Chapter 7
AUTOHAUS:
An Optimized Framework for Secure and Efficient Parking

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ABSTRACT

In this chapter, an optimized parking framework, AUTOHAUS, is presented that focuses on three aspects (i.e., automation, security, and efficient management of parking space). A combination of advanced technologies is used to design the proposed framework. AUTOHAUS provides two ways of security implementation such as authorized QR codes and OTPs (one-time passwords). Furthermore, for efficient management of parking spaces, the still images of the front and side view of the car are used to extract the license plate and size of the car for effective allotment of parking space based on the size of the car. This proposed system can reduce human effort to a great extent and can also be used as a path-breaking technique in parking and storage management.

DOI: 10.4018/978-1-6684-4991-2.ch007

INTRODUCTION

Nowadays there is a tremendous rise in the automobile industry and the need for an efficient and secure parking system is of great concern today. This great increase in this industry has led to an abundance of cars which leads to a shortage of parking spaces (Jusat et al., 2021). There are various automated parking systems available, but none of those systems has the ability to manage space efficiently (Mathijssen & Pretorius, 2007); (Serpen & Debnath, 2019). Hence, there is a need for a mechanism that will replace the current system which doesn't have the ability to manage special resources. The current automated parking systems have shown a great deal in the evolution of automation technology but technology can always be optimized and improved (Pala & Inanc, 2007). Seeing these current systems and the issue of the decreasing parking spaces, a solution comes to light that is based on the type and the length of the car these spaces and can be efficiently managed and utilized. Also seeing today's users are very convenient using mobile devices for everyday tasks. The integration of the parking system with mobile device brings additional functionality to the system which not only provides ease of access to the users by finding the parking system and automatic payments, but it can also provide a layer of security that only the mobile device will be able to control the entry and exit of the car from the system.

Motivated by the mentioned problem domain and through the development of new technologies, here an efficient and automatic parking model is presented, where two main parameters are presented i.e., security of cars and the efficient use of parking space. When the car enters the parking system based on its type and size a parking spot is assigned to the car, this is based on the theory that three small cars take up almost the same space as two sedan cars. Furthermore, with this, some security features are also implemented and an app was developed to speed up the parking process.

This proposed framework is a solution to various parking problems that a man faces daily, first it caters to the biggest problem of efficient parking spaces which is a major concern in today's world, especially where there is a scarcity of space. Secondly, the system's interface has two options for making an entry which includes scanning of the QR code option for the user who has a mobile app pre-installed, in this option the user has to just scan the QR, and the rest is done automatically at the system's end, and at the time of existing user just has to show the generated code at mobile in the system for the successful exit. The second option is for the user who doesn't have the mobile application installed on their mobile device, this is option is an OTP password system an OTP (One Time Password) is sent to the user's mobile number and the user has to enter the password at the time of entry, and at the time of exit, the user has to put in another password sent to the same mobile device to

exit the system. The mobile application of this system will have some additional features which will cater to some problems like finding the parking system and paying for the services. The application will have an option to automatically pay for the parking services and it will have another tab that will have the option to find the parking system for the users who are unaware of the location of the parking or are new to the area, the application will help them find and navigate to the nearest parking system.

BACKGROUND

Vehicle parking is one of the major issues, Indian cities are currently facing. Due to the rapidly expanding population, more cars are added continuously in the restricted public areas, and thus the majority of Indian cities are facing traffic congestion and parking-related issues. Developing an advanced and optimized parking system is always a key issue among researchers and developers. With the advancement and incorporation of new technologies, developers are trying to develop more advanced methods to solve parking issues more effectively.

