

## **Parking System Optimization Based on IoT using Face and Vehicle Plate Recognition via Amazon Web Service and ESP-32 CAM (Case Study: Institut Teknologi Sumatera)**

Ilham Firman Ashari, Mahesa Darma Satria, Mohamad Idris

*Program Studi Teknik Informatika Sub Jurusan Teknik Elektro Informatika dan Sistem Fisis, Institut Teknologi Sumatera*

*\*firman.ashari@if.itera.ac.id*

### **ABSTRACT**

Today's technology has developed rapidly. One application of technology is in the parking lot. Most parking lots in Indonesia can already recognize the vehicle plate image, but it is hoped that it can be even better by applying Internet of Things (IoT) technology that is integrated with facial recognition images. One of the parking problems is in the parking lot at the Sumatran Institute of Technology, where checking is still done manually by security officers. This of course will take time and the level of security is also not good, because when you enter there is no checking. Checks are only carried out at the time of exit and the officer who checks is not necessarily the same and memorized as the owner of the vehicle. The addition of this facial image recognition feature is expected to increase the security of the parking system. Facial image recognition can be assisted by Cloud services from Amazon Image Recognition. With this service, no training data is required. The system developed is only a prototype. The developed parking system can recognize facial images and vehicle license plates with 2 cameras using the ESP32-Cam when entering and exiting the parking lot. The use of the ESP32-cam can recognize facial images both during the day and at night. The results obtained by the system can work effectively with an increase of 21 %.

**Keywords:** IoT, Parking System, Image, ESP-32 CAM

### **1. INTRODUCTION**

In today's era, technology is developing very rapidly, so it requires a facility that is able to support and facilitate work in all fields and also to help develop institutions related to the existence of more supportive technology [1]. Internet of Things is a network of devices that are connected to each other via the internet. Internet of Things aims to make it easier for users to control devices remotely [2][3].

Most of the parking systems in Indonesia have used the help of computer technology, but some of these systems still work manually. Where the manual parking system usually uses two paper tickets for each vehicle [4]. Recently, a computerized parking system has also developed that is capable of automating several stages of the parking process with the help of computers and other hardware. [4], where this system can automatically record vehicle plates that enter through the parking barrier. Cross according to the Big Indonesian Dictionary is a wooden rod (bamboo, iron, etc.) that is installed across roads, doors, and so on [5]. So, the parking bar itself means a rod that is installed across the vehicle parking door. The

**Ilham Firman Ashari, Mahesa Darma Satria, Mohamad Idris**  
**Parking System Optimization Based on IoT using Face and Vehicle Plat Recognition**  
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existing parking system uses image processing to process vehicle number plates automatically. Image Processing is a two-dimensional representation of real three-dimensional physical forms, where with a method or technique that can be used to process images by manipulating the image to become the desired data to obtain information [6][7][8].

Where in the campus area also has a parking area, on the Sumatra Institute of Technology campus itself has a parking lot that still uses manual parking services. Where drivers who park at ITERA, when they want to leave the parking lot, must show the identity of the vehicle to the existing officers, this is not effective and is still considered unsafe because the current security guard is still limited and works in shifts [9]. A system like this is certainly less effective because it also consumes energy and time, therefore we need a system that can process parking data automatically [1][10].

Research conducted by Kiki and Dery [11] is optical recognition for vehicle number plate detection. the identification process on the vehicle number plate will be clearer during the day or with sufficient lighting. Another study was conducted by MF Wicaksono and MD Rahmatya [12], The implementation of Arduino and ESP32-CAM for this smart home has been successfully created and is running well where the percentage of success is in accordance with the test for sending sensor data, receiving commands to control equipment such as lights, fans, taking photos manually and taking photos automatically by 100%. Another research conducted by Eko Didik Widiyanto [13], Parking systems that use work based on RFID authentication and the results of vehicle number plate image recognition have been successfully developed to improve system security. The system has been able to authorize private building parking users who have an RFID card and a registered vehicle number. Fast RFID and license plate readings will reduce queues for parking. Nopi Ramsari and Suharjanto Utomo [14], The smart parking application that has been built can solve the problem of congestion caused by drivers not knowing the parking slots and their location so as to reduce the time to find a parking space.

