(Research/Review Article)

Design of an Automatic Gate Barrier Based on Quick Response Code at Sultan Ageng Tirtayasa University Campus

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Abstract: This research presents the design and implementation of an automatic gate barrier system based on Quick Response (QR) Code, integrated with Optical Character Recognition (OCR) technology for vehicle license plate verification. The system is controlled by an ESP32 microcontroller connected to a web server, enabling real-time data verification through the Internet of Things (IoT) network. The study applies the Waterfall development model, including system requirements analysis, hardware and software design, and comprehensive testing stages. Testing with 54 vehicle data samples showed that the system achieved a 70% success rate in validating both QR Code and license plate data, while 30% failed due to insufficient lighting and improper camera positioning. These results demonstrate that the system significantly improves security, efficiency, and organization of parking management, especially within university environments. The integration of QR Code and OCR technologies provides an effective solution for IoT-based automatic parking systems, enhancing both convenience and reliability for users.

Keywords: Automatic Gate Barrier; Internet of Things; OCR ESP32; QR Code; Smart Parking System

1. Introduction

Parking spaces and systems are crucial elements in public facility services, especially in campus environments like Untirta. A good parking system must be able to support security, comfort, and ease of access for students who use the facility. In addition to providing a sense of security and comfort, the system must also facilitate entry and exit of the campus area so that student activities are not disrupted [1] . Currently, the parking system on the Untirta campus still uses a manual method that is not optimal. This system is not only less comfortable and less safe, but also opens up opportunities for criminal acts such as vehicle theft due to conventional security [2] . Therefore, innovation is needed to change the manual system into a more modern automatic parking system. With an automatic system based on a microcontroller and QR Code, vehicles entering and leaving can be properly recorded through barcode scanning, increasing security and ease of access [3] . The implementation of this automatic parking system uses microcontroller technology that automatically controls the barrier with input from an infrared sensor. Data obtained from the QR Code scan is directly connected to a computer database, so the system can filter incoming and outgoing vehicles more efficiently [4] . This system not only provides better security, but also creates a more comfortable and well-organized campus environment, in line with the need for modernization of public facility services on campus [5] . By utilizing electronic components instead of manual systems, the parking security system can be significantly improved. A microcontroller, which is a single computer chip with a core processor, memory, and input and output components, acts as the brain in managing this system. This innovation ensures that the parking system is not only safe and comfortable, but also more efficient and in accordance with the latest technological developments. [6] [7] . A web-based automatic gate system based on Quick Response Code (QR Code) is very important because it affects various aspects of life and helps management become more organized and efficient. This system enables integrated

cooperation to produce fast, accurate, and precise information [8] . The system itself can be understood as a collection of elements or parts that interact with each other to achieve a certain goal. The characteristics of the system include components that work together, system boundaries that separate one system from its surrounding environment, and important elements such as input, output, processor, and system objectives [9] . In its application in a campus environment, an automatic parking system with QR Code is designed to facilitate and improve parking security. Students only need to scan the QR Code using their smartphones when entering the campus area [10] . Vehicle user data will be automatically recorded in a web-based database, which records the user's identity and entry and exit times. This system ensures that the vehicle leaving is the same vehicle that entered, so the gate will only open if the data matches [11] . This prevents vehicle theft and streamlines the parking process without long queues, while replacing the less efficient manual parking system [12] . This automated system uses hardware and software to support its operation. The ESP32 microcontroller functions as the main brain of data processing with WiFi and Bluetooth capabilities, facilitating the Internet of Things (IoT) concept to detect vehicles using infrared sensors. QR Code acts as a data storage medium that is easy to scan and integrated with the internet, so that user information can be accessed in real-time. This system is also controlled by an Arduino Uno microcontroller that executes pals commands and the door opening mechanism [13] .

2. Literature Review

The creation of automatic gates using a web-based Quick Response Code (QR Code) system is a very broad system that impacts all aspects of life. It is essential for effective and structured management. The integration of these systems enables collaboration to produce fast, precise, and accurate information.