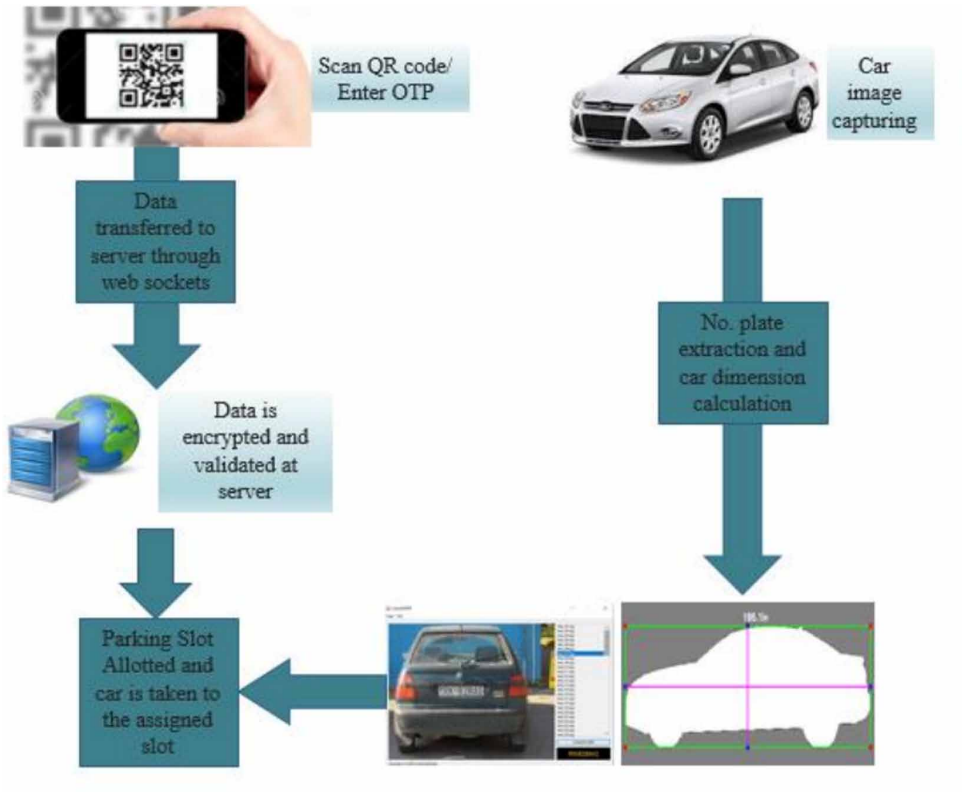
Various novel approaches have been successfully implemented. One can see a multilevel parking system in metro cities, where the optimized utilization of vertical parking space can be seen (Mathijssen & Pretorius, 2007). These types of multilevel parking system have made the parking situation a little better, but still, a lot of issues exists such as waiting time, spacing issues, searching for parking space, etc. Various smart parking-related systems were also developed to solve the existing parking-related issues. Technologies of all kinds are being employed to solve the parking issues in public areas. For instance, RFID technology can automate the payment system and shorten the time required for vehicle check-in and check-out. Similar information can be gathered via wireless sensors, such as parking duration, available slot, payment details, directional details, etc., which will benefit drivers and ease parking woes (Pala & Inanc, 2007). Given the growing number of parking issues in both established and emerging nations, smart parking is a niche market in which many businesses are currently making significant investments. IoT and advanced technologies such as AI, ML can provide more efficient and optimized solution to the current issue (Jog et al., 2015); (Hongyan, 2011). Some of the related systems are discussed here to show the need of the more optimized solution for the mentioned issue.

A Car Parking Framework (CPF) based on IoT technology is suggested by Karbab et al. (2015). The framework integrates a radio frequency identification system with a networked sensor and actuator system to manage parking spaces automatically (RFID). The CPF offers security, parking lot retrieval, payment options, and vehicle

guiding. Instead of standard nodal communication, the system employs a hybrid communication technique. As a result, the system uses little energy and is inexpensive to implement. A protected parking reservation system using the Global System for Mobile (GSM) technology is proposed by (Rahayu & Mustapa, 2013). A parking space monitoring module and a security reservation module make up the system. The reservation of a specific parking lot is handled by the security reservation module. To reserve a parking space, the user must send a Short Message Service (SMS) containing detailed instructions. The parking lot monitoring module shows the user animation of the layout showing the occupancy status of the parking spaces, allowing them to select a parking lot for reservation. A password is generated by the system and is necessary at entry and exit points. Further the use of computer vision technology for solving parking related issue is explored in (Masmoudi et al., 2014), where the system offers an outdoor parking service that can locate vacant parking spaces in real-time and transmit the address to the driver for vehicle navigation. To deal with the security issues in parking system, an IoT-based system is proposed by (Singh et al., 2019), which uses a two-way security using face recognition and license plate recognition-based approach to offer a key-based parking reservation system that guarantees the right person will be assigned the parking space

Although a lot of systems have been proposed to date (Serrão & Garrido, 2019); (Fahim et al., 2021), still their real-time using is missing due to a range of implementation and cost issues. Motivated by the issues discussed, in this paper, an automated parking framework is proposed which focuses on three main factors i.e., complete automation, security, and efficient utilization of space. In the proposed approach, complete automation is proposed where users can enter the system through QR code or OTP-based authentication method, in parallel using the front and side view of the car, the license plate number and size of the car will be calculated using a computer vision technology. Further, an optimized slot according to the size of the car will be allocated to the unique license plate number. The proposed approach can be used in both fully automatic and semi-automatic way, where users can park the car themselves or it can be parked by the automated parking machine at the calculated optimized slot. The user can simply check out through the system by showing the QR code at the exit. After successful authentication, the car will be delivered to the user at the exit point. The proposed system deals with the security and space-related issues and provide a complete hassle-free solution to the parking issue.

Figure 1. Flow diagram of the proposed parking framework



AUTOHAUS: PROPOSED PARKING FRAMEWORK

System Designing

The proposed AUTOHAUS parking framework is a model for providing an effective parking framework to the users, which utilizes the parking space effectively and an end-to-end automated and secure parking system using a combination of advanced technologies. The workflow of the proposed parking framework is presented in Figure 1. Various steps of working of the system is discussed below.

- The system consists of two types of authentications for secured entry of cars into the parking infrastructure. The first one is QR code-based authentication, and the other is One-time password (OTP) based authentication. Both methods can be accessed by the user through the mobile application. After the successful authentication, the data of the user will be transferred to the web

server using web sockets which create an open-bidirectional communication channel. After the data is sent to the server, the server decrypts the data received for validation and after the validation, two parallel processes are started for finding the correct slot for parking

- The two parallel processes are then executed to extract the information from the images of the car. The still images of the car are extracted using installed cameras in two directions, one contains the front view of the car to extract the license plate no. of the car and the other one contains the side view of the car to estimate the size of the car.
- The extracted data from the above-mentioned steps are then used by the system to assign the specific slot of parking to the particular car based on its size.