Another research from Arman Syah Putra is to create an information system for parking reservations which can be done remotely, and does not focus on the tools used as parking systems [15]. In the next study implemented a system that can determine parking positions using RFID, research conducted by Freeon et al, resulted that the system helps make it easier for parking officers to carry out parking management [16]. Another study was conducted by Decy et al, in a research to make a parking system using infrared sensors for automatic doorstops and raspberry pi, in testing using a miniature [17]. Research conducted by [18] is to build a prototype of an automatic car parking area system using an electrical energy source from solar panels, the result is that the program execution time requires 1.1 ms. Research from Arthur, et al [19] Using ultrasonic sensors and the Internet of Things to deliver information on Lot parking is empty to parking users used to detect there and not vehicles. The study was conducted by Adlan R, et al [20] [17] is to create a system registration with a QR code on the driver and vehicle when entering and out. This guarantees the drivers' partner when entering the same as it comes out, because the system will not open the door if the rider-vehicle pair is different between when entering and when it comes out. From research conducted by [21], Make a system that can facilitate parking users in finding an empty parking lot without having to

surround the parking area. In this study, a design simulation that utilizes the Arduino Mega 2560 module component, 4x20 LCD, servo motor, infrared sensor

In this study, we will discuss the parking system using IoT and facial recognition image processing and vehicle plates to increase the effectiveness and security of vehicle parking [22]. Where the system is installed on the parking barrier entering and exiting the parking lot, which later when you want to enter the parking lot the system installed on the parking barrier will record the face and license plate of the vehicle with the camera and will also identify the data again when you want to leave the parking lot, whether the data matches the data entered. The camera used is already installed on the ESP32-Cam microcontroller module. ESP32-Cam itself is a microcontroller module equipped with a chip that functions as an electronic circuit controller via Wi-Fi [23]. With this identification system, it is expected to increase the effectiveness of vehicle parking so that the efficiency of human resources is expected.

## 2. MATERIAL AND METHODS

In this study, several steps were taken to build a parking security system using the ESP32-Cam camera. The steps to realize the system are as follows:

### 1. Literature Study

At this stage, learning theories that support the research being carried out by collecting several journals from previous researchers, the internet and other references regarding security systems using ESP32-Cam with IoT technology.

### 2. Data Analysis and Collection

At this stage a problem analysis is carried out as part of the solution given in this study. The analysis is also aimed at the requirements and specifications of the system and the design of the system to be built. In data collection, which is done by asking the effectiveness of checking STNK when you want to leave the ITERA parking lot.

### 3. System Design

At this stage the researcher provides clear stages in making a parking security system. Device arranged can take the motor vehicle plate object and the owner's face motor vehicle when entering the parking lot, then the parking bar will Open for further users can park the vehicle. Then when the user wants to get out the parking area of the camera again takes the object the face and motorized vehicle plate to check the similarity of data that has been stored or entered before, when the data exists then the cross is out of land Parking will open.

### 4. System Implementation

At this stage the author describes the previously designed devices that will be implemented, starting from the manufacture of hardware to how the system works [24].

### 5. Testing

At this stage the author conducts testing on devices that have been designed and built, to ensure the devices work well or not.

### 6. Documentation and Report Preparation

At this stage, documentation and preparation of reports are carried out to show the results of research that has been carried out by the researcher

## Research Design

This study has a system design that is described using schematic diagrams, flowcharts, and Activity diagrams.

### 1. Schematic Diagram

The diagram is a representation of each component of a process contained in the system. The schematic of the research diagram can be seen in Figure 1.

