Automated Vehicle Parking Slot Recognition and Monitoring using Optimised Image Processing Techniques

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Abstract

Due to the increase in individual vehicle usage, detecting an unoccupied parking slot and collecting payment for parking in an ample parking space have become monotonous tasks in the modern era. Traditional and manual parking slot management in large parking slots was inefficient and required a number of human resources. To address these issues, an automated, intelligent, and efficient parking system is required. This work presents an automated parking slot identification and monitoring technique that can be used to search for unoccupied parking spaces, a guide to parking spaces, negotiate parking fees, and track vehicles using number plate recognition. The proposed method employs optimized image processing and optical character recognition techniques to implement the system. When a vehicle approaches the parking entrance, cameras automatically capture its image and number plate information (registration number) and process it to direct the driver to an unoccupied parking slot. The system counts the number of parked vehicles and displays the current parking status. The system can also be used to collect electronic parking fees based on number plate information and parking duration. The presented method in this paper was tested in a modelled environment and yielded more acceptable performance (accuracy 94.28%) with very little use of hardware resources to keep the system cost as low as possible.

Keywords: Image Processing, Parking Slot Detection, Optical Character Recognition (OCR), MATLAB

I. INTRODUCTION

Due to the growth of vehicle production and individual usage of vehicles, people spend a tremendous amount of time and effort finding a parking space in a vehicle parking. Even after finding a parking space, some may occupy it before reaching it (Dutta, Bhattacharjee and Gupta 2021). Therefore, we require a huge parking space with proper management. Presently, most existing vehicle parks do not have systematic monitoring and management. Most of them are manually managed with little effect. The majority of the parking system is based on the technique used to determine whether or not a vehicle is parked in the space. This technique could be as simple as an ultrasonic sensor or as complex as cloud-based solutions. The time spent searching for available parking spaces is the most significant concern in the car park (Mufassirin and Naleer 2017). Drivers will circle the parking lot until they locate an open spot. This problem is most common in urban areas and supermarkets, where the number of motor vehicles exceeds the number of parking places available (Ding, X. and Yang 2019). Parking slots management should be responsible for informing the availability and location of parking spaces at the entrance. If the status of the parking slots is shown at the entrance, it would be very convenient for the drivers to locate and park their vehicles in an appropriate place.

However, manually managing such a parking space system necessitates a large number of people (Moranduzzo and Melgani 2014). As a result, numerous systems have used unsupervised parking slots detection to ensure smooth traffic at vehicle parking zones by measuring the number of parking spaces, identifying their position, and tracking changes in space status over time (Karunamoorthy, Suresh and Jaya 2015). In recent years, various researchers have proposed many methods for improving parking slot detection systems, such as ultrasonic sensors, IR sensors, and magnetic sensors (Karunamoorthy, Suresh and Jaya 2015). Magnetic sensors have recently been suggested for parking space occupancy detection. However, these methods are affected by

adjacent interference problems, i.e. the magnetic signal is easily interfered with by the vehicles parking in adjacent spaces (Dong, Zhang & J Chen 2019). A parking management system with image processing technology provides the latest and innovative solution for temporary parking places: where no approach is used for parking a car, reducing the hustle at a rushed time, helping to park and manage properly and efficiently (Waqas *et al.*, 2021).

The proposed system in this paper is based on image processing and Optical Character Recognition (OCR) which consists of three subsystems working simultaneously to ensure security and integrity. In this research, a camera is used as a sensor for video image detection. This camera is used to capture images at the entrance and the parking slot. These images are used to detect the parking space and vehicle identity. The image captured from the entrance identifies the number plate and the type of vehicle. The image acquired from the parking slot area detects the free parking space and counts the total number of vehicles parked in the area. Based on this information, the vehicles are directed to appropriate parking spaces. MATLAB is used as a software development tool in this research to implement and test the system.

The rest of this paper is structured as follows. Section 2 describes the existing studies and motivation. Section 3, it is presented the proposed system and objective. The methodology is presented in Section 4. Section 5 describes the results and discussion, and we conclude this paper in Section 6.

II. EXISTING WORKS

The industrialisation and enhanced lifestyle of people accelerated the advancement in automobile technology. Thus, many people started to use their own vehicles for travelling. On the other hand, these advancements have become hard at times, requiring a vast number of parking spaces in busy cities and developed organisations (Juneja, Kochar and Dhiman 2018). Various technologies are used in vehicle tracking, identification, and related fields (Maalik and Pirapuraj, 2021) (Razeeth, Kariapper and Nawaz, 2021). Moranduzzo and Melgani (2014) proposed a technique for automatically detecting and counting the vehicle in uncrewed aerial vehicle (UAV) images. SVM is used as a classifier for detecting and counting cars. Karunamoorthy, Suresh and Jaya (2015) suggested a parking space detection and vehicle classification system based on image processing. Image segmentation and area calculation were used to detect the parking space and direct the vehicle towards it, while feature extraction and Artificial Neural Networks (ANN) were employed for counting and classifying the vehicle.

