GRADIVA

Volume 64 | Issue 01 | January 2025
DOI: 10.5281/zenodo.14697731

# Smart Parking System: Automated Assistance and Management

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## Abstract

With the increasing number of vehicles on the roads, parking has become a major concern in most urban areas. To address this problem, a smart parking management system that uses image processing and objects detection techniques to detect parked vehicles and generate text from number plates is developed. The system uses two webcams, one to check the availability of parking slots and the other to capture the number plate of the incoming cars. The proposed system uses image processing and object detection algorithm to detect parked cars and extract number plates from the images. The number plates are then processed to generate text that can be used to identify the cars. From that the duration of stay will be identified and a bill for the parking is generated. Once the bill gets generated the gate sets to be opened. The proposed system is designed to detect the shortest distance for parking and assists drivers with directions to available parking spaces at the front. To assist the user in searching for free parking slot and to ensure the security of the parking slot, a gate control mechanism is implemented. The gate will only open if there is a free parking space available, and the incoming car's number plate is recognized and verified by the system. This proposed system is suitable for real-time analysis and provides an efficient solution to managing a large area of parking slots with less human labor and in less time.

**Keywords**: *Parking Management, Object Detection, Image Processing, Machine Learning.*

## 1. INTRODUCTION

The need for a smart parking system has become increasingly urgent in today's urban environments due to the increased population and the vehicles used. Traditional parking systems are often inefficient because the drivers have to move around the parking lots to seek for an available spot. This leads to congestion, frustration, and increased pollution. In addition to this, physical sensors used in many parking systems can be expensive and difficult to install.

The major issues faced by the parking system are misuse of available parking spaces, consumption of more time and fuel, encroachment of business parking lots by passenger parking in finding parking spaces and incorrect parking etc. So it is necessary to automate the parking system, reducing the need for human intervention and increasing efficiency.

In [1, 2 & 19], an IoT based smart parking management system is proposed. This system uses IR sensors to check for free car parking slot and mobile application to check for the free available slots for parking. In [3], IR sensor based car parking system is proposed. The system produces higher output voltage when the object coming closer to it.

The count of free slots available is displayed to the entering the parking area. In [4], IR sensor and IoT based parking system is developed. The system uses mobile application for booking the slots. An IoT based smart car parking system is developed in [5].

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This work illustrates the types of sensors used for identifying free slots and compares the different system requirements such as hard ware and software tools used and its significance in specific place of implementation. An analysis of different methods and system components used in smart car parking system is performed in [6, 7 & 8].

The analysis explains the methods and devices used for information sensing, sensor connectivity, parking meter, Crowd sensing, Shared Parking and about the software and hardware system used and requirements. An IoT based car parking system is developed in [9], to guide the user for free parking spaces. To provide secure parking, RFID is used with cars. In [10], an IoT based car parking system is studied. The parking occupancy rate is determined using machine learning methods. A smart parking system using facial features is proposed in [11].

This system includes web application, face recognition and free slot detection. Face recognition is used to identify the person requesting the parking slot. The user first has to book for the parking through web application along with the face feature. When the user enters the parking area, facial recognition will be done by comparing the face recorded during entry and the face in the database created during registration.

The user then will be guided for free slots. In [12], a Bluetooth reader is used to identify the user and the user has to register for utilizing the parking area. The Bluetooth has to be re-started at the time of exit. In [13 & 14], for the smooth flow of traffic, parking slot allocation is performed based on the number of people actually utilizing and by reducing gap between the slots. Genetic Algorithm based dynamic shared parking method is proposed in [15].

This method enables people nearby to rent the parking slots to private sectors. In [16& 17], an online parking assignment method is proposed for connected cars. It uses a multi-agent deep learning framework to fulfill parking demand but without the parking price management system. Mobile application based parking management system is proposed in [18], and uses IR sensors for locating free slots. In [20], IoT and wireless sensor network based smart parking management system is proposed. To sense the free parking slots, the proposed approach uses infrared sensors and light dependent sensors to sense the light beam from the parking alarm to display the information regarding free or occupied slots.

The existing system uses IR sensors, complex web application and blue tooth modules for booking slots. Most of the systems use pre-registration for availing parking space. The user needs to have the web application in their car or mobile for registration. The smart parking management system proposed here includes two image acquisition systems: one for monitoring available parking slots and the other for capturing the details of the vehicles such as number plate. The data collected are processed using object detection and image processing techniques. The prototype of the proposed system uses a microcontroller with the FIRMATA library to control the opening and closing of the gate using a servo motor.

The gate will only open if there are available parking slots. Once the vehicle is parked, the billing system will charge the driver based on the time the vehicle is parked. The billing details will be stored in the same CSV file, and a QR Code for payment transactions will be displayed with all necessary details during check-out.

The proposed system helps save time for both car owners and parking attendants. Car owners can quickly find empty parking spots, and parking attendants can quickly manage parking allocation. This system can help improve parking lot security by keeping track of the number of cars parked and the duration of their stay, reducing the likelihood of theft and offers

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a cost-effective solution to parking management, eliminating the need for costly sensor systems providing an alternative to expensive parking management system.

Reduced fuel/gas consumption in finding open parking spaces because of guidance to parking slots. The system provides a flexible solution that can significantly improve the parking experience for drivers, reducing traffic congestion and making parking more efficient. The existing model uses Sensor for detecting the available free spaces; the proposed smart parking system will use only the camera instead of sensors.

Therefore the proposed system will eliminate the need for physical sensors, which can be expensive and difficult to install. It also provides real-time information about parking availability, which can help drivers save time and reduce frustration.