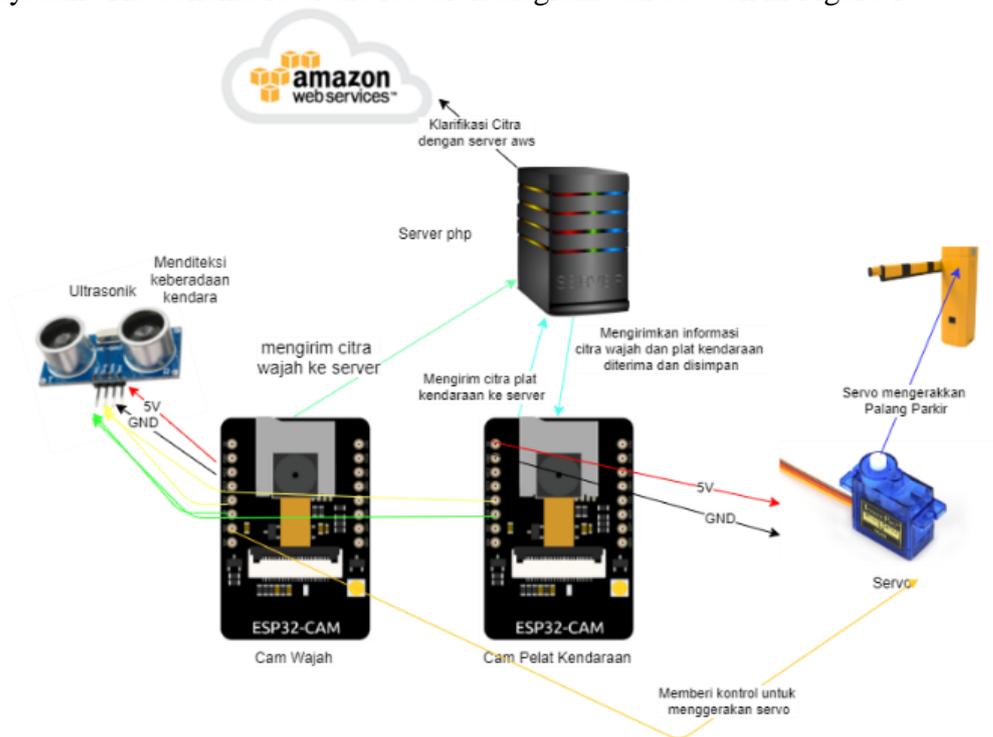


FIGURE 1. Schematic Diagram

Based on Figure 1, the system design consists of components ESP32-Cam, Servo Motor and Server. This design uses ESP32-Cam as a Microcontroller and retrieves objects that will be sent to the server via the internet [25]. The server is used as an object data storage medium, and the server is also used to connect to AWS as a third party to check the object data stored on the server. Then the image classification results will be obtained from the AWS.

### 2. Flowchart Of the Parking Barrier System

Flowchart is an image that displays the flow of the system being developed. The flowchart of this research can be seen in Figure 2. Based on the flowchart in Figure 2, it is explained that the ultrasonic sensor detects the presence of drivers at 10 cm to 15 cm on the prototype parking barrier system. Then if the ultrasonic sensor does not detect the presence of a rider, the ultrasonic sensor will continue to detect whether there is a rider or not. When the ultrasonic sensor detects the presence of a driver, the ultrasonic sensor provides information to camera 1 to take a face object and camera 2 to take a vehicle plate object. After the two cameras take the vehicle plate object and the face, the object will automatically be sent to the server for later storage. Then the parking barrier will open, and motorists can enter the parking lot. Activity diagram

when the user enters the parking lot can be seen in Figure 3 and when the user leaves the parking lot can be seen in Figure 4.

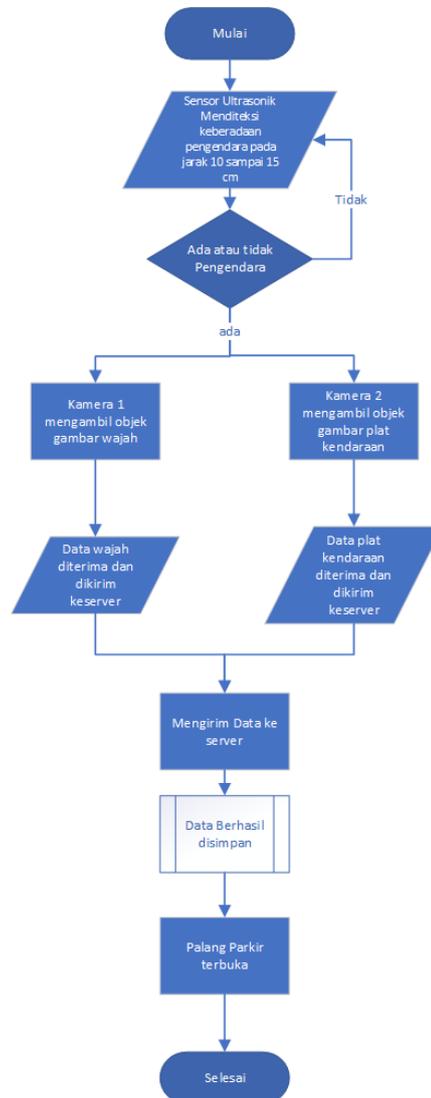


FIGURE 2. Flowchart of the Parking Cross System

**Ilham Firman Ashari, Mahesa Darma Satria, Mohamad Idris**  
**Parking System Optimization Based on IoT using Face and Vehicle Plat Recognition**  
**via Amazon Web Service and ESP-32 CAM (Case Study: Institut Teknologi Sumatera)**

