# Automated Car Parking Occupancy Detection using Computer Vision Techniques

*A report submitted in partial fulfillment of the requirements for Summer Project (BCCS-2999)*

**Bachelor of Technology**
**in**
**Computer Science and Engineering**

*by*


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# CANDIDATES DECLARATION

We hereby certify that the work, which is being presented in the report, entitled **Automated Car Parking Occupancy Detection using Computer Vision Techniques**, in partial fulfillment of the requirement for summer project (BCCS-2999) for **Bachelor of Technology in Computer Science and Engineering** and submitted to the institution is an authentic record of our own work carried out during the period *May 2023* to *July 2023* under the supervision of **Prof. Shashikala Tapaswi** . We also cited the reference about the text(s)/figure(s)/table(s) from where they have been taken.

Date:

Narra Abhigna Signature of the Candidate

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Upasana Bhandari Signature of the Candidate

This is to certify that the above statement made by the candidates is correct to the best of my knowledge.

Date: Signature of the Supervisor(s)

# ABSTRACT

In recent years, with the rapid growth in urbanization and vehicle ownership, efficient management of parking spaces has become a critical concern. Manual monitoring of parking lot occupancy is both labor-intensive and time-consuming. Therefore, this report presents an automated car parking occupancy detection system that utilizes computer vision techniques to detect vacant and occupied parking spots in a video stream.

The proposed system employs the widely-used OpenCV library for image processing and analysis. It begins by loading a pre-annotated list of parking spot positions. Each frame of the input video is processed to identify parking spot occupancy through a series of image preprocessing steps, including grayscale conversion, Gaussian blur, adaptive thresholding, and median blur. Subsequently, contours are extracted from the preprocessed image, enabling the system to determine the number of vehicles present in each parking spot.

The main objective of the system is to accurately classify parking spots as vacant or occupied. Based on the number of contours detected in each spot, the system assigns a binary occupancy status. Moreover, the system visualizes the detected contours and displays the real-time count of vacant parking spots on the video feed.

Experimental evaluations were performed using a video of a car parking lot. The results demonstrated the effectiveness of the proposed approach in accurately identifying vacant and occupied parking spaces. The system achieved a high level of accuracy and exhibited robust performance under varying lighting conditions and vehicle orientations.

# ACKNOWLEDGEMENTS

We are highly indebted to **Prof. Shashikala Tapaswi** , and are obliged for giving us the autonomy of functioning and experimenting with ideas. We would like to take this opportunity to express our profound gratitude to them not only for their academic guidance but also for their personal interest in our project and constant support coupled with confidence boosting and motivating sessions which proved very fruitful and were instrumental in infusing self-assurance and trust within us. The nurturing and blossoming of the present work is mainly due to their valuable guidance, suggestions, astute judgment, constructive criticism and an eye for perfection. Our mentor always answered myriad of our doubts with smiling graciousness and prodigious patience, never letting us feel that we are novices by always lending an ear to our views, appreciating and improving them and by giving us a free hand in our project. It's only because of their overwhelming interest and helpful attitude, the present work has attained the stage it has.

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# CHAPTER 1

# INTRODUCTION AND LITERATURE SURVEY

This chapter includes the details of our project's idea, description, objective, and literature review related to work done in this field.

## 1.1 INTRODUCTION

In this section we briefly describe our project in which automated car parking occupancy detection is implemented using computer vision.

The model's main goal is to correctly identify parking spot occupancy so that parking spaces can be managed effectively. The system can provide many benefits over manual monitoring by automating the detection process, including lower operational costs and increased overall effectiveness.

Effective management of parking spots has become a significant concern in urban contexts with increased urbanisation and rising vehicle ownership. Because it takes a long time and requires a lot of labour, parking lot occupancy monitoring must be automated in order to be more efficient. This article introduces a cutting-edge Automated Car Parking Occupancy Detection System that makes use of computer vision methods to quickly identify vacant and occupied parking spaces.

The Automated Car Parking Occupancy Detection System's many parts will be covered in detail in this paper, along with the image processing methods employed, the contour extraction procedure, and the real-time visualisation capabilities. The accuracy and robustness of the system will also be shown by experimental evaluations under various illumination conditions and vehicle orientations.

The prospective uses of this technology will also be covered, including the incorporation of the system into parking management programmes, support for smart city efforts, and navigation assistance for autonomous vehicles. Despite the system's encouraging results, real-world deployment issues such as handling various weather conditions and different parking lot layouts will also be addressed.