The objective of the proposed work is to develop an automated parking system using Image acquisition systems like camera and Image Processing techniques to detect available parking spaces and recognize the number plates of the incoming cars using object detection methods and to generate a bill based upon the entry and leave time of the car. This system also provides security using a Microcontroller based gate control along with an LCD Screen to prevent new cars from entering when all parking slots are already occupied and automatically opens up when the car is about to leave the parking slot.

This system also provides shortest path to reach the free slots to reduce fuel consumption as well as time for searching the free space. This paper is organized as follows: section 1 describes the need for the proposed work, objective of the automated parking system developed and existing methodologies. Section II describes the proposed system block diagram, flow diagram of the proposed work and the system components. Section 3 presents the results obtained and section 4 concludes the work proposed.

## 2. AUTOMATED PARKING MANAGEMENT SYSTEM

The presented automated parking management system here uses an image acquisition system to capture live video-stream for free slot identification in parking area. Image processing techniques and object detection algorithm is used to find free parking slots and number plate generation. With entry and exit time, the bill for utilizing the parking area is generated and the user is guided to pay through QR scanning. This section describes the proposed system block diagram, flow diagram of the proposed system, system components and algorithms used for free slot identification and vehicle number plate identification.

### 2.1 Block Diagram of Automated Parking Management System

The automated parking management system prototype developed contains two Image acquisition systems one for capturing and identifying free parking slots and the other for capturing the vehicles number plate for the purpose of bill generation. It uses Ardiuno to open the gate for the vehicles entry to the parking area only when the free slots are available. If there are no free slots identified, then the gate remains closed and no vehicle is permitted inside.

The proposed system also guides the vehicles to the nearby free slots using a slot route guidance system to avoid fuel wastage in searching for the free slot location and generates bills to collect charges for the utilization of parking area. The proposed system helps the user to pay their bills by scanning the QR code for quick paying and to avoid crowd for bill payment. Figure 1 shows the block diagram of the proposed Smart Home Security System.

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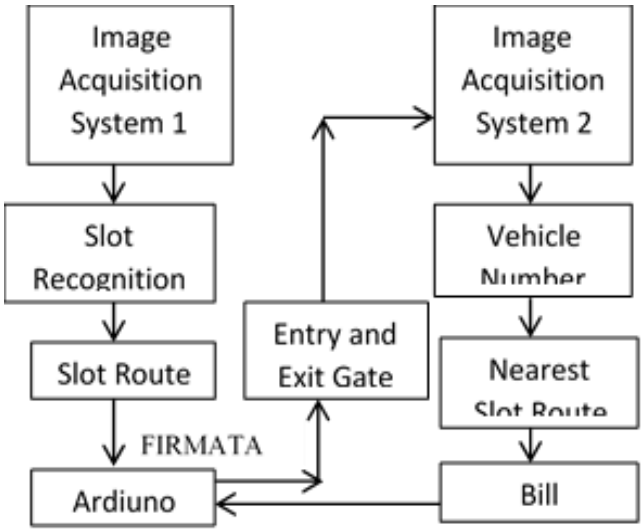


**Figure 1: Automated Parking Management System**

The image acquisition camera 1 captures the parking area to monitor the availability of free slots. The parking area undergoes few image processing steps to identify free parking slots. The available free parking slots are counted and marked with slot numbers so that the total available free parking slots are identified and notified to the users. The free parking slots are identified by the presence of a vehicle within the slot. If there are no vehicles, the slots are identified as free slots. The users are allowed to enter the parking area only when free parking slots are identified. The entry gate is opened by a gate control mechanism controlled by Ardiuno. Once the vehicle is permitted to enter, the vehicle number is captured using a second camera and the vehicle is guided to the nearest parking slot by slot route guidance system. An object detection algorithm is used to identify the number plate details. The entry time of the vehicle is noted along with the number plate information. During exit, the vehicle number is identified and the exit time is noted for bill generation. For easy pay and to avoid vehicles waiting for bill payment, QR code scanning based payment procedure is used in the proposed system.

## 2.2 Flow Diagram

Figure 2 shows the flow diagram of the proposed automated parking management system. Image of the parking area is obtained from the camera1 to check for free slots availability. Free slots are identified first by creating a template image of the parking slots with help of graphical user interface. Then the image of the parking area is obtained and it undergoes series of image processing steps. Now the template image of the parking slots is superimposed on the image obtained and processed live image input. Each parking slot is cropped and the white pixels values are calculated. If the white total pixel value is greater than a predefined threshold, the slot is identified as unoccupied otherwise it is identified as occupied. The free slots are shown by green colored boundary and occupied slots are indicated by red colored boundary. If the free slots are available, the entry gate of the parking area is kept opened and the vehicles are permitted to utilize the free slots available. If free slots are not available, the system will close the gate so that the user need not enter the parking area, search for free slots and leave the parking area is no free slots are identified. With this, the time for searching and fuel consumption is saved and the user will not enter into frustration state after searching for free slots. At the same time, once the free slots are identified and the user is permitted, the user

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will be guided to the nearest parking slot. This will help the user in finding his/her parking slot quickly in a huge parking area. The proposed system contains second camera nearer to the entry gate to capture the number plate details of the vehicles entering to prepare bills. The proposed also helps the user with a quick payment during exit to avoid waiting in a long queue for payment. Hence with the proposed system, the user will be guided at all the stages to avoid time consumption and fuel wastage.