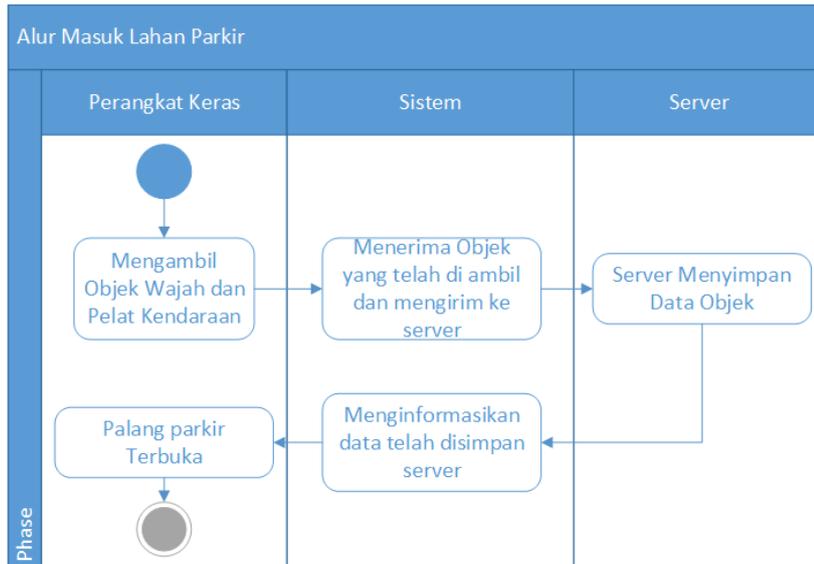


FIGURE 3. Activity Diagram of Parking Lot Entrance

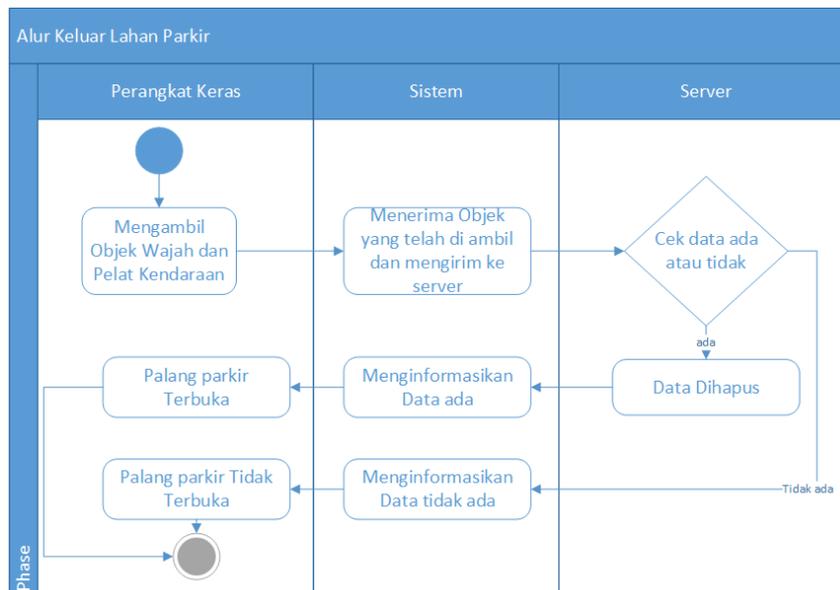


FIGURE 4. Activity Diagram of Exiting Parking Lot

The research needs needed to develop an automatic parking security system are ESP32 CAM, Servo and Ultrasonic.

