Automatic Number Plate Recognition and QR Code Double Authentication System for a Carpark

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***Abstract*— Parking is one of the most important elements in a transportation system in highly populated urban areas. Unattended vehicles have the chance of being stolen if there is no way to authenticate the driver of the vehicle. Given this, Automatic Number Plate Recognition (ANPR) systems are one of the ways to monitor and track vehicles based on the information of the number plate. This information, along with the information about the driver can be used to verify and authenticate if the driver of the vehicle is the actual owner. Quick Response (QR) codes can encode information by transforming alphanumeric data into a unique pattern of data points. Therefore, this study aims to design a double authentication system by integrating ANPR and QR code authentication sub-systems to create a double authentication system that improves the security and safety of vehicles at carparks by creating a double authentication system. The study shows results that are working.**

Keywords—ANPR, QR, double authentication system

I. INTRODUCTION

Parking is one of the most important elements in a transportation system as in cities and highly populated areas with malls, office spaces, hospitals, etc. require a host of parking spaces for the users/customers to safely park their main mode of transportation. Parking spaces offer ways to manage parked cars and reduce the traffic in urban areas, which means that parking spaces should be an area of high priority, with safety and security being an important feature. Leaving the vehicle unattended for long periods of time brings about the potential of theft and without secure ways to verify and authenticate the owner/driver, the vehicles can easily be stolen.

Malaysia was reported to have a total of 17, 486, 589 vehicles registered in December of 2020 [1]. In addition to this, a trend of increasing number of new vehicles being registered in the years prior to 2020 has been identified by the Malaysian Automotive Association (MAA). Although the number of new vehicles being registered has taken a hit from 604, 287 to 529, 434 during the COVID-19 pandemic, the MAA has identified that during the first 5 months of 2021 has increased by 91% to 245, 932 from 128, 790 identified during the same duration in the year 2020 [2]. This shows that the total number of vehicles registered will keep increasing, leading to the necessity of larger and a higher number of car parks. This will also in turn demand good safety and security to ensure that the cars are not stolen. According to the Crime Statistics of Malaysia for 2020 from the Department of Statistics Malaysia, the number of motorcars stolen is 30, 867, whereby the vehicle theft accounts for 46.1% of all property theft [3]. Nearly half of all crime are pertaining to vehicle thefts which demands the necessity of a good security system to allows for proper identification and authentication of the driver and the respective vehicle.

Automatic Number Plate Recognition (ANPR) is a tool that performs processing on images to identify and recognize the unique number plates on vehicles [4]. An ANPR system has a generally composition of several stages. Firstly, the image has to be acquired in order to undergo processing. Next, the image is processed to obtain a cleaner image with the colour of the picture converted to a grayscale for easier processing. Following this, the number plate in the picture is identified and extracted to be processed in the next segment, which is character segmentation. In this stage, the individual alphanumeric characters are identified from the processed image which will be output as valid data that can be manipulated. Applications of ANPR systems ranges from security and law enforcement to vehicle tracking and dynamic management of traffic. The active tracking of vehicles, their models, make, colour and unique number plates allows for management and collection of data for various activities [5].

Quick Response (QR) codes are two-dimensional (2D) barcodes that contain information in an encoded manner. QR codes from regular barcodes as they are coded in a 2D fashion, which means that the encoded information is encased in a horizontal and vertical pattern, unlike regular barcodes which only encode information in vertical lines. This allows for a bigger capacity of data being stored and encased in the code, which also means that there are a higher number of permutations possible with QR codes. According to Blue Bite, the number of interactions involving QR codes has increased a massive 94% from 2018 to 2020. The reach of smart products has also increased a massive 92% from 2018 to 2020, which shows how QR codes are becoming more and more accessible and popular [5]. One of the biggest uses is to perform contact tracing for diseases as almost every person owns a smartphone and this is used by the health authorities to monitor the people and the spreading of diseases. This is due to the ability of the QR codes to simultaneously collect and provide information, whether it be receiving information about a product or providing electronic pamphlets/flyers [6].

Multi-factor authentication (MFA) systems are systems whereby the particular user has to provide two or more different factors of identification, such as a password and an access card, in order to access a particular service or product. This system has stemmed from single factor authentication

systems, whereby in those systems the user only has to provide one factor of recognition in order to access a particular service or product. According to Microsoft, who have encountered over 300 million fraudulent attacks and access attempts, MFA offers up to 99.9% of protection by blocking these incoming attempts. According to the Verizon Data Breach Investigations Report, 5% of all data breaches stemmed from simple brute force attacks [6]. A simple password containing 16 alpha numeral characters could be found in less than 3 minutes, which shows how fragile single factor authentication systems can be. Therefore, adding another one or two requirements to ensure that the user can verify himself/herself using two or more factors will prevent these fraudulent attacks and give full safety to the user [7].