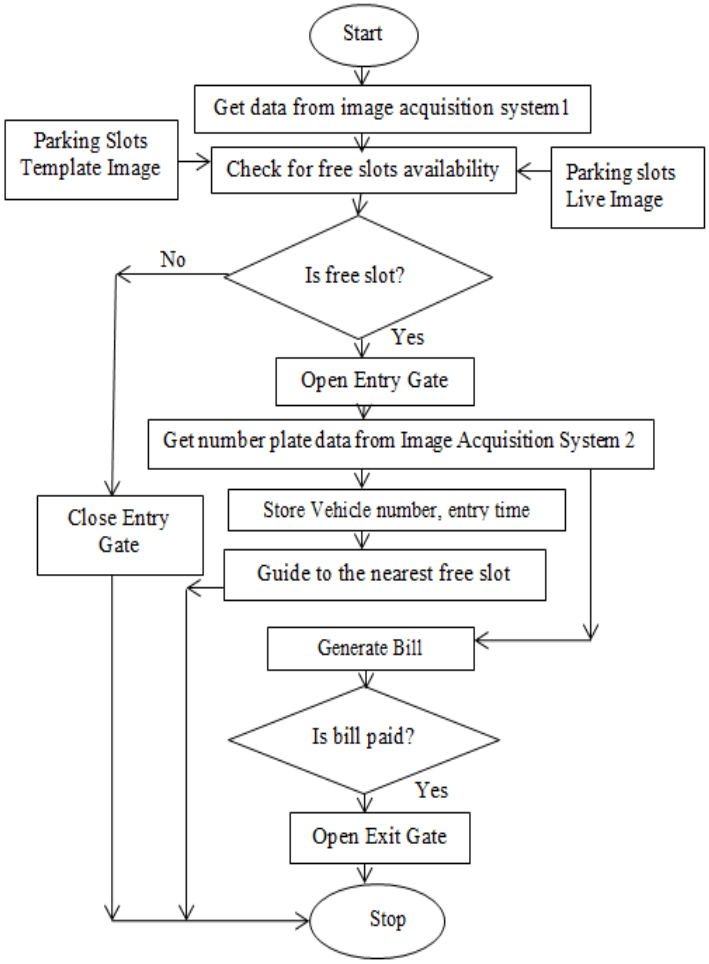


**Figure 2: Flow Diagram**

## 2.3 Components of Automated Parking System

Figure 3 shows the hardware components of the proposed system. The hardware set up contains two webcams for acquiring images of the parking area and the number plate of the vehicles permitted to enter the parking area. A webcam with a resolution of HD 720p and a frame rate of 30 FPS is used for high clarity and easy detection of the objects under its coverage. Servo motors are used in automated system development as they are utilized for precise control over their position, speed, and acceleration. The servomotors are used here for the opening and closing of the parking gate. The servo motor is connected to the microcontroller Arduino Uno, which sends commands to rotate a specific degree for controlling the gate's movement. Arduino is used to control the gate opening to allow the user's to the parking area and open during exit.

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**Figure 3: (a) Webcam (b) Servo Motor (c) Arduino (source: Google Images)**

The software used for developing this proposed work are visual studio, Arduino IDE and python. Visual Studio is used to develop computer programs, web applications and mobile application. Python is used for image processing, image analysis and decision making. FIRMATA protocol is used to synchronize the Arduino, an electronic platform for project development and python.

### 2.4 Image Processing Techniques

Image processing techniques are used to identify the presence of a vehicle in the parking area and to identify free parking slots. The image processing techniques used in this work are image resize, image conversion, image blurring, adaptive filtering, dilation, edge detection, contour detection and contour filtering. Image resizing is the technique used to change the dimension of an image. It is done generally to prepare the image for specific size while processing. Up-sampling and down-sampling techniques are used to increase or decrease the number of rows and columns in an image respectively. The proposed work uses linear interpolation based image resizing method. In linear interpolation, new data points are constructed using

$$b = b_1 \frac{(a - a_1)(b_2 - b_1)}{a_2 - a_1} \quad (1)$$

Where b is the interpolated value, $a_1$ and $b_1$ are the first coordinates, $a_2$ and $b_2$ are the second coordinates and a is the point to perform interpolation. Image conversion is performed here to convert the color images to gray images. It is done using,

$$y = 0.299R+0.587G+0.11B \quad (2)$$

Where y is the gray scale image, R, G & B are the red, green and blue pixel values. To smooth out an image and to reduce noise Gaussian image blurring technique is used. In Gaussian image blurring, the input image is convolved with the Gaussian distribution given in equation 3. Gaussian blurring is found to be effective in smoothing the image, hence it is preferred here.

$$G(x, y) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{x^2+y^2}{2\sigma^2}} \quad (3)$$

σ-determines the kernel width and degree of blurring. To improve the quality of the image, adaptive filtering techniques used. Adaptive threshold technique is used when the lighting conditions are not uniform and the threshold values are estimated based on the local

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properties of an image. The threshold value is calculated based on the weighted sum of the neighboring pixels.

$$\hat{f}(x,y) = g(x,y)\frac{\sigma_n^{\ 2}}{\sigma_l^{\ 2}}[g(x,y) - M_l] \qquad (4)$$

Where $\sigma_l^2$ is the local variance, $\sigma_n^2$ is the variance of overall noise, g(x, y) pixel value at the position x, y and $M_l$ is the local mean. To enhance the image features, morphological operations such as dilation and it is expressed mathematically,

$$\begin{aligned} g(x,y) &= Dilate\,(f(x,y),B) \\ &= \max\{f(x+m,y+n)+b(m,n): \\ &\quad (m,n)\,belongs\ to\ B\} \end{aligned} \qquad (5)$$

Where b (m, n) is the structuring element. The dilation operation is performed on each pixel of the image. The structuring element is placed on the pixel, and the maximum value of the pixels inside the structuring element is calculated. This value is then assigned to the pixel at the center of the structuring element. To identify the boundaries between different regions of an image, edge detectors are used. Canny edge detection is widely used and the edge detection steps are illustrated in figure 4.