### 3. RESULTS AND DISCUSSIONS

Implementation in this study, namely the implementation of hardware design and implementation. In this study the implementation of the system device design can be seen in Figure 5. Some of the hardware that has been used in this implementation phase are:

1. Microcontroller board and internet connection (2 pieces)
2. Proximity sensor (1 Piece)
3. Cross Drive (1 Piece)
4. Power (1 Piece)

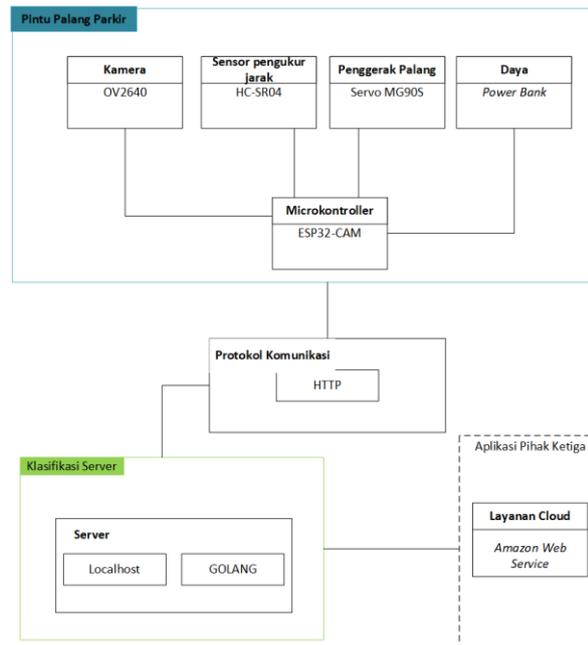


FIGURE 5. Implementation of the Design

The hardware mentioned above is then assembled to work as needed. The circuit can be seen in Figure 6 where the 2 ESP32-CAM on the right are connected to the ultrasonic sensor HC-SR04 on the left via the breadboard and connected to the Servo SG90 on the left. The hardware is powered by a power bank via a micro-USB adapter.

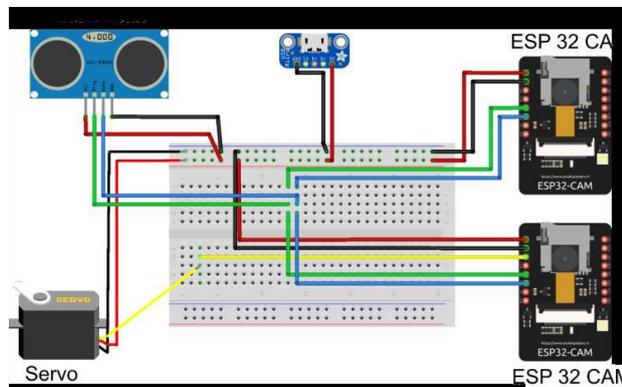


FIGURE 6. Hardware Circuit.

Based on Figure 6 Hardware Circuit, it has a hardware display that has been designed in a prototype form which can be seen in Figure 7 below.

**Ilham Firman Ashari, Mahesa Darma Satria, Mohamad Idris**  
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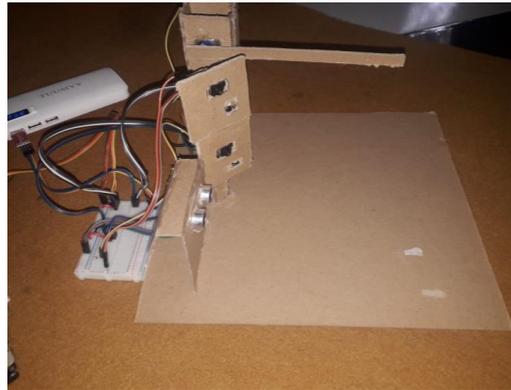


FIGURE 7. Hardware Display.

The hardware components that have been implemented produce a prototype parking bar. This implementation is expected to solve the problem formulation that has been determined. The prototype of the parking bar can be seen in Figure 8 which consists of 1 bar which is driven by a servo. 2 cameras that can take pictures after getting a signal from the ultrasonic sensor. The overall dimensions of the parking bars are 25 cm long, 30 cm wide and 13 cm high using a 1 : 10 cm ratio scale. Classification of face images and vehicle plate images uses ready-to-use services in the cloud, so there is no need for training and testing. The cloud service used is Amazon Image Recognition (AIR). AIR is an image recognition service using deep learning that can recognize objects in the image. The service was developed by computer vision scientists from Amazon who analyses billions of images every day. The AIR system used in this research is text in image and face comparison. Where text in image is used as a vehicle plate image classification, while face comparison is used as a face image classification. Where the text in image system can classify image images by producing text contained in images, while face comparison can classify facial images by comparing one face image with another face.

The face image and vehicle license plate are captured by the camera separately when entering the parking lot and then the URL is sent to the cloud service through the server to generate the image classification and open the parking barrier. The classification for entering the parking lot can be seen in Figure 8.