There are many systems proposed and implemented for automated parking systems to solve parking problems based on magnetic, ultrasonic, and IR sensors (Mithari, Vaze, and Sanamdikar, 2014) (Kianpisheh, Mustaffa, Limtrairut and Keikhosrokiani 2012). When we looked into those systems, we discovered that they required a lot of hardware, which increased the cost and required much maintenance. In such systems, the possibilities of failure and false-positive outcomes were high. Furthermore, we discovered that vehicle tracking was impossible to implement with these systems because it would have necessitated the use of other technology.

Waqas *et al.* (2021) suggested a method for detecting and recognising vacant parking spaces in real time. The camera is mounted on the rooftop of a neighbouring building or a supporting pole at an angle that allows it to cover the entire parking lot. Then obtained image will be sent to a processing module, which is used to detect the cars within the region of interest (ROI) using a Neural Network. The parking space detection module generates virtual lines for parking, which will be visible to the user on an app assisting in vehicle parking. Overall management will be done using a mobile app.

Koushika *et al.* (2021) proposed an automated car parking system design that would decrease human control. Furthermore, the model has a user interface that directs users to available parking spaces. The car parking system counts how many cars are parked and how many idle spaces there are. Rather than using an electrical sensor, image processing was employed to detect the presence of automobiles and the number of available parking spaces. The current image of the parking space with cars is subtracted from an empty image of the parking space. As a result, the number of unfilled slots is calculated. The data will be sent from the server in response to the user's request via the user interface application. Arun, Karthick, Selvakumarasamy and James (2021) propose a

cloud-based system to improve parking vacant identification.

Therefore, we developed a single technology solution for our complete system using image processing techniques. Some existing works were done using image processing. However, those methods, such as edge detection with boundaries condition and point detection with canny operator methods, were more complex (Al-Kharusi & Al-Bahadly, 2014) and required improvement.

III. PROPOSED SYSTEM

Objectives:

- The main objective of this research is to develop and implement a fully automated parking space detection system which uses the camera video frames as input for processing.

To implement unsupervised parking slot detection for counting the number of parking spaces, identifying the location, vehicle number plate recognition and monitoring the changes in space status over time.

The proposed framework comprises three subsystems which are working at the same time. The first subsystem, which is located at the entrance to the parking space, consists of a camera that records the picture of the car number plate and uses the OCR technique to keep a log file of the vehicle registration numbers. This log file can also be used to collect parking fees electronically. The second subsystem comprises a camera in the parking slot that monitors and broadcasts real-time availability of parking slot information to the administrator and a display near the entry through a Graphical User Interface (GUI). The customer is directed to the nearest available parking spot by a

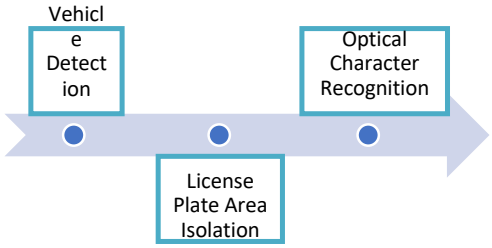

Figure 1. License Plate Recognise Layers

display at the door. The third subsystem is a back-end system that maintains a log and relates the parking slot to the car registration number, as well as the date and time stamp. It allows the user to locate his/ her vehicle's parking place from any location using the vehicle's registration number.

However, in our system, we adopted a more straightforward technique using a point detection method, in which only parking spots are identified and processed; our system also has the capability of identifying the vehicle, which is a novel feature in an automated parking system. In addition, our system captures photographs of vehicle number plates, processes them to extract vehicle registration numbers using the Optical Character Recognition (OCR) approach, and keeps a log file for vehicle tracking and finding.

IV. METHODOLOGY

A. Methodology for Vehicle Number Plate Recognition

Firstly, the vehicle image was captured using a video/ CCTV camera. Then, the system extracted the number plate of the vehicle alone for the purpose of character segmentation. It was accomplished by combining a morphological procedure sensitive to specific shapes in the input image with an appropriate threshold setting for locating the number plate. The extricated number plate was then resized, and the direction was balanced for a simple procedure. Afterwards, character segmentation was done so as to isolate the character from the background. In general, the background was white or yellow with black letters. The resultant image was converted into a grayscale image. Finally, the optical character recognition (OCR) technique was used to identify the individual alphanumeric characters on the number plate. The proposed method for number plate recognition consists of three main tasks, as shown in Figure 1.