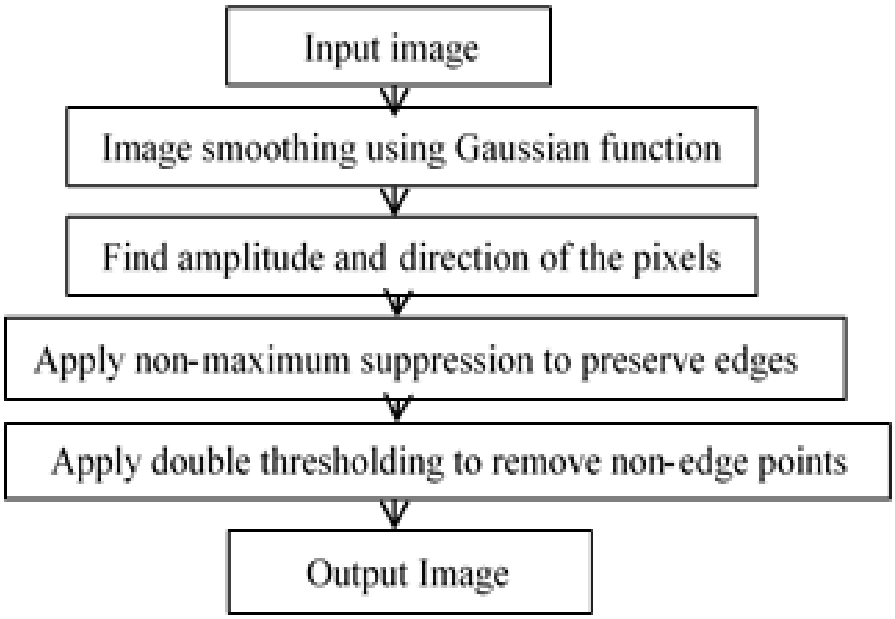


**Figure 4: Flow chart of Canny Edge Detector**

In case of double thresholding, two threshold values ($T_1$ & $T_2$) are used to separate weak and strong edges. Pixel with gradient magnitude greater than $T_2$ is considered as a strong edge pixel. Pixel with gradient magnitude less than $T_1$ is considered as a non-edge pixel and is discarded. Pixel with gradient magnitude between $T_1$ and $T_2$ is considered as a weak edge pixel. If a weak edge is connected to strong pixel then it is considered as strong edge. To extract the boundary of an object in an image, contour detection and filtering is used. Contours are define as a set of all continuous curves with same color intensity or intensity gradient. Contour detection is performed by gradient calculation and finding edges by thresholding. To isolate specific contours, filtering is used.

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### 2.5 Haar Cascade Classifier

Haar cascade classifier is used for number plate recognition of the vehicles entering the parking area for parking. This is needed to generate bills for utilizing parking area along with entry and exit time. Haar cascade classifier is a machine learning approach which uses negative and positive images for classification. Positive images are the images that are to be identified by the classifier and the negative images are the other than the desired images. The classifier contains four stages namely Haar feature estimation, Integral Image creation, Adaboost Training and cascading classifier implementation. Haar features, the convolutional kernels are used to extract features from the image. Haar feature estimation involves use of edge, line and four rectangle features. Features estimation is performed by adding the pixel intensities in each region and finding the differences between the sums. İn case of larger images, these calculations are complex, hence integral images are used to reduce the number of calculations involved. The integral images create array references for the calculations and the value of each point is the sum of all pixels above and to the left of the target pixel and the target pixel. Adaboost training uses only the relevant features and it uses weak classifiers to create strong classifier. The steps involved in Haar cascade classification is shown in figure 5.

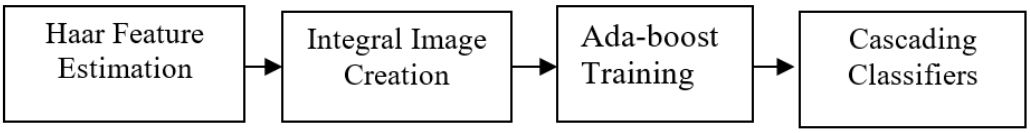


**Figure 5: Haar Cascade Classifier**

## 3. RESULTS AND DISCUSSION

This section explains the results obtained with the developed automated vehicle parking management system. Figure 6 shows the hardware implementation of the proposed parking management system.

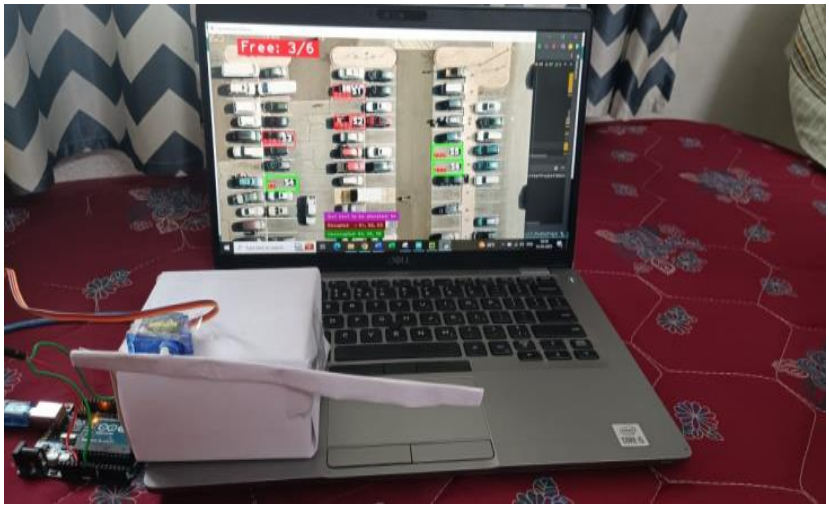


**Figure 6: Hardware Implementation of Parking Management System**

To explain the working of the module developed, a video of parking area was taken. A template image is created from the video and he images of the parking area and the parking slot template are shown in figures 7 & 8.