Hardware/Software Requirements

Software requirements

- Operating System: Windows 10/8.1/8/7
- Processors: Any Intel 64-x86 processor
- RAM: 2 GB is recommended
- Disk Space: 4–6 GB for a typical installation

Hardware requirements

- Arduino Board
- Two Cameras
- Servo Motors

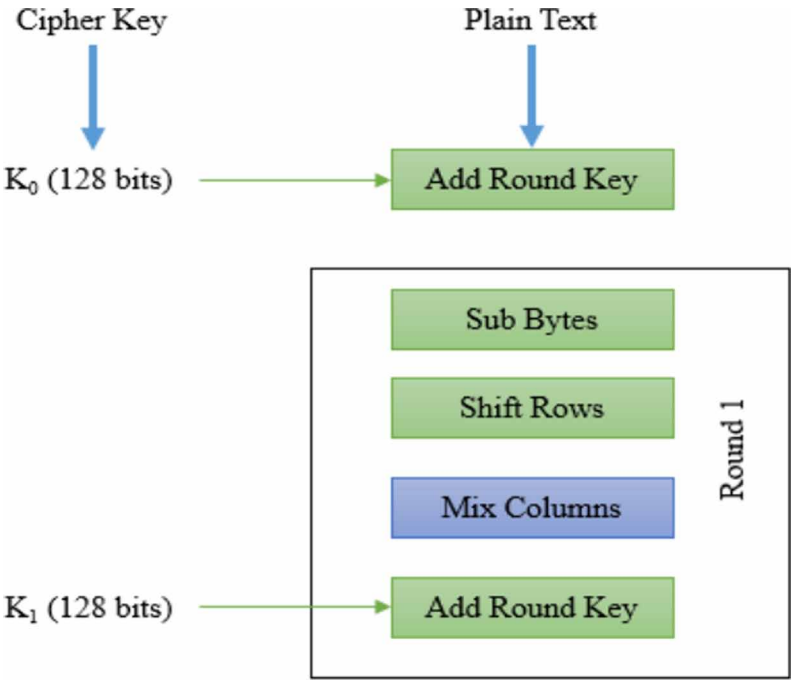
System Implementation

QR Code Authentication

As mentioned in the system designing section, the proposed system consists of two types of authentications i.e., QR code-based authentication and OTP-based authentication. The complete process of QR code-based authentication in the proposed parking framework is discussed below.

An encrypted QR code will be installed in the proposed parking system, and the user will be able to scan the QR code using any scanning-enabled mobile application. The QR Code is designed in such a way that the data it carries is encrypted by 128-bit encryption using AES algorithm. Code encryption is used to ensure that there

Figure 2. Encryption process in QR code-based authentication (Al-Ghaili et al., 2020)



is no security breach when some tries to read this code using other methods which makes it a more reliable and secure method of authentication for entering the system.

Encryption Process (Naser et al., 2020): The encryption process contains four sub processes; it starts with Sub bytes which is the byte substitution method that gives out the result into 4x4 matrix form. Then comes the shift rows in which all the rows are shifted to the left which further includes some sub steps. Then in Mix Columns the transformation of the matrix is done using distinctive mathematical functions, after that during the Add round Key step, the 16 bytes matrix is now considered to be 128 bits which is the last round, after that the output comes as the cipher text, the Flow of Encryption process of the AES algorithm is presented in Figure 2:

Decryption Process: The decryption process is the reverse of the encryption process where each step of encryption process is implemented in the reverse direction to generate the original text (Al-Ghaili et al., 2020).

QR Code Generation (Naser et al., 2020): The data that needs to be represented in the QR Code is encrypted at the server side and sent to the client, then using that data JavaScript prints QR code on the client side with the help of an open source library qrcode.js. The sample code for QR Code generation is presented in Figure 3.

Figure 3. Sample QR Code Generation Code

```
<div id="qrcode"></div>

<script type="text/javascript">
var qrcode = new QRCode("test", {
    text: "Sample QR Code",
    width: 128,
    height: 128,
    colorDark : "#000000",
    colorLight : "#ffffff",
    correctLevel : QRCode.CorrectLevel.H
});
</script>
```

License Plate Recognition

The recognition of number plates is a complex process, for that a special open-source tool is used known as JavaAnpr, which is Java Automatic Number Plate Recognition System (Lubna et al., 2021). The steps that are followed by this tool are described as follows:

a) Rank Filtering and Edge Detection: Figure 4 shows, how the original image is first vertically and horizontally rank filtered then horizontal and vertical edge detection is done using sobel edge detection method (Lubna et al., 2021).