1) Vehicle Detection.

Vehicle image detection consists of the following sub-tasks.

i. Vehicle image captured by the camera

The image of the vehicle is captured using a camera, and it should be taken from a fixed angle parallel to the horizon. Usually, it should be in RGB (Red, Green and Blue) colour model. Figure 2 shows an original vehicle image captured by the camera.

Figure 2. Original Vehicle Image Captured by Camera

ii. Pre-process image

At this stage, images are taken from different backgrounds and lighting conditions to prevent low quality and contrast. Image pre-processing is normally done through image filtering. The captured images are resized into (1024 X 768) resolution. The use of pre-processing enhances the processing speed and improves the contrast of the image.

iii. Identify moving vehicle

In this step, vehicles will be identified using the background subtraction technique.

2) License Plate Area Isolation.

i. Convert into Gray Image

Converting grey images helps to reduce the noise of the image to some degree, and also it makes the processing of the images simpler.

ii. Dilation of an Image

Dilation occurs after Erosion, and it is proceeded to eliminate noise in the black-and-white image. When the complicated image erodes, the extension replaces the displaced image, and the image's primary components have been improved.

iii. Horizontal & Vertical edge processing

The dilated pictures are then passed through a variety of processing models for further analysis at this point. Vertical edge processing and horizontal edge processing are the two main types of edge processing. Both vertical and horizontal edge processing has histograms. Two RAMs are used to store the addition of the pixel values horizontally and vertically.

Figure 4. Dilated Image of the Plate

Figure 4. Eroded Image of Plate

iv. Passing histograms through low pass filter

Each histogram value should be averaged in this step, considering the values on both the right and left sides. This phase is also completed for both horizontal and vertical histograms. Filter off any regions that you do not even wish to see. The undesired areas are identified by low histogram values in the rows and columns, showing very tiny variations between adjacent pixels.

Grayscale image

Sobel vertical edge detection

Effect of threshold

Figure 5. Steps of Horizontal & Vertical Edge Processing

v. Segmentation of region of interest

This step is used to find all the areas of the high-probability image with a license plate. In the previous step, dynamic filters detected all undesirable rows and columns. As a result, these likely candidate zones are formed by additional columns and rows.

vi. Extract license plate area

Of the selected regions, the region with the highest histogram value is regarded as the most conventional choice for the license plate. This is the case because the license plate region is typically thought to have few letters on a translucent cloudy background. To locate a common region with the highest horizontal and vertical histogram values, all of the regions are processed row-by-row and column-by-column. It is thought to be the area with the most excellent chance of containing a license plate.

3) Optical Character Recognition

Optical character recognition is the final layer of the number plate recognition process. It is the process of identifying and recognising characters in a picture and converting them to intelligible text in ASCII (American Standard Code for Information Interchange) or another machine-editable format.

i. Resizing image

Compared to the whole vehicle, the license plate area is too small. As a result, the cropped license plate image may be too small, and the image size may vary depending on the vehicle type.

Isolated Number Plate

Cropped Image

Figure 6. Resizing Process of Number Plate Image

ii. Character Segmentation

Figure 7. Character Segmented Image

Character segmentation is a kind of technique. It decomposes the image of lines or words into individual characters.

iii. Template matching.

Template matching is also known as matrix matching, and it is one of the most common classification methods. The input photos from the previous step are split for matrix matching, and the template with the highest similarity is regarded as the match. Once a certain template has been identified, its centre is used to calculate the parameters.

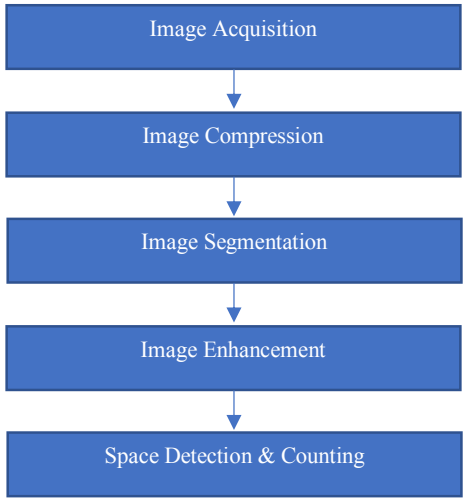

Figure 8. Schematic Illustration of the Parking Space Detection Module

B. Methodology for Parking Space Detection

The proposed method for parking space detection consists of five interrelated modules. The first module corresponds to image acquisition, which automatically captures the parking space's image and the vehicle entering it using video cameras and storing it in the system. These images can be treated as an input for the image processing element in MATLAB. The second module is responsible for image compression. The size of the acquired images through the image acquisition module is large and requires a tremendous amount of storage which will be challenging to process. Therefore, these images are compressed and stored to improve processing speed.