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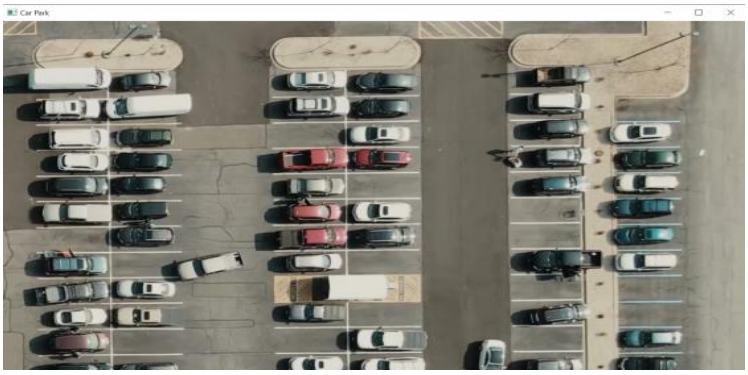

**Figure 7: Car Parking Template Image**


**Figure 8: Parking Slot Template Image**

The parking slot template image is created and used for identifying free slots in the live parking image. A sample parking slots created using graphical user interface (GUI) is shown in figure 8. The slots are marked as S1, S2, S3 etc. Totally six slots are indicated in figure 8 just for an example. Figure 9 shows the 7 parking slots selected (for example and for illustration of the proposed work) in the entire parking area. In the same way, all the parking slots are marked and created as a template image.

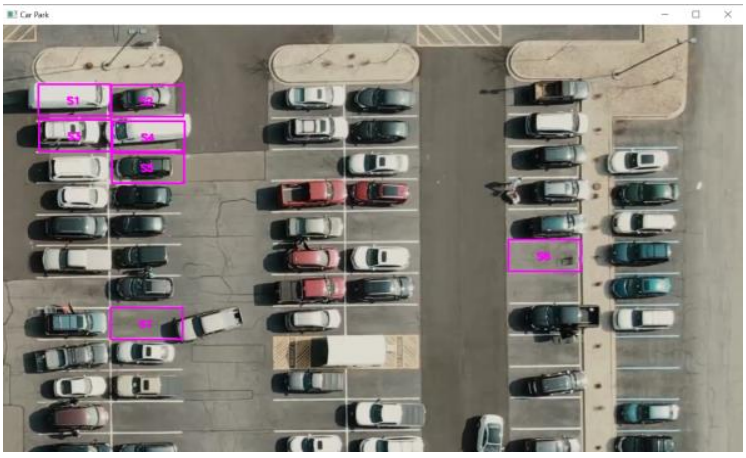

**Figure 9: Parking Slot selection (Template Image)**

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Now the live video is converted into multiple frames and gray scale images of the parking area are obtained. It is shown in figure 10.

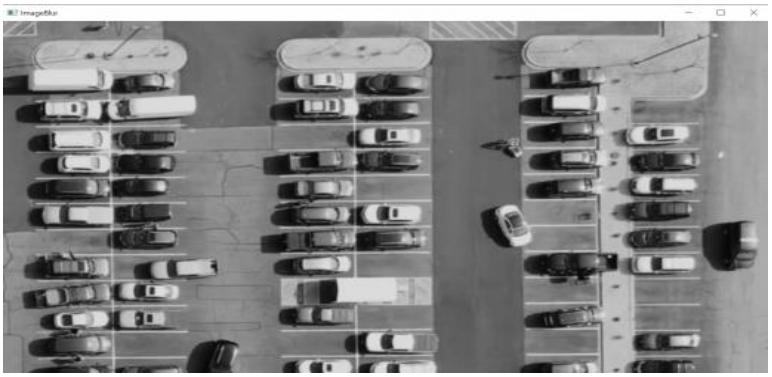

**Figure 10: Gray scale Blur Image of the Parking slot**

Figure 11 shows the result of the image processing techniques applied on the live image of the parking area.

**Figure 11: Parking Area İmage - Processed**

Now the parking slot template image is superimposed on this processed parking area image and pixel values are estimated in the superimposed slots. A threshold of 800 is fixed based on threshold estimation approach explained in 2.3 and the free slots and occupied slots are identified. Free slots are marked with green boundary and occupied slots are marked with red boundary. This is shown in figure 12. The number of free slots available is highlighted as free 2/7 and free 1/7. For explaining the concept, only 7 slots are considered. Out of 7 slots 2 slots are in image 12 and once the free slot is occupied, the free slot count is reduced. This is shown in figure 13. It shows that S6 is the free slot.

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**Figure 12: Live Stream Boundary Marked Parking slot**


**Figure 13: Indication of the Next Available Slot**

If all the slots filled (here out of 7 chosen), the system indicates with the message. This is shown in figure 14.

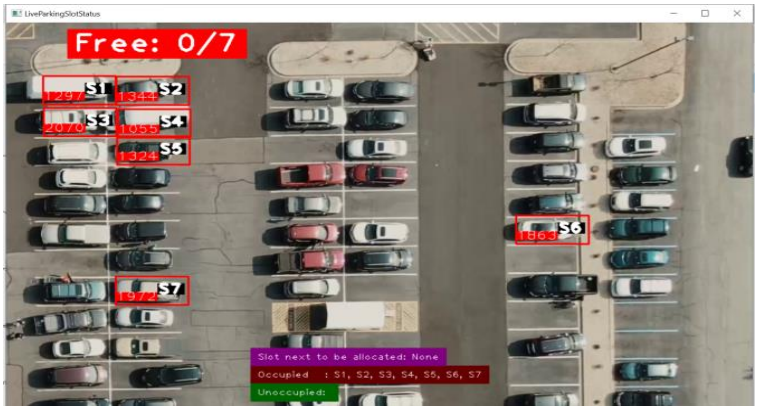


**Figure 14: Indication When All Slots Are Filled**

To test the proposed system with live processing, the web camera is used and live parking video is played and the result is shown in figure 15. The results are shown for three parking slots.