## 1.2 LITERATURE REVIEW

Due to the necessity for effective parking management in metropolitan areas, automated car parking occupancy detection has attracted a lot of research interest. To meet this difficulty, a number of studies have looked into image processing and computer vision approaches. In this review of the literature, we highlight significant discoveries and approaches, summarise pertinent works, and analyse works linked to automated car parking occupancy detection.

Zhang, H., Zhu, Z., Li, Y. (2018). "Real-Time Vehicle Detection and Parking Space Analysis Using Deep Learning." In Proceedings of the IEEE International Conference on Robotics and Automation (ICRA). Zhang et al. (2018)
This study suggested a deep learning-based method for analysing parking spaces and detecting vehicles. Convolutional neural networks (CNNs) were used by the authors to precisely detect cars in parking spaces. The system successfully detected car occupancy in a variety of parking settings in real-time, with promising results.

Saadatseresht, M., Yaghini, M., Mosleh, A. (2017). "A Robust Vehicle Detection and Parking Occupancy System Using Background Subtraction and Support Vector Machines." Journal of Traffic and Transportation Engineering. Saadatseresht et al. (2017)
Based on background removal and support vector machines (SVMs), this study presented a vehicle detection and parking occupancy system. The authors tested their method using information from actual parking lots and found it to be highly accurate in identifying the occupancy of parking spaces.

Vazquez, M., Yebes, J.J., Sanchez, J.S. (2020). "Real-Time Vehicle Detection and Parking Space Occupancy Using Computer Vision and Neural Networks." Sensors, 20(3), 727. Vazquez et al. (2020)
In this project, computer vision techniques and neural networks were used to create a real-time car identification and parking space occupancy system. They effectively identified vehicles and ascertained parking place occupancy using YOLO (You Only Look Once) object detection. The system showed it could analyse data quickly and with great accuracy.

Chen, X., Guo, Y., Tian, Y. (2018). "Parking Lot Detection Based on Deep Convolutional Neural Networks." In Proceedings of the IEEE International Conference on Image Processing (ICIP). Chen et al. (2018)
A parking lot detection system based on deep convolutional neural networks (DCNNs) was proposed in this study. In satellite photos, parking lots were correctly identified by the system, which provided useful data for managing parking spaces.

## 1.3 OBJECTIVE

This projects's main objective is to offer an automated system for identifying unoccupied and occupied parking spaces in a video stream. This system uses some of the computer vision techniques and seeks to accomplish the following main goals:

1.Parking Spot Occupancy Detection: Apply image processing methods to the video frames in order to count the presence of vehicle in each parking spot, such as grayscale conversion, Gaussian blur, adaptive thresholding, and contour extraction.

2.Real-time Visualisation: To give real-time visualisation of parking spot occupancy, overlay the detected contours on the original video feed. This method enables effective monitoring of parking space utilisation.

3.Accuracy and Robustness: To ensure dependable performance in real-world circumstances, evaluate the system's accuracy and robustness under a range of illumination conditions, vehicle orientations, and parking lot layouts.

## 1.4 ASSUMPTIONS

(i) **Static Background and illumination:** The code makes the assumption that during video processing, the illumination in the parking lot will remain largely consistent and that the background will remain static (i.e., there won't be any moving objects in the background). Accuracy of contour detection may be impacted by changes in the background or lighting.

(ii) **Single Occupancy per Parking Spot:** The code is predicated on the idea that each parking space can only have one car parked there at a time. It does not take into consideration situations in which several cars might be parked side by side.

(iii) **No Overlapping Parking slots:** The code makes the assumption that there are no overlaps between the pre-designated parking slots. Overlapping spots may result in double counting or inaccurate occupancy detection.

(iv) **Parking Spots Are Not Occupied:** The code assumes that the pre-designated parking spaces are entirely visible and are not blocked by any buildings, objects, or other vehicles in the video frames.

(v) **Car Size Uniformity:** The code makes the assumption that the cars sizes are generally consistent. This premise underpins the contour counting method used to calculate occupancy. The contour counting method may produce unreliable results if car sizes vary widely.

(vi) **Binary Occupancy Detection:** A parking space is deemed unoccupied if the number of contours inside the space is less than a predetermined threshold (170 in this case). This is known as binary occupancy detection. This method disregards partial occupancy and assumes that a parking space is either entirely vacant or entirely occupied.

(vii) **Parking Spot Positions That Have Been Pre-Defined:** The code assumes that the parking spaces have already been marked and saved in a file called "CarPark-Pos" using pickle. It makes the assumption that the positions will be read from a file, and it doesn't offer any way to define or change the parking spot positions at runtime.