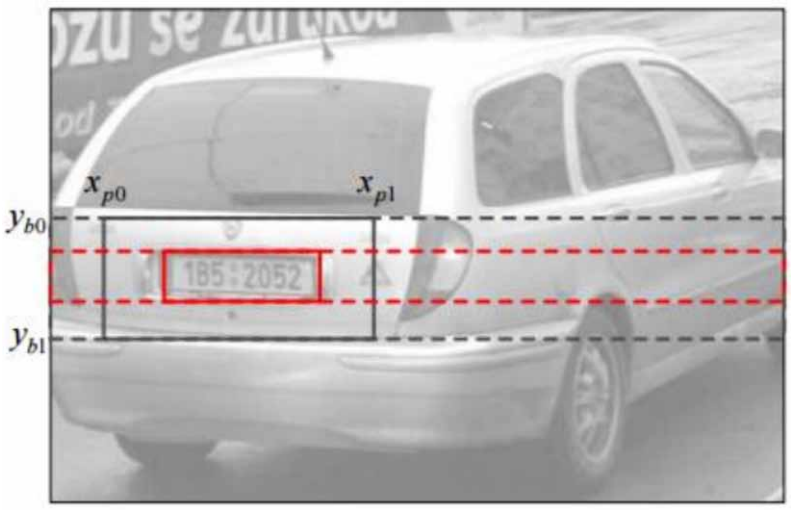
b) Two Phase image analysis: In the first phase, the detection of the portion of the number plate which covers the wider area is covered (Lubna et al., 2021). Then when it comes to the second phase the result from the first is skewed and then processed as shown in Figure 5.

c) Segmentation of the Number plate: Number plate is segmented using the horizontal projection, adaptive thresholding is done in order for the separation of the dark foreground from the comparatively light background as shown in Figure 6.

Figure 4. Rank filtering and edge detection

d) Feature Extraction: To extract the specific characters in a number plate, a pixel matrix is created as show in Figure 7, then the number of loops are determined as shown in Figure 8.

Figure 5. Two phase plate clipping



e) Recognition of characters: After feature extraction step, the specific characters are then recognized which results into the recognized number plate.

Figure 6. Result of application of adaptive Thresholding on number plate

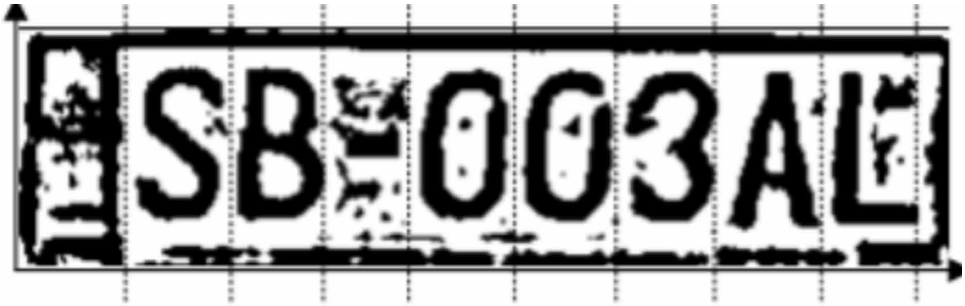


Figure 7. The "pixel matrix" of specific character

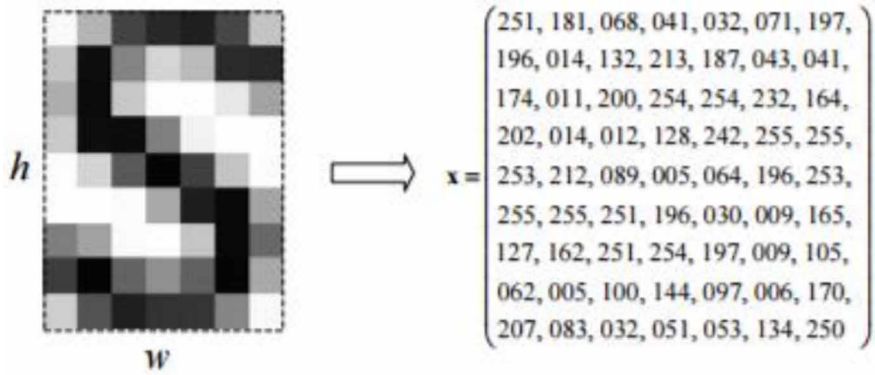


Figure 8. Calculation of number of loops

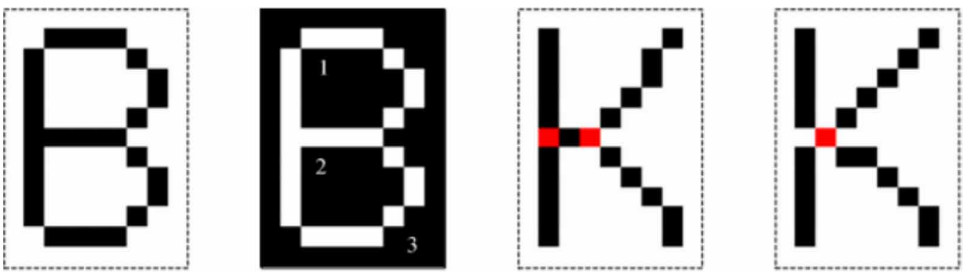


*Figure 9. Image Conversion from RGB color space to L*a*b* color space (a) Input Image (b) Converted Image*

Car Size Estimation

To estimate the size of the car from its image, first, the car part is segmented from the background, then the length of the car is calculated. Various steps in achieving this are discussed below:

Segmentation of Car from Background: For the segmentation of the car from the image background, the color-based segmentation is used which is done by using K-Means Clustering algorithm (Na et al., 2010). K-Means clustering is a powerful algorithm and can be easily implemented using requires "Statistical and Machine Learning Tool Box of MATLAB". The various algorithmic steps of implementing K means Clustering algorithm on the colored images is described as follows:

a) Image Conversion into L*a*b* color space from RGB color Space: Converting the image into L*a*b* color space from RGB colors: In this step, the image is converted into "L*a*b*" color space, which comprises of "luminosity layer L*", "a*" layer which is the chromatic layer, and is used for indicating the falling point of the color on the "red-green" axis (Li & Wu, 2012). Another layer "b*" which is the chromatic layer, is used for indicating the falling point of the color on the "blue-yellow" axis. The output of the color conversion is presented in Figure 9.

b) K-Means Clustering: The K-means clustering is then applied to separate object from the background. K means clustering follows the principle that every object is having a unique location in 3-d space. The main task is to discover partitions in such a way that objects of the same clusters are kept as close as possible and the objects of the other clusters are as farthest as possible (Na et al., 2010).

Figure 10. Image labelled by clustering index

c) Labeling the pixels in the image after K means clustering: After the K Means Clustering is applied every pixel in the image is labeled with it is corresponding clustering index, as shown in Figure 10.

d) Car Segmentation: With the help of K-Means clustering, different clusters were extracted, to extract the cluster contains car as shown in Figure 11.

Car Size Calculation: Measuring the length of the car is done by using an open-source tool OpenCV which is fully packed with computer vision algorithms. Here OpenCV on the python programming language to calculate the length of the car. There are various steps involved in the calculation of the length of the car which is described as follows:

• First, various required packages were imported into the python program, the most important package is "imutils". The input image is loaded and the important preprocessing steps were implemented. First, the image is converted into grayscale, followed by smoothening of the image using Gaussian filter as shown in Figure 12

Figure 11. Different clusters of the input image

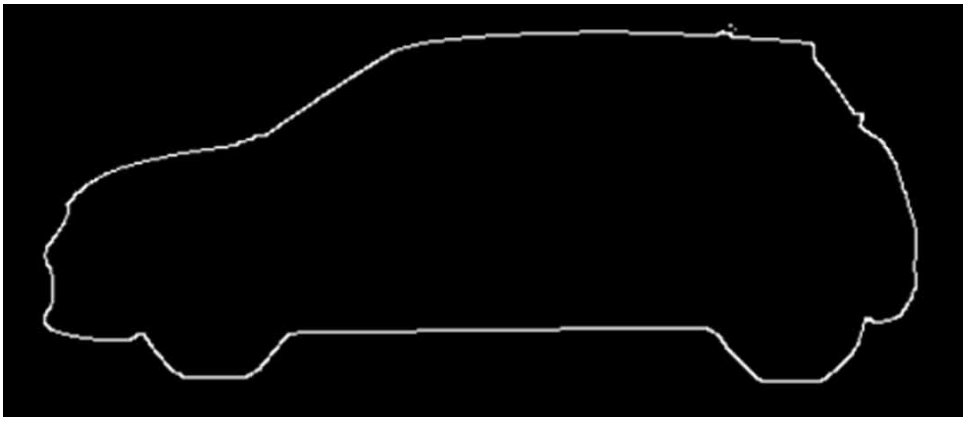
Figure 12. Segmented Image conversion into Grayscale

and Figure 13 respectively. Then edge detection is performed using a combination dilation and erosion as presented in Figure 14 (Canny, 1986).

- Then a midpoint () function is implemented, which is used for computing the midpoints for the major and minor axis. In this step a loop is started in order to decide that if a contour is not sufficiently large it should not be taken into consideration assuming that as noise (Manchanda & Sharma, 2017). If the contour is found to be considerably large then the rotated bounding box is computed, with surrounding midpoints as shown Figure 15.

Figure 13. Smoothening of Image using Gaussian Filter

Figure 14. Output of Dilation Erosion on filtered Image



- Finally, the length of the car is calculated using the Euclidean distance between points on the extracted bounding box as mentioned in figure 16.

Parking Slot Assignment

After successful authentication from the QR code, and through the extracted data from the car image i.e., car length and license plate, the assignment of slot is made. The availability of the slots is derived from a custom-made database as shown in Figure 17. The slot assigning algorithm is designed in such a way that it caters to