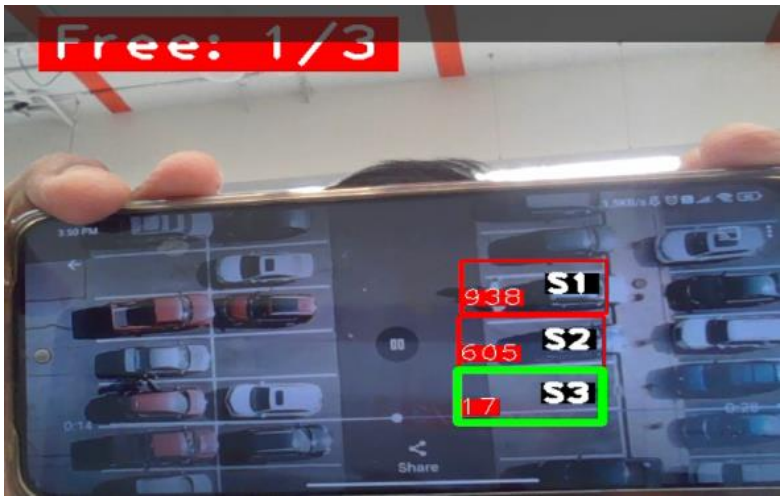


**Figure 15: Live Detection of the Free Available slots**

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Figure 16 & 17 show the result of real time number plate detection.

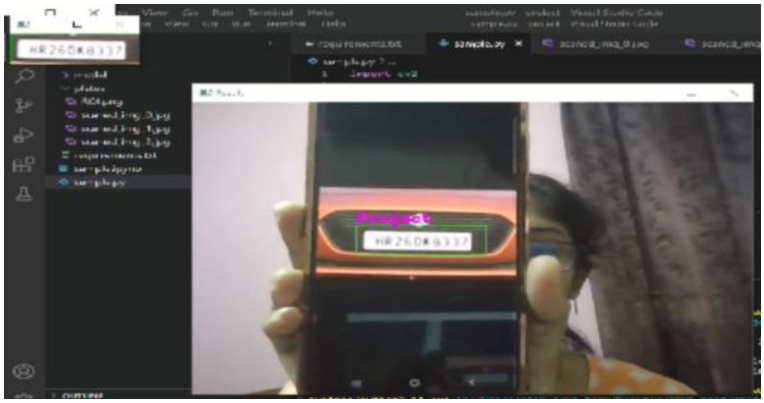

**Figure 16: Real Time Number Plate Detection**

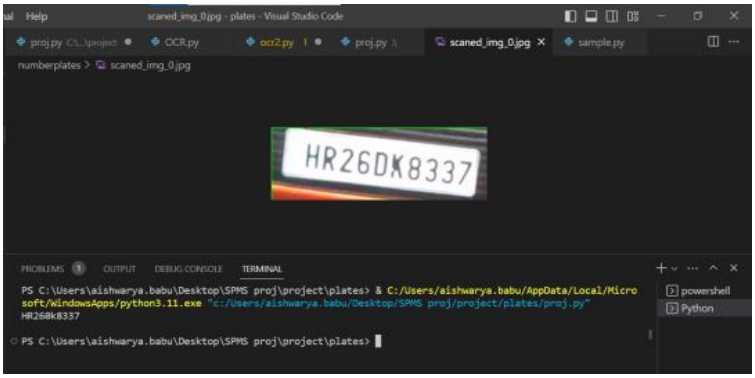


**Figure 17: Number Plate Display**

The number plate and the state to which the vehicle belongs are displayed for different vehicles. These results are shown in figure 18 & figure 19.

