databases. Cloudinary is incorporated for media storage because it is necessary to store media files, such as pictures of faces and license plates, for the recognition. Images may now be handled, processed, and served, including being resized and altered to better fit the recognition algorithm, thanks to the integration of Cloudinary.

b. Website design

Generating a dashboard for administrators to manage the users activities is a requirement. The dashboard has to meet the core features, such as displaying the users database as well as the status of the parking lot, showing the screen recorded by the external camera. For actualization, a client-server architecture is in use. On the client side, to render the user interface and functionalize the dashboard for the interaction between administrators and the system, ReactJS is a good option for front-end development. This is a JavaScript library based on the JavaScript programming language. It works best to build user interfaces by combining sections of code into a full website. Besides, Axios is used for communicating with the back-end side. On the back-end side, focus on the Flask server, which is a collection of one or more computers that are packed together and solely dedicated to running software applications over the internet. It is server software that can handle HTTP requests on the public internet, private LANs, and private WANs.

c. Application design

The registration, login and logout functionalities will be included in the Flutter-developed application. Flutter is a framework that supplies a base for mobile development platforms. It can satisfy the native performance and fast development features. Flutter provides the HTTP protocols for the communication with the backend side. In addition, the back-end server is the same with the website platform when using Flask-server for handling the users' gestures, such as authentication or displaying the parking lot information. Users can sign in to the account by entering their email, password, vehicle's license plate number and the avatar of the user on the registration display. After enrolling all the information needed, the data will be saved and direct the user to the login page where they have to re-enter their email and password to get into their account.

On the homepage, the rate charged for parking per hour, as well as the allocation of parking slots to the user, are both presented. Furthermore, the system is designed to showcase the personal profile particulars of the user, comprising name, electronic mail, contact number, dwelling city, vehicle registration identifier, and avatar. The ability to log out of an account is readily available to users by means of selecting the designated logout button depicted on the screen interface.

The user profile screen will exhibit the personal information of the user that comprises their cognomen, electronic mail address, contact number, vehicle license plate number, city, and avatar.

d. Integrated AI models

AI models are integrated into this project, each with their own specific purposes.

First, the easyOCR[6] model is applied to recognize the vehicle's license plate. The easyOCR is always ready-to-use for detecting many kinds of text including Latin and numbers due to the convolutional neural networks (CNNs) to locate and extract the texts to many blocks for detection**[ref]**.

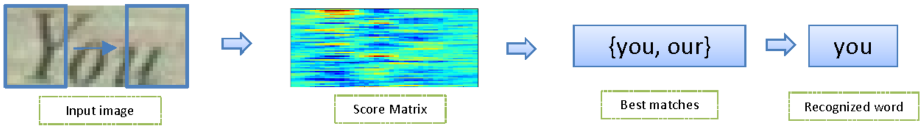


Figure 2. Example for text detection using CNNs algorithm

With the provided functionalities of the easyOCR model, it is available to design a system for catching the text on the user's license plate. Besides, for extensibility, this model has to be modified for many specific purposes, such as a feature about the classification of vehicle number plates based on province. Because the easyOCR model works best for plain text only, so license plate recognition will not be optimal in many situations. Therefore, it is necessary to change the input format by string processing techniques of Python such as regex[7].

In order for the model to recognize the image, several steps are required to process it.

- Python Imaging Library (PIL) is used to image class within it to display the image
- Base64 is used for encoding and decoding the URL/URI of images
- BytesIO is a class of Python that permits an object of IO, data will be stored and executed in the format of byte