Figure 15. Bounding box Estimation

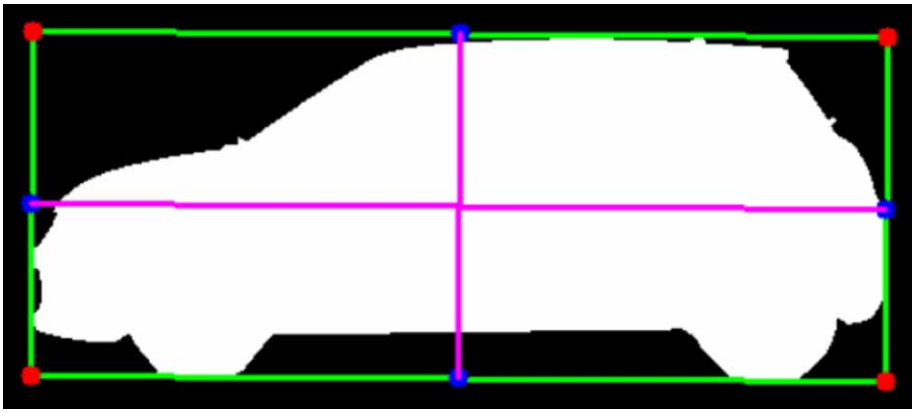
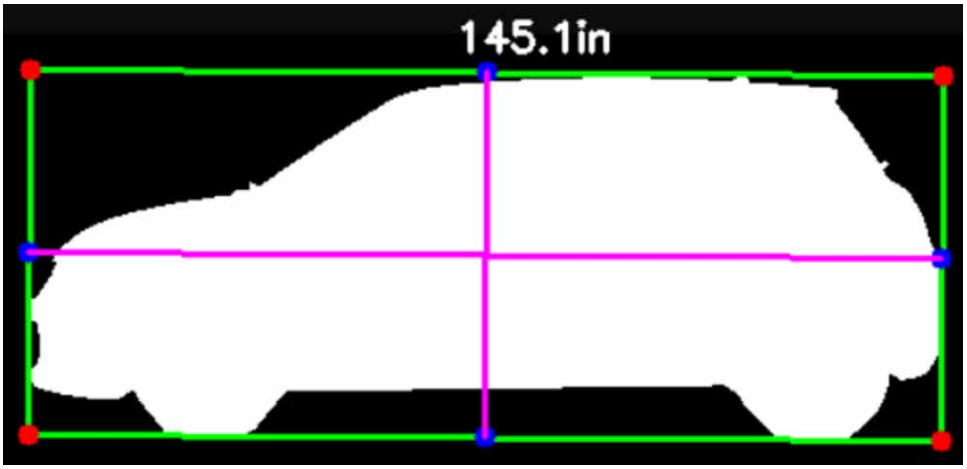


Figure 16. Car Length Calculation



every possibility to assign a slot so that no slot is wasted and the maximum number of cars can be parked in the system.

AUTOHAUS: SYSTEM INTERFACE AND USE

In this section, various results obtained during the testing of the model are presented and discussed. The front-end startup interface of the AUTOHAUS parking system is shown in Figure 18, in which there are two options for making an entry into the parking system, first being the QR Code method and second being the OTP method.

Figure 17. Database Snap for Slot Allocation

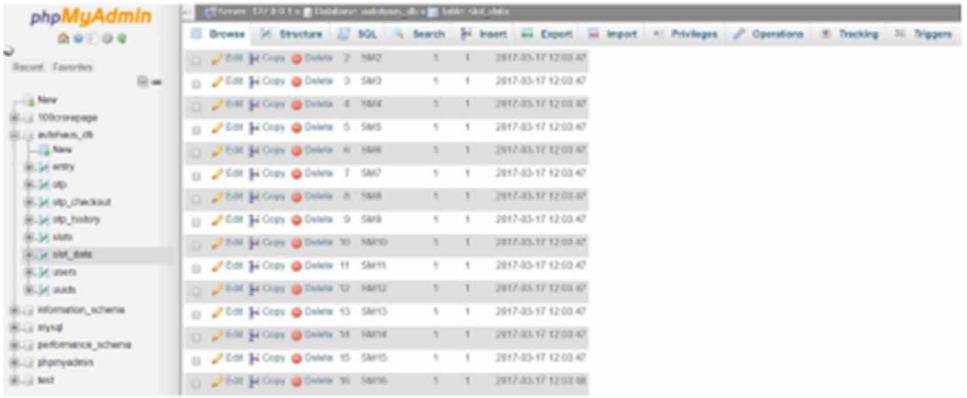
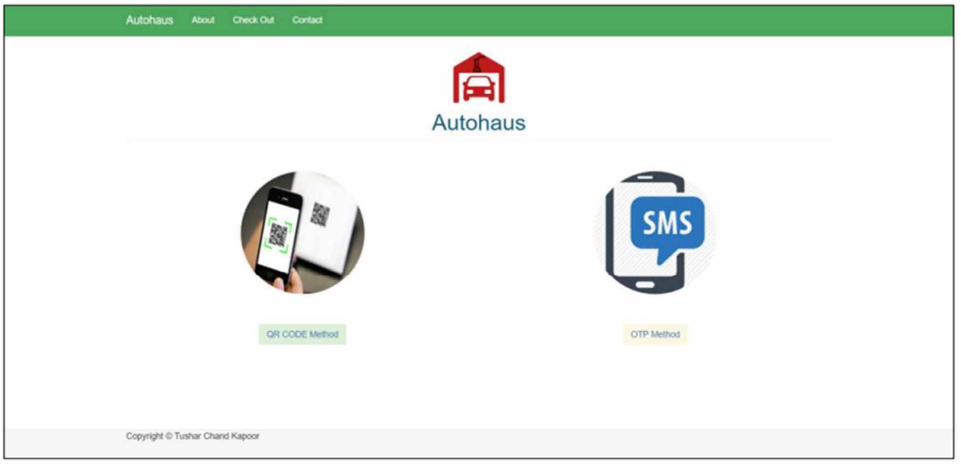