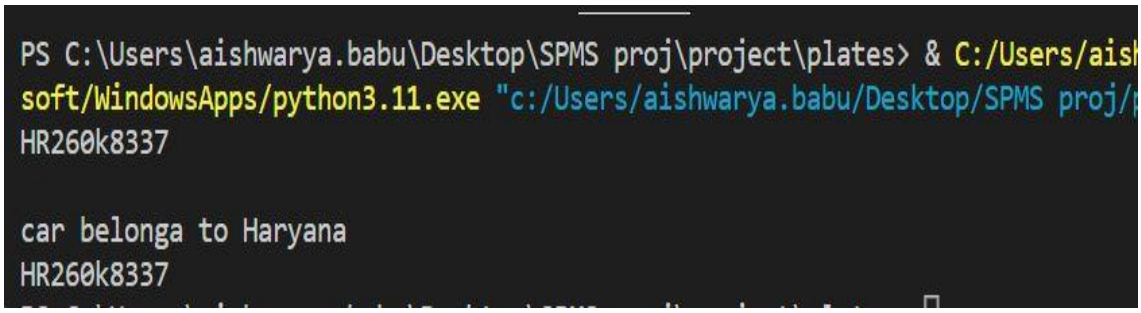


**Figure 18: Vehicle Number and Details**

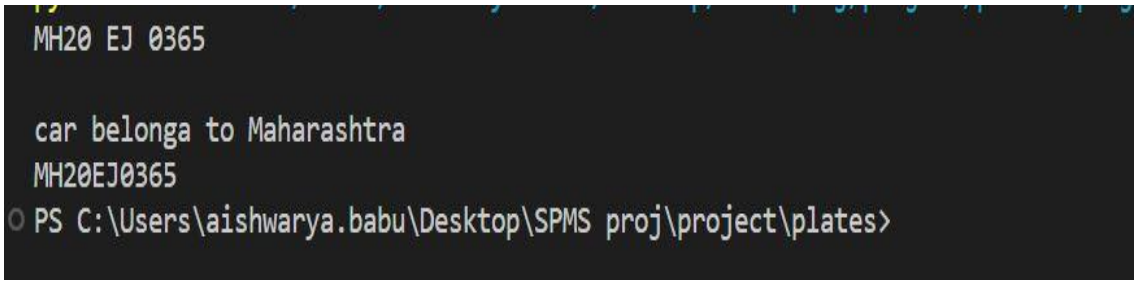


**Figure 19: Number Plate Details**

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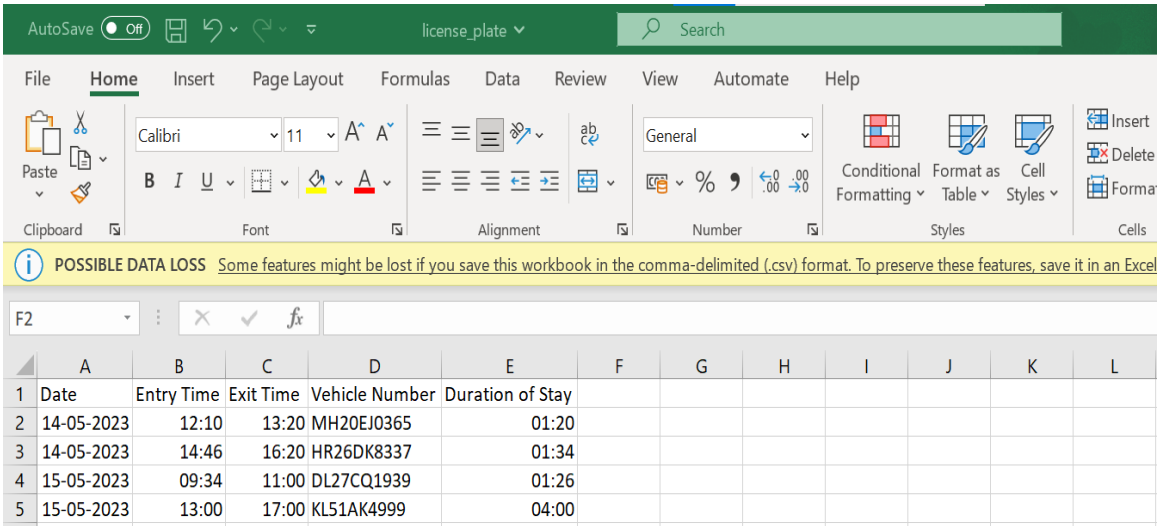
A comma-separated values file (CSV file) is created with the data like entry time, exit time, date, Vehicle number which is obtained from the live video. Depending on the entry and exit time the duration of stay will be calculated for a particular vehicle and the bill will be generated for the duration of the vehicle stay. It is shown in figure 20.




| | A | B | C | D | E | F | G | H | I | J | K | L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Date | Entry Time | Exit Time | Vehicle Number | Duration of Stay | | | | | | | |
| 2 | 14-05-2023 | 12:10 | 13:20 | MH20EJ0365 | 01:20 | | | | | | | |
| 3 | 14-05-2023 | 14:46 | 16:20 | HR26DK8337 | 01:34 | | | | | | | |
| 4 | 15-05-2023 | 09:34 | 11:00 | DL27CQ1939 | 01:26 | | | | | | | |
| 5 | 15-05-2023 | 13:00 | 17:00 | KL51AK4999 | 04:00 | | | | | | | |

**Figure 20: CSV file**

The proposed work has the ability to guide the customer with the route and distance he/she must take to reach the final free space slot. So, this screen includes data of the number of free spaces available in the parking slot and it assigns the next free/ nearby slot using a simple concept. The available slot counts, the slot next to be allocated and their respective directions are displayed along with a small representation of the parking area to say the direction to be traveled towards that particular slot. All slots are assigned up with the values of slot number ranging from 1 to N. So these slots are actually arranged and picked based on the numbering system. Hence, the slot with lower number is displayed with the higher priority of availability, because this slot lies near to the gate. This means lower the number of slots the higher the ranking to be mentioned in the next free space.

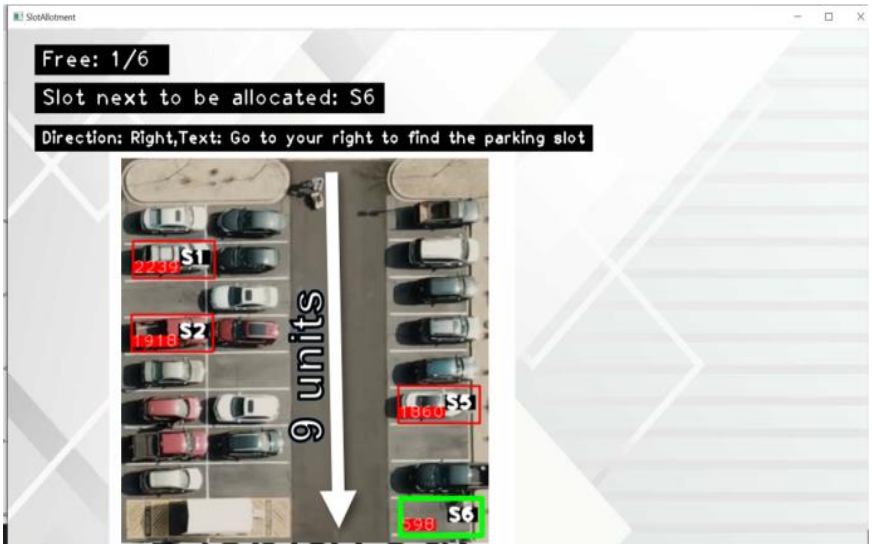



**Figure 21: Slot Allotment Screen**

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In the figure 21, the slot S5 has the lower numbering than slot S6, but the distance between slot S5 and entrance is of 6 units and that of S6 is of 9 units, hence based on the lower distance value, S5 slot is suggested significantly even though there is an available slot at S6.