Automatic Parking System

This automatic parking design is certainly inseparable from the use of hardware and software, this software and hardware certainly have different operational performance and usage, understanding the basic concepts of the use of technology that will be used in this system is very important, this chapter explains the basic concepts of the technology used as the basis for designing this system, including:

a.   NudeMCU ESP32

I Wayan Suriana, I Gede Adi Setiawan, I Made Satya Graha. (2021) also stated that ESP32 is a microcontroller introduced by Espressif System which is the successor of the ESP8266 microcontroller. The differences that are the advantages of the ESP32 microcontroller compared to other microcontrollers, starting from its more pin outs, more analog pins, larger memory, there is Bluetooth 4.0 low energy and WiFi is available which makes it possible to apply the Internet of Things with the ESP32 microcontroller. ESP32 which functions as the core source of the entire circuit for processing data which is also assisted by an infrared sensor which functions as a sensor that detects objects or cars entering and leaving the parking area [14] .
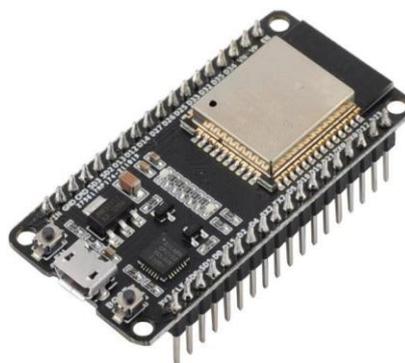

Figure 1. ESP32 microcontroller

b. Quick Response Code

According to Fiqshallah Suyendra Apriano (2023), the Quick Response Code has been widely used in various applications, including storing and retrieving data in real-time, for example, social media, e-commerce, and so on after being recommended by the Japanese company "Denso". In several applications that use Quick Response Code technology, two-dimensional barcodes function as a tool to obtain data stored on the server and are directly connected to the internet with high quality. QR-Code is a public patent standard, so QR-Code can be read by various QR-Code reader standards [15] .

Figure 2. Quick Response Code

c. Visual Studio Code

According to Hartati Sri (2020), Visual Code is a lightweight, yet powerful, desktop-based code editor. It comes with built-in support for JavaScript, script, node, js, and has a wide array of extensions available for other languages, including C++, C#, Python, and PHP. Electron, according to Github, is a cross-platform version of the Atom code editing component, based on JavaScript and HTML5. This editor is a full-featured integrated development environment (IDE) designed for innovation that works with Microsoft's open cloud technology. Visual Studio Code uses open source .NET tools to support ASP.NET and C# code, as well as the Omnisharp .NET development tool and the Roslyn compiler [16] .

Figure 3. Visual Studio Code

3. Method

In this research, the focus is directed at designing a safe automatic parking system by utilizing QR Code technology and the NudeMCU ESP32 microcontroller. This system is capable of reading, processing, and storing data directly into the available database. The main stages of the research include hardware and software design, as well as system testing to ensure smooth operation, data storage accuracy, and the website's ability to generate QR codes for users. The main device in this system is the NudeMCU ESP32 microcontroller, which acts as the automatic barrier security control center. Before entering or exiting the campus, vehicle users must register through the web server and enter their vehicle data to obtain a unique QR Code [17] . This QR Code is then scanned by the scanner and verified by the microcontroller by matching the data in the database. This process causes the barrier to open automatically for registered vehicles. In addition, the system is equipped with a thermal camera that functions to detect vehicle license plates for an additional layer of security. This way, only verified vehicles with the appropriate data can pass through the barrier, thus preventing unauthorized access and increasing security in the campus area [18] .
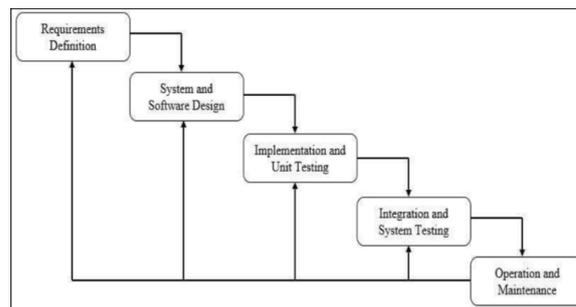

Figure 4. Waterfall Research Method

To develop this system, a phased development method known as the waterfall model was used. This method requires each stage of the work to be carried out sequentially, starting from requirements analysis to implementation and testing. The waterfall model simplifies project management and minimizes errors that often occur in manual data processing. This system makes data management more effective and accurate, resulting in more reliable reports and reducing the risk of human error [19] . The automated parking system designed not only simplifies parking management on campus but also prioritizes security aspects with Internet of Things (IoT) technology. With a fast response barrier that opens automatically when the QR Code and thermal verification match, the potential for theft or illegal access can be minimized. This project demonstrates how cutting-edge technology can be applied practically to address everyday challenges, providing a safe, efficient, and reliable solution for the modern campus environment. [20] .