Figure 18. Front End Startup Interface of the AUTOHAUS parking system

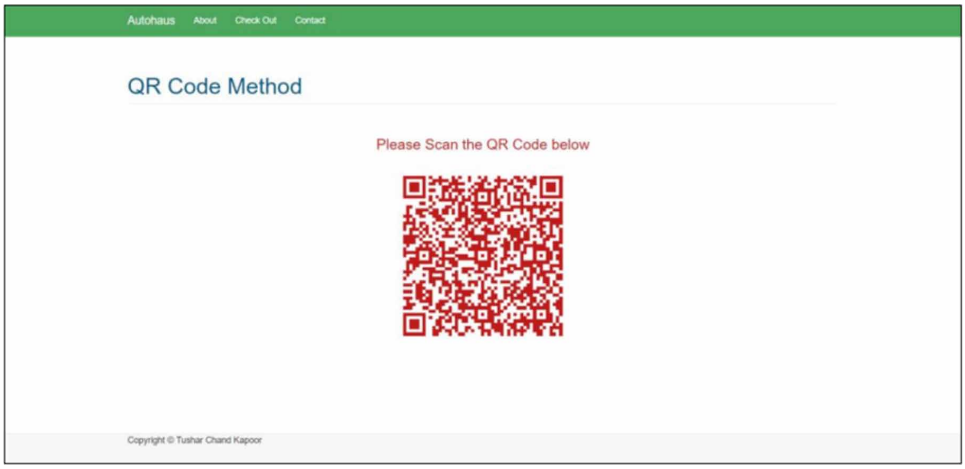


After the successful selection of the provided options by the user, the second phase of the interface starts as per the selection. If the user selects the QR Code method, an encrypted QR code is generated as shown in Figure 19, in which a unique code is displayed for each entry. The QR code can be scanned through a mobile application. The front end of the mobile application is presented in Figure 20, which also performs the task of decrypting the code displayed on the system. After successful authentication of the user, a parking slot will be assigned to the user according to the length of the car as shown in Figure 21.

Further, if the user selects an OTP method for entering into the parking system, an option to enter a mobile number is displayed as shown in Figure 22. After successful entering of mobile number, and an OTP is sent to the mobile device as shown in Figure 23.

After successful authentication of the user into the car parking system through any of the provided options i.e., OTP based authentication or QR code-based authentication, the second phase of the system starts which is the assignment of parking slot according to the length of the car. This system runs in parallel to authentication phase when the car enters the system. First, an automatic license plate recognition is performed on the front view of the car as shown in Figure 24. Second, the length of the car is calculated through the side view of the car. The side view of the car is presented in Figure 25, which is then used to calculate the length of the car as per its size using the approach mentioned in the previous section. Based on this calculation a parking slot is assigned to the user on the name of its license number.

Figure 19. Encrypted QR Code



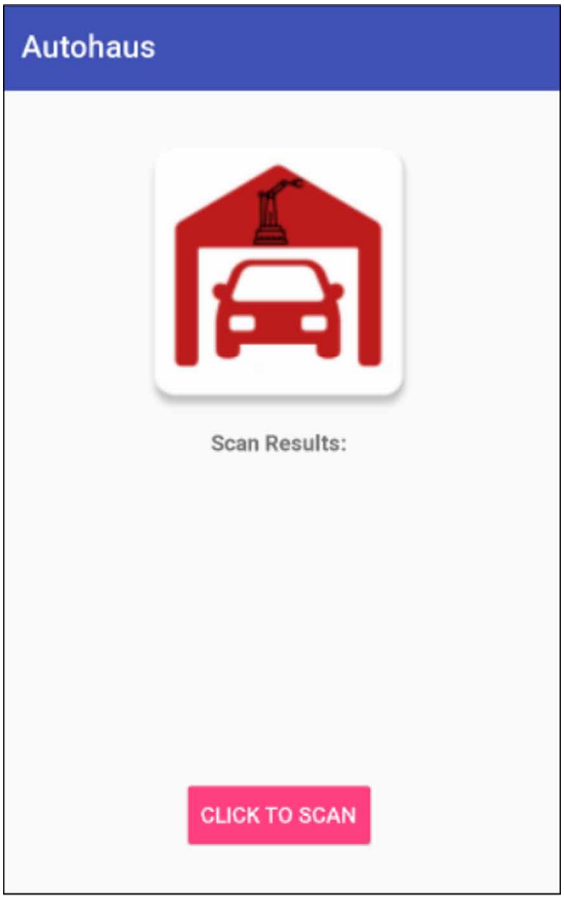
After successful parking of the car at the assigned parking slot, a user can check out from the system using the same two options i.e., OTP or QR code-based checkout. The checkout interface of the parking system is shown in Figure 26.

The user will have to show the QR code at the exit of the system, which will provide the car and the parking slot information to the backend. This QR code will be used to authenticate the user, and after successful authentication, the car will be delivered to the user.