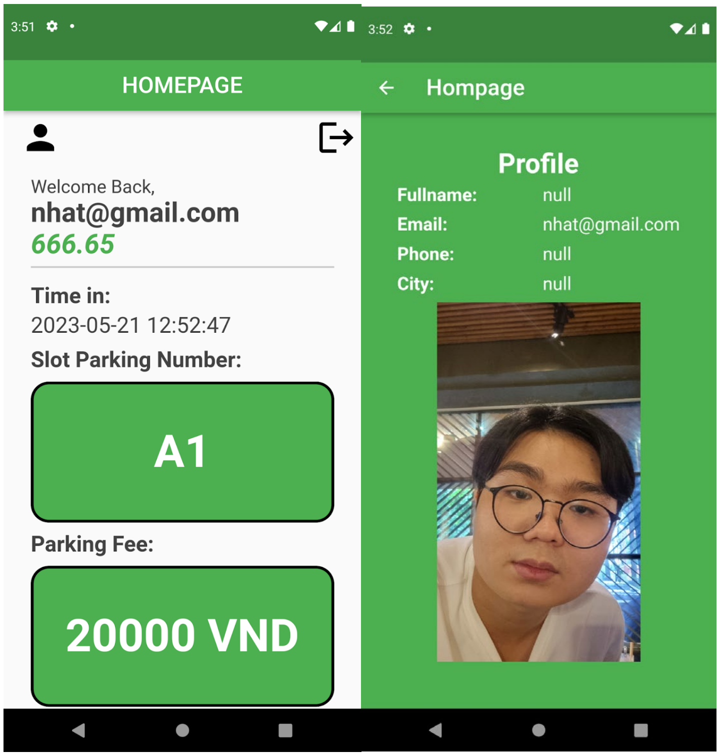
e. External Hardware

The main purpose of this project is to be able to interact with real people, so actualizing software combined with the external hardware is a requirement. For the microcontroller board, Arduino Uno is available in this system. Arduino Uno provides an easy-to-use platform for building interactive electronic projects and prototypes **[ref].** This board provides for a very large range of applications when it has a sufficient number of analog and digital pins for connection with sensors and actuators. Arduino Uno is completely affordable, which is a big plus for a student project. Besides, an ultrasonic sensor is applied to the hardware system for realizing the motivation of the user's vehicle to automatically capture the transportation's license plate via an external camera. In addition, the barriers work like actuators, which will achieve the physical movements for performing the real action, in this case, opening or closing the gates.

4. RESULT OF IMPLEMENTATIONS

a. Result of user mobile application

The figure above perform the user mobile application, which is for the interaction between the drivers with the IoT parking lot system



Welcome Back,
nhat@gmail.com
666.65

Time in:
2023-05-21 12:52:47

Slot Parking Number:
A1

Parking Fee:
20000 VND

Profile

Fullname:	null
Email:	nhat@gmail.com
Phone:	null
City:	null

Figure 3. User mobile application

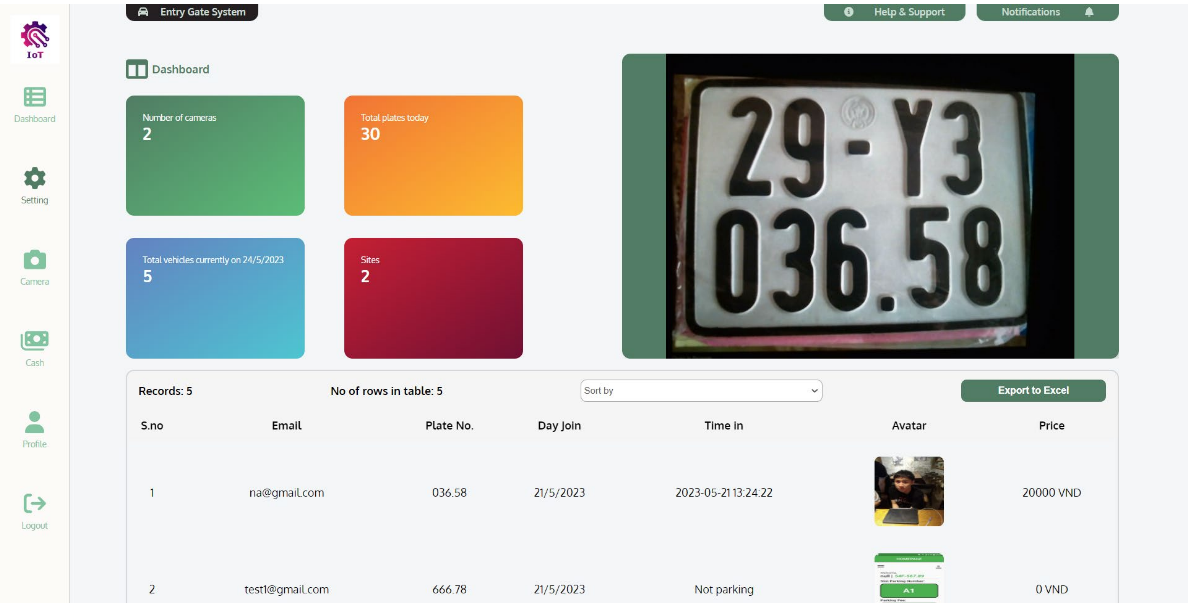
The dashboard shows the driver necessary in the parking Iot system, which include “Parking Slot Number”, “Parking Fee”, “ Time in”, User’s registration gmail and their license plate.

- The Parking Slot Number indicates where the driver should park their car based on what slot is free and what slot is not. The free slot will be signal for the driver which a light on
- Parking Fees show the driver the number of money they will pay which will be determined by the number of hours they park. In the demo we fix the parking fee number, but in future work we will try to make it work
- Time in function shows the time the driver gets in, this function gives the driver control of what time their car gets in. Which will get the user more security about their car at times when unfortunate things may happen.