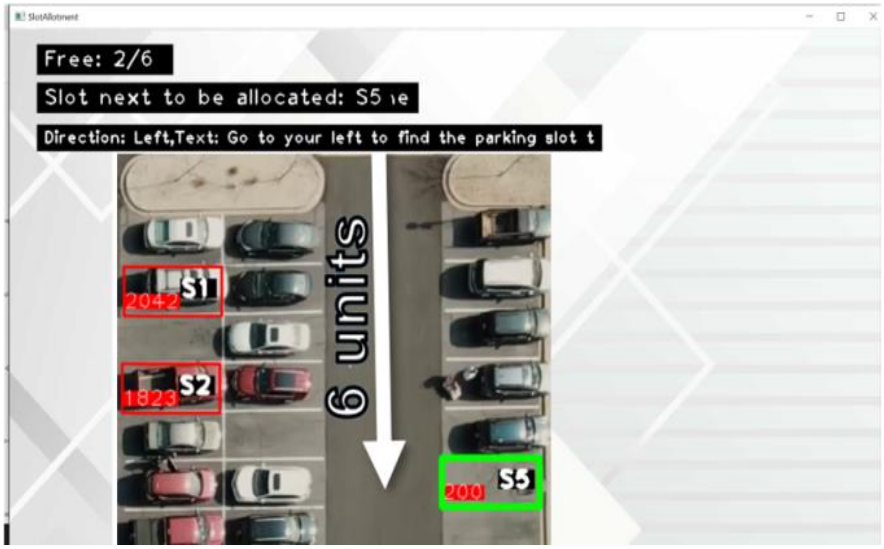


**Figure 22: Slot Allotment Screen with the Nearby Slot Preference**

If all the marked slots are full and filled with cars, it displays the screen as shown in the figure 23, and the next slot to be assigned is marked to be “NONE”.


**Figure 23: Slot allotment Screen with All Slots Filled**

Ardiuno controlled entry and exit gate opening system is used to help the user. The Arduino UNO linked with the servo motor is used to drive the gate by opening and closing. In the figure 24, the gate control servo is fixed and is under the state of “CLOSED” and it sets “OPEN” (as mentioned in the figure 25) when a car is about to leave or enter the parking area.

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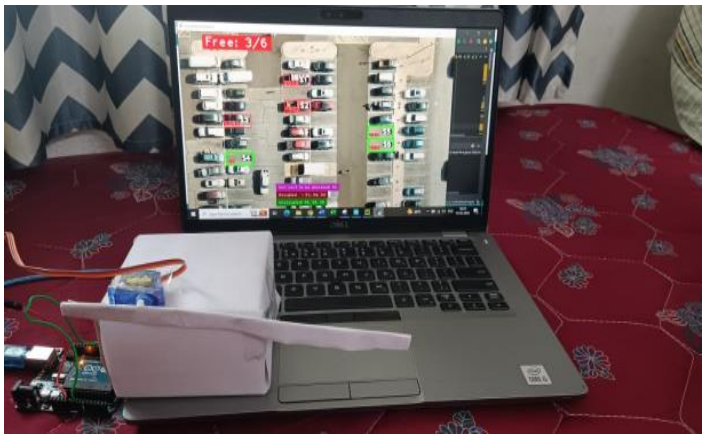


**Figure 24: Gate Control Servo at "CLOSED" state**

Figure 24 describes the servo made to be adjusted to zero degree of rotation and makes the gate look closed, whereas in the figure 25 ,the servo motor gets changed to open state by adjusting the servo angle of rotation to 120 degrees.

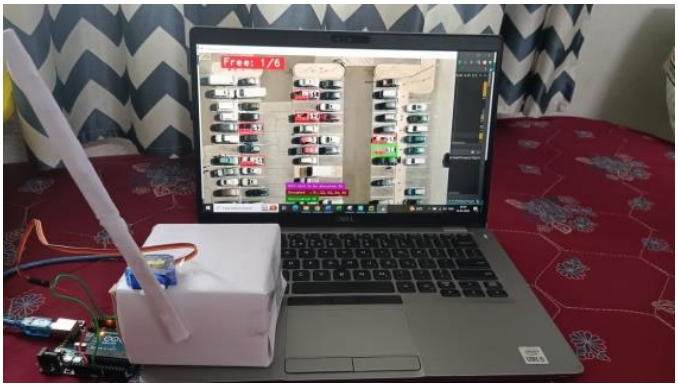


**Figure 25: Gate Control Servo at "OPENED" state**

## 4. CONCLUSION

The proposed automated parking assistance and management system leverages image processing techniques to monitor and manage parking spaces. It allows the users to enter into the parking area only when parking space is available, reducing the time for searching for free parking area. The system can detect license plates and provide accurate parking guidance to drivers, eliminating the need for traditional sensors. By utilizing existing infrastructure, the approach offered a cost-effective and efficient solution to parking management than the conventional systems.

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