Therefore, the research objectives are as follows:

- To improve the recognition process of ANPR sub-system.
- To develop a smartphone application for QR code authentication sub-system.
- To integrate ANPR and QR code authentication sub-system to create a double authentication system that improves the security and safety of vehicles at carparks.

Table 1 shows the summary of related works employing the two-factor authentication systems and Quick Response (QR) codes. It can be seen that in [6], the author has successfully created a double authentication system that employs both ANPR as well as RFID which was localized to the university carpark. However, the limitations in this system are that the RFID comes in the form of an external gadget, therefore there is no real security if the card gets stolen. The paper also does not highlight any information about the accuracy of the system nor of the success of the system, which does not really show how effective the is the system. In [7], the author combines the technology of ANPR as well as facial recognition to create a two-factor authentication system, localizing the system to a mock setup. However, the primary issues are that both technologies employed rely on good lighting conditions and if one fails, the whole system fails. The way the system is setup is that it only works for existing users so there is no way a new user can enter the system, limiting the potential of the system. Another issue is that the overall recognition rate is given as 84% with a small sample size. A larger sample size would reflect the true overall recognition rate of the system, which will truly reflect the efficiency of the system.

In [8], the author employs the technology of QR codes to reserve parking spaces before the user is able to utilize the car park which helps with congestion and the flow of traffic in the carpark. However, the issue here is that an external authority still has to be present at all times to check and validate the user manually, so the system is prone to errors due to human interference. It also only works for registered customers, so the system is not flexible to include other customers. In [9], the author's system will check the QR code of the incoming car into the carpark for the details about the car and the driver before allotting them a vacant spot in the car park. However, this system does not perform an authentication process during the exit process, nor does it have a two-factor authentication system on the way in and out, so the danger of the car being stolen is still present. In [10], the author's system provides a unique QR code to the customer who reserved a parking spot before utilizing the carpark. Upon entering, the customer's QR code is checked to see if he/she has reserved a parking spot and is allowed to enter. However, similar to [9], this system does not perform a verification process during the exit process. The system also lacks a double authentication feature as the system solely relies on the QR code to check for whether the customer has reserved a parking spot. In [11], the author's system acts as a parking reservation system based on QR codes for customers to reserve parking spots before they utilize the car park. Similar to the system in [10], the QR code is solely used to check for the details and verify that the customer has indeed reserved a parking spot before allowing them to park. This authentication feature is not present during the exit process, nor does the system utilize any sort of double authentication features, which leaves room for the cars to be stolen.

TABLE I. SUMMAR OF RELATED WORKS

No	Ref	Mechanism	Limitations
1	[6]	The implementation of a two-factor authentication system combining the elements of ANPR and RFID	• Need an external gadget (RFID card). • System fails if card gets stolen, so no security. • Lack of information of accuracy.
2	[7]	A two-factor authentication system combining the elements of ANPR and facial recognition	• Both, if not one, systems fail with poor lighting conditions. • Only works for registered/existing customers. • Overall number plate recognition percentage is 84% for a sample size of 50 (10 tests per number plate for 5 number plates), so small sample size.
3	[8]	QR generator is used for customers to reserve parking spaces and also used as a verification tool to verify the owner/driver.	• No autonomy, a person/security guard still has to check and verify the owner/driver. • Only works for authorized/registered customers.
4	[9]	The entering car's QR code is scanned and information is stored and is allotted a parking space if spots are vacant	• No verification feature (verifying the owner/driver) during exit process. • No two-factor authentication process.
5	[10]	The customer is identified by parking authorities by their unique QR codes, which contains info about the reserved parking space.	• No autonomy for the driver since parking authorities are present. • No two-factor authentication process, car can easily be stolen as the authorization process is only done during the entry.
6	[11]	The customer reserves a parking space and is later authenticated using a QR code in the carpark.	• No autonomy for the driver since parking authorities are present. • No safety/verification feature during the exit process.

The discussed related works has many demerits whereby a novel double authentication system is needed to improve the security as part of the carpark management systems. This research is trying to address this by introducing a double authentication system which comprises of ANPR and QR code sub-systems to help improve the safety and security of vehicles at carparks.

II. Methodology

The Automatic Number Plate Recognition Double Authentication System (ANPR-DAS) has two sub-systems, which is the Automatic Number Plate Recognition (ANPR) sub-system and the Quick Response (QR) code authentication sub-system. The sub-sections further discuss each sub-system.

A. Automatic Number Plate Recognition System

Fig. 1 shows the ANPR Sub-system broken down into several stages. As can be seen from Figure 1, there are 6 main stages involved in ANPR. Each stage is as crucial as the next.