CONCLUSION

In this chapter, an automated parking framework is proposed to tackle the space, security, and automation-related issues during the parking of the car. The proposed AUTOHAUS parking system provides a hassle-free automated facility to the user. It is observed that the space provided for a big car can be used to park two small cars. Based on this space-related concept, here the size of the car is used to assign a specific parking slot to the car. Furthermore, to provide a completely automated parking environment to the user, here two methods have been proposed to authenticate the user i.e., OTP-based authentication and QR code-based authentication. The user can check in and check out from the proposed automated parking system using any of these methods. The system provides a space-efficient parking slot to the car, further at the time of checkout the same authentication method can allow the hassle-free successful delivery of the car to the user. In this paper, the prototype of the proposed parking system is presented, which shows its real-time efficacy and

Figure 20. Front End of the Mobile Application



applicability. This type of automated parking system is much-needed system in the world of advanced technology.

Figure 21. Confirmation after Successful Authentication

Figure 22. OTP based authentication method

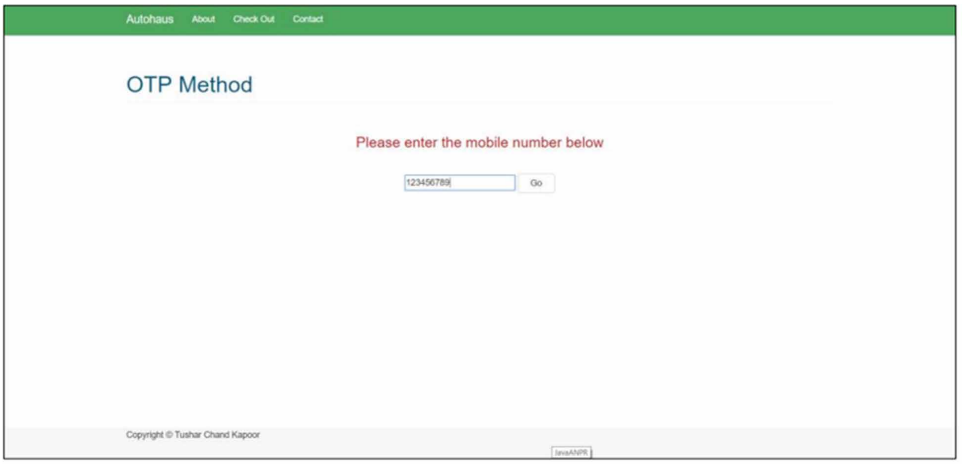


Figure 23. Successful authentication through OTP

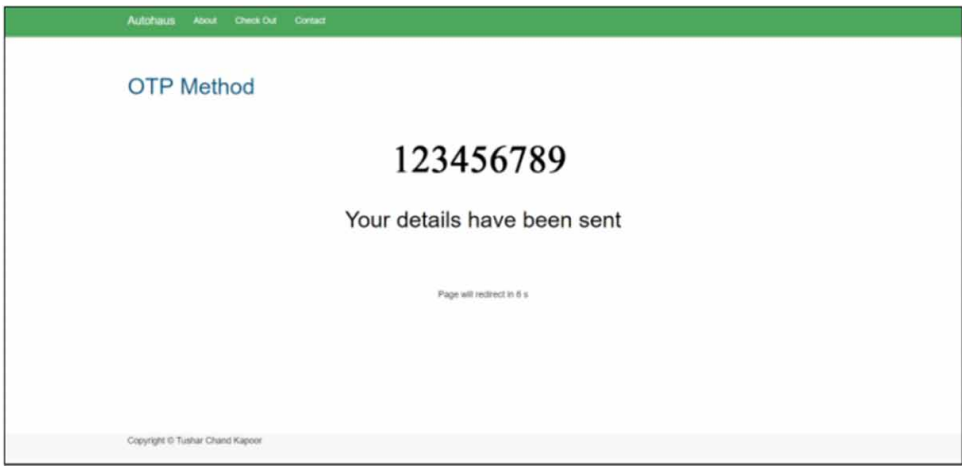
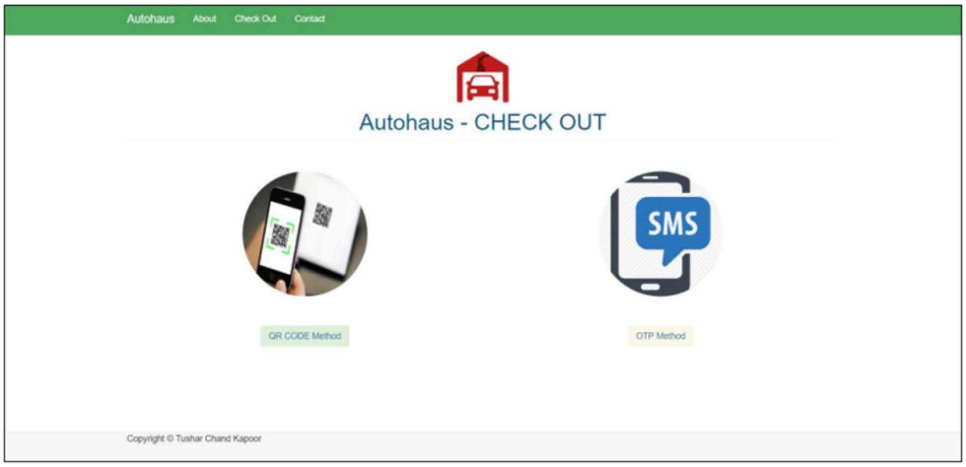


Figure 24. License plate recognition through front view of the car

Figure 25. Side view of the Car

Figure 26. Front End of the Checkout Interface



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