4. Results and Discussion

The automatic barrier system based on QR codes and license plate detection was tested on 54 test cases, resulting in 35 valid cases that successfully opened the barrier and 15 invalid cases that remained closed. The system achieved a 70% success rate, indicating its reliability in performing dual verification through QR code scanning and license plate reading using OCR (Optical Character Recognition).
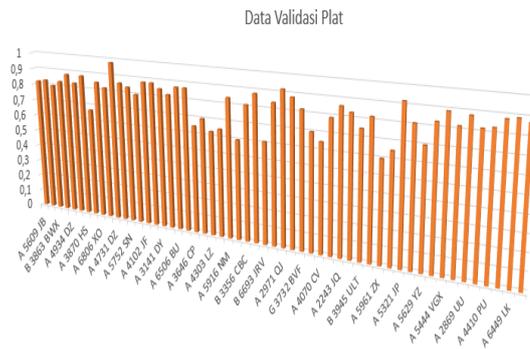
Figure 5. Comparison Data of the Whole Plate Experiment

OCR reading accuracy is affected by environmental factors such as lighting, license plate quality, camera position and angle, camera resolution, and the OCR model used. OCR Confidence values range from 0.60 to 0.98, with values below 0.70 indicating visual interference that reduces reading accuracy. The system implements a layered security principle where access is only granted if the QR Code is valid and the license plate is read correctly; most errors originate from the imperfect OCR process.

Table 1. Comparative Data

Information	Amount	Presentation
QR And Plate Valid (Door Open)	39	70%
QR And Plate No Valid (Door Closed)	15	30%

The system's working mechanism begins with a QR Code scan, which is verified against a database. If valid, the system then reads the vehicle's license plate using OCR. Door access is opened if the OCR result has a Confidence above 0.80 and the license plate matches the registered data. If any of the validation processes fail, access is denied. Some obstacles encountered include low OCR values, damaged or undetectable QR Codes, network disruptions, improper time synchronization, and incompatible data formats between the server and the local system. To improve system performance, the use of high-resolution cameras, artificial lighting settings, and deep learning-based OCR algorithms such as EasyOCR or PaddleOCR are recommended. With these improvements, the system's success rate can be increased to nearly 90%, making this system an effective solution for safe and efficient automated parking management, especially in campus environments or parking areas.

4.1 . Data Collection Instruments

Testing of the control components in this parking system covers two main aspects: the vehicle user barcode and license plate detection using OCR. The barcode serves as the user's digital identity, containing unique data such as ID and student ID number, which can be scanned to automatically identify the vehicle owner without manual input. This barcode also acts as a digital ticket to open the automatic barrier gate by scanning the code at the entrance or exit gate, where the data is verified through a database. Each user has a unique QR Code that is difficult to counterfeit, thus increasing system security by ensuring access only to authorized owners. In addition, this system combines QR Code with automatic license plate detection as a double layer of verification.