FIGURE 8. Parking Lot Entry Process

The face and license plate image classification will later be classified again when the driver wants to leave the parking lot, where the camera returns to take a separate face and vehicle plate image then the URL sends to the cloud service to classify whether the face image and vehicle license plate match the image shown previously. The classification can be seen in Figure 9.

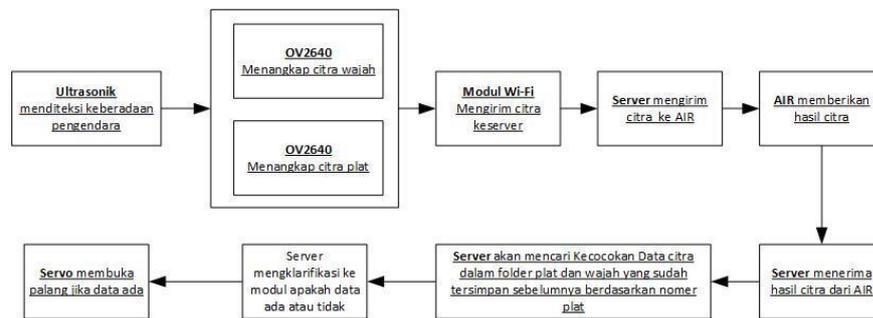


FIGURE 9. Parking Lot Exit Process

The results of the processed vehicle plate image will be sent by AIR text in image in Figure 10. Where there is an image of the vehicle plate on the left and right side is the result of the text in image process carried out by AIR.

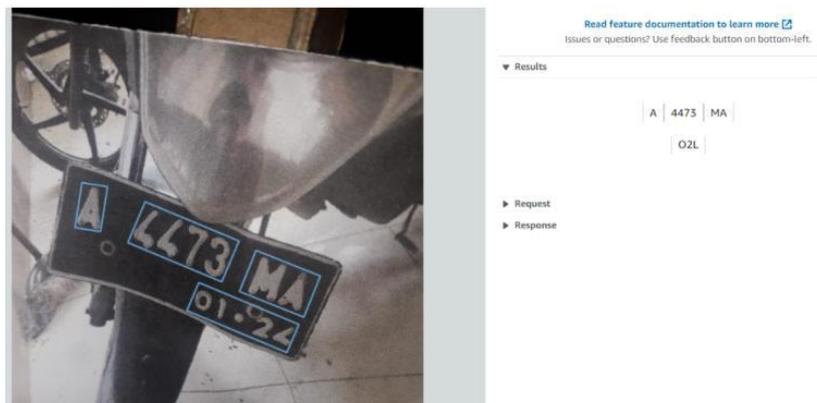


FIGURE 10. Example of Text in Image Results on Vehicle Plates.

Then the results of the classification of the driver's face when entering and leaving the parking lot will be processed and sent by AIR face comparison in Figure 11. Where there are 2 images captured when they want to enter and want to leave the parking lot. Then the image is matched by the face comparison process carried out by AIR, from this process the match value is obtained in the form of a percent value. Which will be used to move the bar out of the parking lot when the data is accurate.

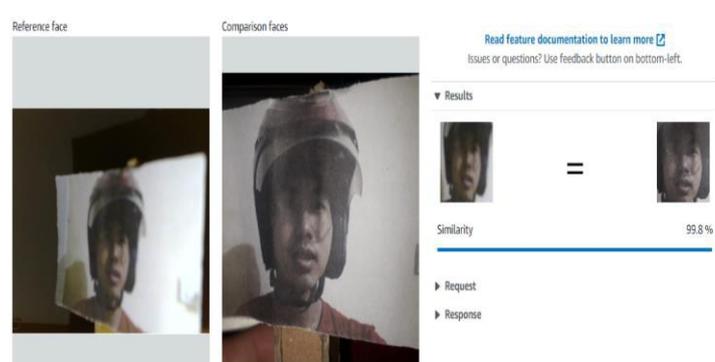


FIGURE 11. Example of Face Comparison Results on Rider's Face.