The third module is related to image segmentation, which distinguishes the vehicle objects from the background in order to increase the contrast. The output of this module is a matrix of black-and-

white images. The fourth module is responsible for image enhancement from which the noise is removed from the segmented image using morphology operations such as Dilation and Erosion. The last module corresponds to image detection, which is used to decide the object in each parking slot and display the occupied and unoccupied spaces. Figure 8 shows the schematic illustration overall.

The initial stage of the system is image acquisition, where the image is obtained. Capturing and storing digital images from video cameras is part of this module. After that,

a processing unit is linked to the high-definition camera that was used to capture digital photos.

The software is in real-time mode. The camera is placed inside the view of parking lots, capturing a constant scene. The camera's height must be sufficient to provide a good, unobstructed top view of the parking lots. The image obtained by the camera is shown in Figure 9.

After the image acquisition, the input RGB image was converted to a binary image using grey thresh (as shown in Figure. 10). Then perform the image segmentation, which separates the objects from the background by Dilation and Erosion and differentiates the pixels having nearby values for improving the contrast. After performing image enhancement which removes noise by using morphology functions. Then Classify available points and store them in a matrix. The matrix has the centre points of each parking space in coordinates. The coordinates are obtained using Skeletonization.

followed by Branching. The last process is image detection, which determines the object at each parking slot. The tested prototype GUI is given in Figure 11.

V. RESULTS AND DISCUSSION

The vehicle parking space detection system with parking lots status reporting and guidance parking system based on image processing was designed and tested in the simulated environment successfully. Identifying the image object of the vehicle makes the process of detecting the image as a reference more efficient than the sensor base system. To reduce the cost of sensors and the bother of wiring, the system was created utilising an integrated image processing technique. The

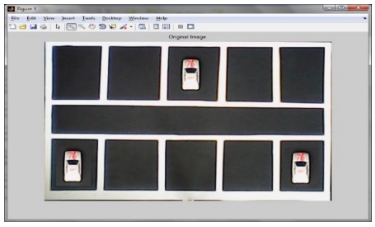

Figure 9: Original Image

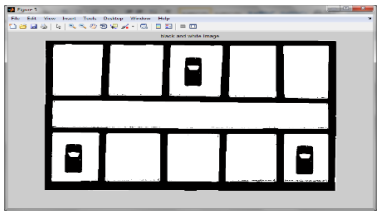

Figure 10: Binary Image

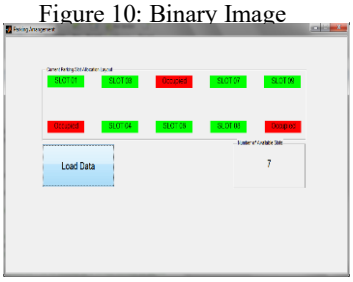

Figure 11: The Tested

performance of our proposed system is listed in Table 1.

Table 1. Performance matrix of our proposed system

Entered Vehicle	Correctly identified number plates	Incorrectly identified number plates	Accuracy	Average time taken
140	132	8	94.28	9 seconds

The performances of a few similar works were compared based on their reported results. Table 2 shows the comparison results.

Table 2: Comparison of our results with other methods

Source	Tested vehicles	Accuracy percentage
Rashid *et al*. (2012)	80	90.00
Ding and Yang (2019)	2315	91.60
Prasetyo, Wibowo and Suhendri (2021)	-	80.00
Our Method (2022)	140	94.28

The current limitation of this work is the processing time. The vehicle should wait at least 8

seconds at the entrance to get the number plate details using the camera. It may result in a long queue during a busy time.

VI. CONCLUSION

The main aim of this study to implement unsupervised parking slots detection for counting the number of parking spaces, identifying the location, vehicle number plate recognition and monitoring the changes in space status over time using video surveillance cameras. The Vehicle Parking Space Detection system with parking lots status reporting and guidance parking system based on image processing was designed and tested in the simulated environment successfully. Identifying the image object of the vehicle makes the process of detecting the image as a reference more efficient than the sensor base system. The proposed parking system integrated an image processing approach to reduce the cost of sensor and wiring issues. Number plate recognition and electronic billing system are in progress for future integration. The detection performance of the vehicle and available parking space is within an acceptable range. We intended to improve the processing time of our method by optimising the method further.

AUTHOR CONTRIBUTIONS

Both authors, M.M. Mohamed Asjath and M.M. Mohamed Mufassirin contributed equally to this work.

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