Table 2. Test Data

No	Bar Code Value	BarCode Valid	Plate Text	OCR Conf	Plate Valid
1.	MAH20250212090614415	✓	A 5609 JB	0.82	✓
2.	MAH20250528104754404	✓	A 3453 VV	0.83	✓
3.	MAH20250917061210772	✓	B 3863 BWX	0.80	✓
4.	MAH20250917061515225	✓	B 5719 TRM	0.83	✓
5.	MAH20250917061712844	✓	A 4934 DZ	0.88	✓
6.	MAH20250917061849894	✓	F 4480 TAH	0.83	✓
7.	MAH20250917062037711	✓	A 3870 HS	0.88	✓
8.	MAH20250917062205219	✗	A 3782 QC	0.67	✗
9.	MAH20250917062322905	✓	A 6806 XO	0.85	✓
10.	MAH20250917062438458	✓	A 1277 YS	0.82	✓
11.	MAH20250917062641210	✓	A 4731 DZ	0.98	✓
12.	MAH20250917062817848	✓	B 6134 JLW	0.86	✓
13.	MAH20250917063034542	✓	A 5752 SN	0.84	✓
14.	MAH20250917063212969	✓	A 5408 DR	0.80	✓
15.	MAH20250917063340685	✓	A 4102 JF	0.88	✓
16.	MAH20250917063452930	✓	A 5049 DV	0.88	✓
17.	MAH20250917063647505	✓	A 3141 DY	0.85	✓
18.	MAH20250917063805558	✓	B 4320 NJH	0.82	✓
19.	MAH20250917063920864	✓	A 6506 BU	0.87	✓
20.	MAH20250917064052435	✓	B 5004 TCC	0.87	✓
21.	MAH20250917064213401	✗	A 3646 CP	0.65	✗
22.	MAH20250917064326123	✗	A 2771 TT	0.70	✗
23.	MAH20250917064445234	✗	A 4303 LZ	0.63	✗
24.	MAH20250917064701248	✗	A 5963 TB	0.65	✗
25.	MAH20250917064811254	✓	A 5916 NM	0.84	✓
26.	MAH20250917064905361	✗	A 2413 VBH	0.60	✗
27.	MAH20250930224511976	✓	B 3356 CBC	0.81	✓
28.	MAH20251002153403104	✓	A 5614 CD	0.88	✓
29.	MAH20251002153724388	✗	B 6693 JRV	0.61	✗
30.	MAH20251002153822259	✓	B 6982 CUE	0.84	✓
31.	MAH20251002153913711	✓	A 2971 QJ	0.92	✓
32.	MAH20251002154127225	✓	A 5629 YZ	0.88	✓
33.	MAH20251002154306986	✓	G 3732 BVF	0.82	✓
34.	MAH20251002154440808	✗	A 3688 TC	0.70	✗
35.	MAH20251002154549195	✗	A 4070 CV	0.65	✗
36.	MAH20251002154824766	✗	A 5021 MO	0.79	✗
37.	MAH20251002154911645	✓	A 2243 JQ	0.86	✓
38.	MAH20251002154955810	✓	8 6837 JRU	0.83	✓
39.	MAH20251002155108294	✗	B 3945 ULT	0.75	✗
40.	MAH20251002155230462	✓	B 4093 NBB	0.82	✓
41.	MAH20251002170825439	✗	A 5961 ZX	0.60	✗
42.	MAH20251002173921287	✗	B 4731 BVL	0.65	✗
43.	MAH20251014141954519	✓	A 5321 JP	0.92	✓
44.	MAH20251014142122373	✓	A 6247 ME	0.81	✓
45.	MAH20251014142308302	✗	A 5629 YZ	0.70	✗
46.	MAH20251014142505929	✓	A 2031 SH	0.83	✓
47.	MAH20251014142632368	✓	A 5444 VGX	0.89	✓

48.	MAH20251014142807464	✅	B 4384 TPD	0.82	✅
49.	MAH20251014142954980	✅	A 2869 Law	0.88	✅
50.	MAH20251014143154763	✅	A 5967 DM	0.82	✅
51.	MAH20251014143321260	✅	A 4410 Public Works	0.83	✅
52.	MAH20251014143548540	✅	B 4486 NDX	0.88	✅
53.	MAH20251014144017244	✅	A 6449 LK	0.89	✅
54.	MAH20251014144126725	✅	B 3777 CTM	0.87	✅

Vehicle license plate detection using sensors and OCR is carried out in an integrated manner with QR Code scanning. After the user scans the barcode, the system takes a picture of the vehicle in front of the barrier using an external camera, then performs image pre-processing such as thresholding and noise reduction so that the characters on the license plate are clearly readable. OCR technology is used to recognize the license plate characters, and the reading data is sent to the barrier control system. The validation process involves matching the data between the user's QR Code and the OCR results on the license plate, so that if both match, the barrier will open automatically. All detection data, including time, license plate, is by the admin.

6. Conclusion and Suggestions

Based on the results of research and testing that has been carried out, (1) an automatic barrier gate system based on Quick Response (QR) Code with Optical Character Recognition (OCR) integration for vehicle license plate detection has been successfully designed and implemented. This system uses an ESP32 microcontroller as a control center connected to a web server, enabling the vehicle data verification process to be carried out in real-time via the Internet of Things (IoT) network. Every vehicle that wants to enter or exit the campus area must scan a unique QR Code registered in the database, while the camera reads the license plate for a double validation process. (2) The results of testing 54 vehicle data show that the system is able to work with a success rate of 70%, where 39 data were successfully verified correctly and 15 data failed due to various technical factors such as uneven lighting, inappropriate camera position, and the quality of the license plate that is difficult to read by the OCR system. However, this system has been proven to improve security, efficiency, and accuracy in the vehicle entry and exit process compared to conventional manual systems. (3) The implementation of QR Code and OCR-based technology in the automated parking system has a positive impact on the modernization of campus facilities, because it can reduce the risk of theft, speed up the parking process, and simplify vehicle data management. For further development, it is recommended to improve camera quality, implement deep learning-based OCR algorithms, and integrate an automatic notification system to provide a better and more responsive user experience. Overall, this system is an automated, intelligent, and efficient solution that is relevant for implementation in various modern parking areas, especially in academic environments.

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