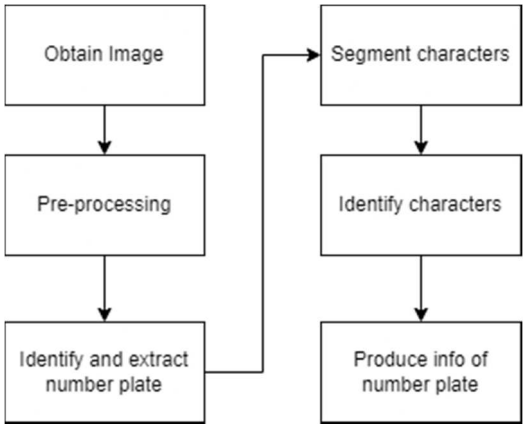


Fig. 1. The process of Automatic Number Plate Recognition.

Step 1: Obtain Image
The first step in an ANPR process is to obtain or acquire an image of the car, either front or back, with the number plate in view in the image. The image quality can vary a lot therefore the picture should be of a high resolution [12].

Step 2: Pre-processing
In this stage, the image attained in the previous stage will be put through a few processing tools, such as the transformation from an RGB image to a grayscale image, noise filtration, binarization and enhancement to ensure that the number plate from the image can easily be identified [13].

Step 3: Identify and extract number plate
The location of the region of interest is found in this stage. The region of interest, being the location of the number plate, will be recognized and several varying methods could be used to extract the number plate [14].

Step 4: Segment characters
In this stage, once the number plate has been recognized and extracted, the individual characters will have to be divided in order for them to be recognized and transformed into valid information. Several varying methods can be used to perform the segmentation of characters [15].

Step 5: Identify characters
In this stage, once the characters are segmented, the characters will be recognized and identified from the image component and will be output as a valid data/information that can be used. The main method is to use template matching, whereby in this method, a cross-referencing method is utilized to identify and recognize the characters [16].

Step 6: Produce info of number plate
In this final stage, the characters that have been identified will be in a usable format of information, whereby the output of the alpha numerals will be in the order of recognition which will match the number plate [17].

Performance Metric is calculated by taking the number of correct characters identified over the total number of the characters in the number plate multiplied by 100%, showing the percentage accuracy. This is shown in Equation (1).

$$a = \frac{n}{t} \times 100\% \quad (1)$$

whereby

a = accuracy,
n = number of correct characters,
t = total number of characters

B. Quick Response (QR) Code

Fig. 2 shows the QR Code Authentication generating model. As seen in Fi. 2, the breakdown shows the number plate data extracted from using ANPR will be paired with a unique row ID. This is then converted into ASCII code and a matrix receives this. Following this, a QR code is generated from the matrix.

As can be seen from Table 2, the information encoding capacity of QR codes includes over 4000 alpha numerals and over 2800 bytes of information.

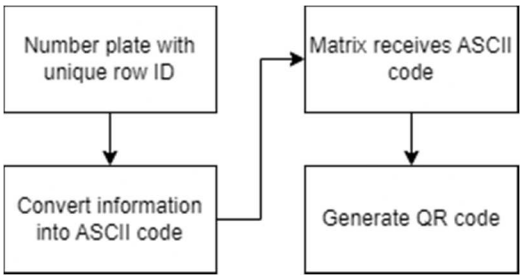


Fig. 2. QR code generating model.

TABLE II. Type of Input Data and the Maximum Number of Symbols

Type of Input Data	Maximum Number of Symbols
Numerals	7096
Alpha Numerals	4296
Bytes	2953

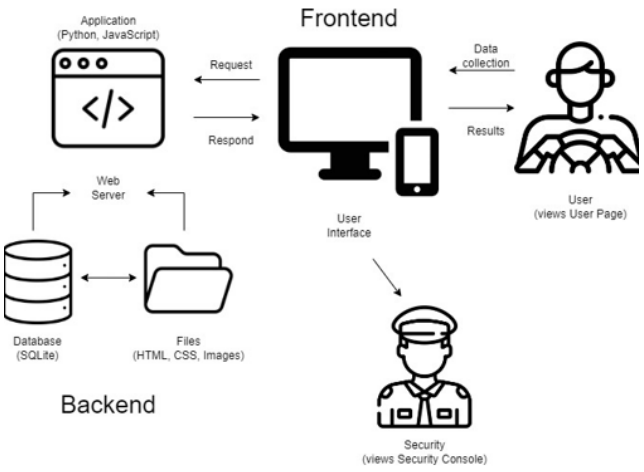


Fig. 3. Architecture of the system.