### Parking Lot Entrance Test

In the parking lot entrance test, the system will later capture the image of the face and vehicle plate when the ultrasonic sensor detects the presence of the driver in the front area of the parking barrier with 10 cm to 15 cm. Several tests were carried out at night and during the day. For taking images at night, it can be seen at numbers 1, 2, 3. Where at the time of testing camera 1 was in the top position capturing face images and camera 2 was able to capture plate images. Then the face and plate image data will be stored with the file names being face\_plate numbers and plate\_numbers. Where the plate number is obtained from the text in image classification of the plate image that is caught and processed on Amazon Image Recognition and gets the text in the form of the plate number. The test can be seen in table 1.

Based on the parking lot entrance test in table 1, it can be seen in Figures 1, 2, 3 where the test was carried out at night and 4,5,6 was carried out during the day. From 3 tests at night and 3 tests during the day, it can be analysed that the ESP32-Cam camera can work optimally. Due to 3 tests at night the object can be captured quite clearly because the microcontroller which has an LED FLASH and the bar can be opened to enter the parking lot. On 3 tests during the day the object was caught very clearly and the bar can also be opened to enter the parking lot. The results of the parking lot entrance test can be seen in table 1.

**TABLE 1.**  
**Results of the Parking Lot Entrance Test**

No	Sensor Distance	Face Image	Plat Image	Status
1	12 Cm			Open
2	13 Cm			Open
3	14 Cm			Open

No	Sensor Distance	Face Image	Plat Image	Status
4	12 Cm			Open
5	15 Cm			Open
6	13 Cm			Open

### Parking Lot Exit Test

In testing out the parking lot later the system will capture the image of the face and license plate of the vehicle when the ultrasonic sensor detects the presence of the driver in the front area of the parking lot with a certain distance, and the system will match the image data that comes out is the same as the incoming image data. By means of the system to classify the plate image first to get the plate text. After the plate text is obtained, the system will search for files in the storage by looking for the face\_plate number. The face image at the time of exit is stored temporarily with the name temp\_face\_out. Then the system will classify whether the incoming and outgoing faces are the same or not, if they are the same then the incoming and outgoing image data will be deleted simultaneously, and the exit gate of the parking lot is open. The test can be seen in table 2.

In the test of Table 2, it can be seen in Figure 6 that there are bars that are not open. because the data entered in Table 1 number 5 and exited in Table 2 number 5 have different faces, which causes the outgoing bars to not open. The results of the parking lot exit test can be seen in table 2.

**Ilham Firman Ashari, Mahesa Darma Satria, Mohamad Idris**  
**Parking System Optimization Based on IoT using Face and Vehicle Plat Recognition**  
**via Amazon Web Service and ESP-32 CAM (Case Study: Institut Teknologi Sumatera)**

TABLE 2.  
 Results of Parking Lot Exit Testing.

No	Sensor Distance	Face Image	Plat Image	Status
1	13 Cm			Open
2	13 Cm			Open
3	14 Cm			Open
4	12 Cm			Open
5	13 Cm			Not Open

No	Sensor Distance	Face Image	Plat Image	Status
6	15 Cm			Open

### System Efficiency Test

System efficiency testing is carried out by comparing the existing system with the designed parking system, namely by using 10 samples of driver data used simultaneously, of which 5 samples are used at the entrance to the parking lot and 5 more data are used at the exit from the parking lot. To calculate efficiency, time is used as a comparison. The test can be seen in table 3.

TABLE 3.  
System Effectiveness Test

	No.	Entry	Estimate Time	Out	Estimate Time
Previous System (Manual Checking)	1.	Data 1	6 seconds	Data 1	20 seconds
	2.	Data 2	4 seconds	Data 2	19 seconds
	3.	Data 3	7 seconds	Data 3	17 seconds
	4.	Data 4	6 seconds	Data 4	21 seconds
	5.	Data 5	6 seconds	Data 5	22 seconds
	6.	Data 6	2 seconds	Data 6	19 seconds
	7.	Data 7	6 seconds	Data 7	21 seconds
	8.	Data 8	3 seconds	Data 8	21 seconds
	9.	Data 9	7 seconds	Data 9	22 seconds
	10.	Data 10	3 seconds	Data 10	19 seconds
Designed System	11.	Data 11	6 seconds	Data 11	21 seconds
	12.	Data 12	4 seconds	Data 12	21 seconds
	13.	Data 13	6 seconds	Data 13	22 seconds
	14.	Data 14	3 seconds	Data 14	19 seconds
	15.	Data 15	6 seconds	Data 15	21 seconds
	1.	Data 1	7 seconds	Data 1	15 seconds
	2.	Data 2	7 seconds	Data 2	19 seconds
	3.	Data 3	7 seconds	Data 3	12 seconds