- The user’s gmail and license plate show basic information the user had input.

b. Result of dashboard

The figure below perform the web interface, which is for the interaction between the admin with the IoT parking lot system



Number of cameras 2

Total plates today 30

Total vehicles currently on 24/5/2023 5

Sites 2

Records: 5

No of rows in table: 5

S.no	Email	Plate No.	Day Join	Time in	Avatar	Price
1	na@gmail.com	036.58	21/5/2023	2023-05-21 13:24:22		20000 VND
2	test1@gmail.com	666.78	21/5/2023	Not parking		0 VND

Figure 4. Web dashboard for admin

About the dashboard, a website is generated for supporting the administrators control and managing the parking lot system, which can show us the number of cameras, total license plate has been input in a day or week, and the user's basic information for admin to see.

c. Result of external hardware

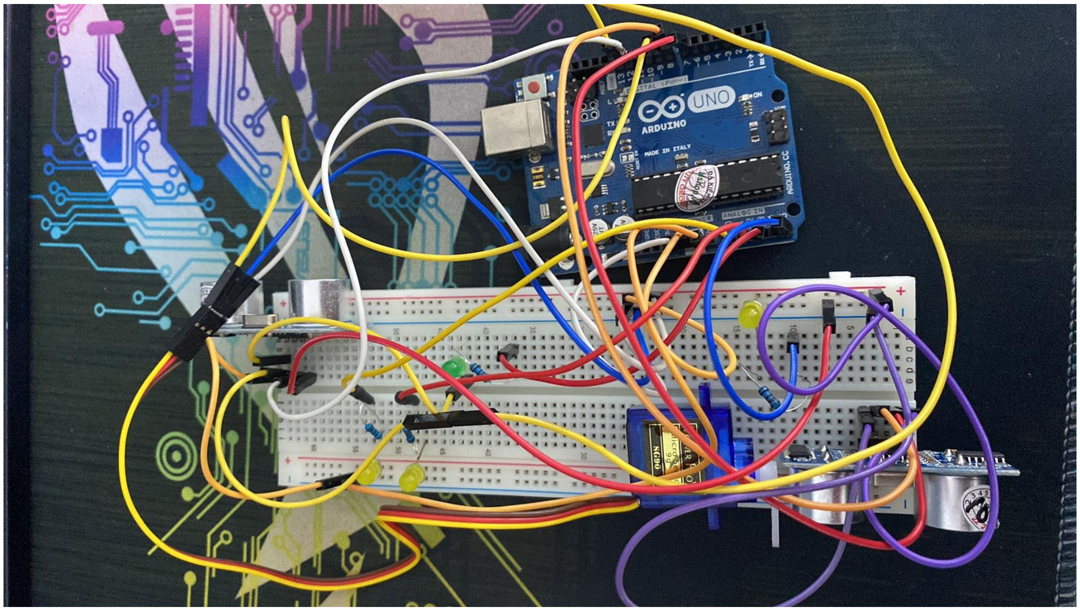


Figure 5. External hardware of Iot system

External hardware in our project is the prototype of the real Iot system which will actually be deployed. It includes 4 resistors of 330 Ohm, 4 LED, 1 Ultrasonic Sensor HC-SR04, Arduino Uno, Micro Servo. The LED is the parking signal for the driver, and when plate scan successfully. Ultrasonic Sensor HC-SR04 will measure the distance for the camera to trigger to take a picture, in the prototype we set it below 10 cm for demonstration. Arduino Uno acts like a control panel where code is stored and how users can interact with external hardware. Micro Servo is attach to stick for the purpose mimic the barrier being lift up when the scanned plate is correct

d. Result

Currently, the system can support the admin's work as well as connect with users when they have a need to use smart parking. After the tests, it can be concluded that the system is moving in the right direction according to the original plans. The application of artificial intelligence to the system has made a clear difference with the existing systems on the market. By recognizing license plates, combined with facial recognition, users can be more comfortable in entering and leaving the parking lot without having to worry about losing their cards like other systems.

5. DISCUSSION AND EVALUATION

5.1. Comparison

Although most parking solutions on the market have met the desire for a contemporary parking lot, they suffer from a variety of challenges such as security and wait time. These issues are mostly the result of non-automation processes and human variables, all of which are the primary targets of our system to tackle on.

While most systems attempt to leverage RFID technology and still require physical transactions/tickets, our idea proposes the usage of e-tickets and immediate transactions through smartphone applications. This would reduce the demand for human resources while also greatly reducing parking queueing time and at the same time improving the overall customer experience.

With the understanding that the fundamentals of the Parking Lot is security, our team invests heavily into it through the use of face recognition algorithms, where most competitors only stop at license plate recognition. We also implement a database to record the driver's faces to each respective license plate to prevent fraud.