C. System Architecture

As shown in Fig. 3, the architecture of the system comprises of the backend and the frontend. The backend comprises of the database, which is SQLite and files for the design of the web application which are HTML, CSS files as well as images, which are static images and the dynamic images of the QR codes and the car images. These are on a web server which allows to communicate with the primary logic of the web application, carried out in Python and JavaScript to achieve the communication between the ANPR and QR sub-systems. The frontend of the application is the actual interface utilized by the security and the user/driver in the carpark. The frontend involves the primary interface in which the security can observe the new information being stored and the user will interact to receive and send QR codes to validate their person and car.

III. Results and Discussion

The results in Table 3 are the preliminary results from the ANPR code. A sample of 5 images was used to see whether the ANPR code is able to identify, extract and output information about the number plate from the given images. The input image column shows the image in a grayscale colour fashion before it is processed and the number plate information is found. The output image column shows the image with the information of the number plate which has been identified layered near the number plate on the image.

As shown in Table 4, the input number plate data is shown along with the next two columns displaying the input image and the output image with the number plate data extracted and placed on the original image. Table 5 further shows the performance of the ANPR sub-system. As seen in Table 5, the number of runs each sample data was put through with the success rate varying from 82% to 93%, leaving an average error of 11% which is less than 15%. A sample size of 30 images were run but the table displays a sample of 5.

TABLE III. Results of the images processed by the ANPR system.

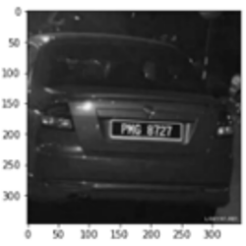
No.	Input	Output
1.		
2.		
3.		
4.		
5.		

TABLE IV. Results of image acquistion

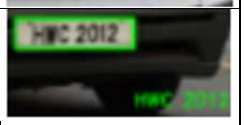
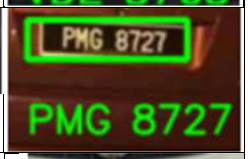
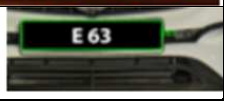
Input Number Plate Data	Input Image	Output Image
QAT 3111		
HWC 2012		
VDE 3763		
PMG 8727		
E 63		

TABLE V. PERFORMANCE OF THE ANPR SUB-SYSTEM.

Input Number Plate Data	No. of Runs	Success Rate
QAT 3111	10	90% – 93%
HWC 2012	10	84% – 89%
VDE 3763	10	85% – 90%
PMG 8727	10	86% – 92%
E 63	10	86% – 93%

Fig. 4 shows a screenshot of the QR code generator, whereby the picture on the left is for the QR code generator and the picture on the right is the generated QR code based on the text input

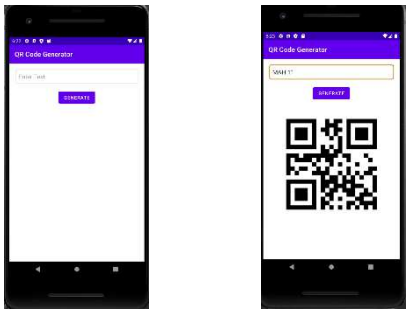


Fig. 4. Screenshot of the QR code generator.

The primary advantage of ANPR systems is the added security, both for public and private use. The system acts a huge deterrent as the system can operate based on existing information about vehicles and the respective number plates or to obtain new information, with the system's capability to perform real-time data collection. The next advantage is that it is a fully automated service. Although at certain places the need for human interference, the system can perform data collection and verification in a fully automated fashion, providing high-accurate readings and 24/7 operation.

One of the biggest advantages right now during the coronavirus pandemic is that it is hygienic to use. This reason attracts customers and business alike to use QR codes, as they can distribute and collect information safely and quickly, which means that they are trackable. Another advantage is that is hugely accessible. 94% of people look for information about local things on their smartphones, and since smartphones have an in-built QR code scanner, it is very easy for people to find information. Another advantage is that is it very cost effective and leaves a small carbon footprint. Since information can be delivered and viewed digitally, the need to print a high number of flyers, pamphlets, menus, etc. is now reduced drastically, if not eliminated. The small size of QR codes also mean that printing costs are much lower, so it is extremely cost effective to utilize.

Therefore, this research utilizes the advantages of both systems to perform double authentication on the driver to ensure the safety and security of the vehicle in the carpark.

IV. CONCLUSION

The sub-systems are working as the ANPR sub-system is successful performing image processing and extracting the number plate data from the images while the QR code sub-system is able to generate the data from the extracted number plate data with a unique ID. The results are successful. Future work involves improving the ANPR sub-system to better perform segmentation and identification of characters. The QR code authentication system will also be improved to have a QR code decoding system to so that the driver can also receive the info encoded in the QR code. With these two sub-systems, ANPR-DAS works as intended by extracting the number plate information from the image of the car and generating a unique QR code for the driver to perform double authentication.

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