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**Parking System Optimization Based on IoT using Face and Vehicle Plat Recognition**  
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No.	Entry	Estimate Time	Out	Estimate Time
4.	Data 4	7 seconds	Data 4	14 seconds
5.	Data 5	7 seconds	Data 5	17 seconds
6.	Data 6	7 seconds	Data 6	13 seconds
7.	Data 7	7 seconds	Data 7	14 seconds
8.	Data 8	7 seconds	Data 8	15 seconds
9.	Data 9	7 seconds	Data 9	19 seconds
10.	Data 10	7 seconds	Data 10	12 seconds
11.	Data 11	7 seconds	Data 11	14 seconds
12.	Data 12	7 seconds	Data 12	17 seconds
13.	Data 13	7 seconds	Data 13	13 seconds
14.	Data 14	7 seconds	Data 14	14 seconds
15.	Data 15	7 seconds	Data 15	15 seconds

The explanation in table 3 is explained as follows, where:

1. The previous system was a parking system where the entrance and exit were the same, did not have a parking barrier, and when leaving the parking lot, manually checked the vehicle registration certificate. the timed distance is determined 3 meters from the entry point to the entry barrier point, and 3 meters from the exit point to the exit barrier point.
2. The system designed is a parking system where the entrance and exit are different, have parking bars. Using face image and license plate on each door to increase security.

For the calculation of efficiency, it is obtained based on the time results obtained in Table 3, then the calculation results are obtained as follows:

$$\text{incoming data on the old system} = \frac{6+4+7+6+6+2+6+3+7+3+6+4+6+3+6}{15} = \frac{75}{15} = 5$$

seconds

$$\text{data enters the new system} = \frac{5+5+5+5+5+5+5+5+5+5+5+5+5+5+5}{15} = \frac{75}{15} = 5 \text{ seconds}$$

$$\text{Data Out on the old systems} = \frac{20+19+17+21+22+19+21+21+22+19+21+21+22+19+21}{15} =$$

$$\frac{305}{15} = 20.3 \text{ seconds}$$

$$\text{Data Out on the new systems} = \frac{15+19+12+14+17+13+14+15+19+12+14+17+13+14+15}{15}$$

$$= \frac{223}{15} = 14.9 \text{ seconds}$$

$$\text{Total Time Difference Between old and new system} = (20.3 + 5) - (5+14.9) =$$

$$\text{effectiveness} = 5.4 / 25.3$$

$$= 0.21 * 100\%$$

$$= 21 \%$$

Based on the above calculation, it is obtained that the average value of the data entering and leaving the old system and the new system is obtained. With the efficiency level of the old system, it is more efficient when entering the parking lot, because the old system at the time of entry does not have a parking barrier and checks to enter the parking lot so that the time required is very short to enter the parking lot. For the level of efficiency when exiting the parking lot, the new system is more efficient than the old system. Because when exiting the old system, manual checking of the vehicle owner's letter was used, while the new system only required checking the vehicle's plate and the driver's face by the system. So, to estimate the time to enter and leave the parking lot through the above calculations, it can be concluded that for overall time efficiency, the new system is 9% more efficient than the old system.

#### 4. CONCLUSION

After conducting research and testing the system, the conclusions that can be obtained from this research are:

1. A system is produced that can make it easier for drivers to leave the parking lot without showing a certificate of vehicle ownership.
2. Based on efficiency testing by comparing the manual system and the system made. So, the system created has an efficiency level of 21 % more efficient when entering and exiting the parking lot.
3. Based on the testing of entering and exiting the parking lot, a system that uses an ESP32-CAM microcontroller is produced which can automatically capture the image of the face and license plate of the vehicle. The system can also distinguish the incoming image is the same or not with the image that leaves the parking lot.
4. Based on the results of tests carried out at the time of entering and exiting the parking lot, using 3 objects at night and 3 objects during the day. the system can work optimally because it has an LED FLASH on the ESP32-CAM microcontroller.

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**Ilham Firman Ashari, Mahesa Darma Satria, Mohamad Idris**  
**Parking System Optimization Based on IoT using Face and Vehicle Plat Recognition**  
**via Amazon Web Service and ESP-32 CAM (Case Study: Institut Teknologi Sumatera)**

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