Function	**iSP**	Study 1	Study 2	Study 3
Dashboard for admin	**x**		x	x
Good accuracy	**x**	x	x	x
Saving time	**x**			
Low cost		x	x	x
Outsource code	**x**			
Parking management methods		x		
UI / UX	**x**	x	x	x
Security	**x**			
Performance	**x**	x	x	x
Automatic	**x**	x	x	x

Table 8. Evaluating iSP with other studies

5.2. Evaluation

All in all, our project strives to introduce automation into the process of parking as well as reducing the use of human resources. Due to the scope of this study and the result of our findings and implementations, the interactions between humans and technologies has been limited. Therefore, we can further enhance performance by customizing the system design for future development.

Our system has advanced to a crucial level and has obtained a considerable edge over previous research on the same topic.While there are certain issues that need to be addressed, such as the lack of parking lot management options and the cost of adopting our system.The advantages heavily outweigh the disadvantages, as evidenced by a dashboard system for simpler monitoring, a user-friendly mobile application, and measures to improve the automated process. Furthermore, the introduction of AI into the system, where many studies would opt for RFID or QR technologies, as well as open source code for future community support, may all contribute greatly to the total benefits provided by our project.

6.CONCLUSION AND FUTURE WORK

6.1. Conclusion

The implementation of EasyOCR, ReactJS and Firebase in developing a web-based parking solution showcases a promising approach to address the challenges faced by traditional parking systems. By using the power of optical character recognition(OCR), with a friendly web development, this solution may offer a transformative way to manage parking space effectively. The use of easyOCR is to provide the efficiency and its accuracy of recognition, enabling the system to detect and read the license plates. This will ensure that every vehicle will be tracked correctly, and streamlined access control. Then, the web page was built with a user-friendly interface that facilitated easy navigation, real-time updates of vehicles (in-out), and very convenient reservation for parking slots.

Lastly, by utilizing Firebase as the database platform, the parking solution shows it benefits from reliable and scalable cloud storage. The integration of Firebase and Flask server allows for efficient data management and retrieval, enabling real-time monitoring of parking occupancy, and transaction records.

By this integration, we can optimize parking operations, enhance user experiences and contribute to sustainability efforts. AIoT is a promising technology that can greatly benefit both individuals and communities.

6.2. Future work

However, future work can focus on several areas of improvement. Enhancement can be made in the accuracy and speed of the OCR technology, further optimizing the system operation to detect and process text from different sources(license plate, face) accurately. Furthermore, the cameras can be upgraded for better image quality and real-time operation. Improving the ReactJS (JS framework) web interface so its more usability, accessibility, and visual appeal, providing more information and engaging user experience. For the payment and ticket (transactions), we will try to improve that vehicles will not stop their car for payment, instead, each vehicle will pass the gate at the speed of 10-15 km/h so it not only reduces the time but also reduces the traffic congestion in the rush hour..

With the prototype of the project finished, we can look further to improve on many features in the future: enhance user experience through personalization, smart parking navigation, advance sustainability features, and integration of predictive analytics.

REFERENCES

[1][2] JP Fabros, D Tabañag ,A Espra ,OJ Gerasta,"Automated Car Park Management System", January 2009

[3]Pankaj Chougale, Vaibhav Yadav, Dr. Anil Gaikwad,"FIREBASE - OVERVIEW AND USAGE", December 2021

[4]Teng Lv, Ping Yan, * and Weimin He, "Survey on JSON Data Modelling"

[5]Kirill Smelyakov, Anastasiya Chupryna, Dmytro Darahan and Serhii Midina, "Effectiveness of Modern Text Recognition Solutions and Tools for Common Data Sources"

[6]ABDULLAH ALJOHANI,"Ultrasonic sensor"

[7]Carl Chapman, Kathryn T. Stolee, "Exploring Regular Expression"

[8]BUILDING A MODEL OF SMART PARKING SYSTEM IN VIETNAM BASED ON INTERNET OF THINGS AND CLOUD SERVER TECHNOLOGIES Pham Thanh Nam* , Pham Xuan Kien, Doan Manh Cuong

[9]J. Cynthia, C. Bharathi Priya, P. A. Gopinath, "IOT based Smart Parking Management System", November 2018

[10]Mohd Mustari Syafiq Ismail , Muzammil Jusoh, Thennarasan Sabapathy, Mohamed Nasrun Osman, Hasliza Abdul Rahim, Mohd Najib Mohd Yasin, Ainur Fasihah Mohd Fazilah, "IoT Based Smart Parking System", January 2021

[11] Lukas Blecher. "GitHub – computervisioneng/automatic-number-plate-reecognition-python"

[12] Nicolai Nielsen. "OCR for Text Detection and License Plate Recognition with EasyOCR in Python and OpenCV"

[13] ageitgey. "GitHub - ageitgey/face_recognition"