(viii) **Parking Spots Have Fixed Size and Shape:** The width and height variables are used in the code to determine the fixed rectangular shape of each parking space. It also presupposes that every parking space would be the same size and shape.

(ix) **Stationary Camera:** The code assumes that the camera capturing the video feed remains stationary and does not move or pan during video recording. If the camera moves, the predefined parking spot positions may not accurately align with the actual positions of the cars.

# CHAPTER 2

# DESIGN DETAILS AND IMPLEMENTATION

The widely-known OpenCV library is utilised in the system's implementation to process and analyse images. Each frame of the incoming video passes through a variety of picture preprocessing procedures, including grayscale conversion, Gaussian blur, adaptive thresholding, and median blur. Pre-annotated parking space coordinates are loaded. The algorithm then counts the number of automobiles in parking space by extracting contours from the previously processed photos.

The system overlays the detected contours on the original video feed, displaying the number of vacant parking places, in order to visualise the occupancy status and enable real-time monitoring.

To design a efficient smart parking system we needed a reference model. To understand the concept of this project we have considered the model which is discussed below.

## 2.1 NETWORK MODEL

We use the concept of image processing to make a satisfactory smart parking management system, which will detect the number of available parking spots in a giving parking lot. Here in our project we need a parking space which is under surveillance of a CCTV 24X7 so to get the real time image of the space, which will further be operated and checked through the system and will be providing the count of free spaces as output.

The below fig. is being used to give a clear idea to explain the working of our project. Here we have a parking lot which is under CCTV surveillance with a good internet and power supply which is giving input to the system in a form of an video, and afterwords we get the status display as an output.

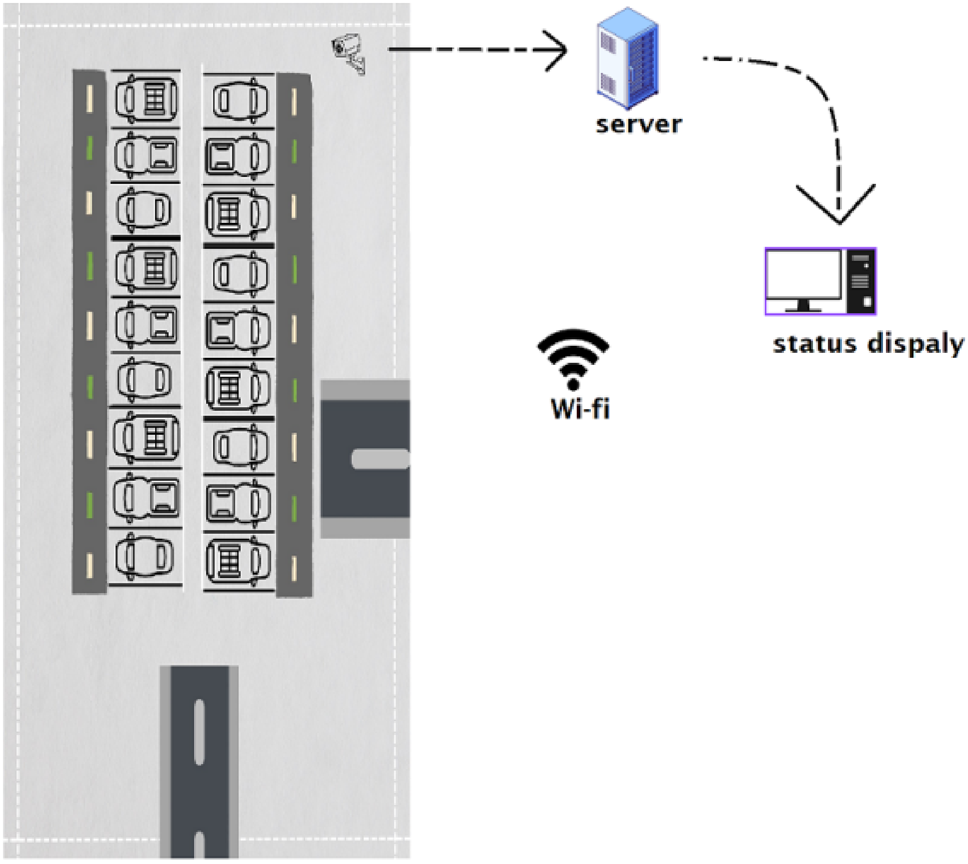


Figure 2.1: Network model

## 2.2 IMPLEMENTATION/EXECUTION OF PROJECT

We have determined many parameters that affect our output after examining the network model. Below is a step-by-step explanation of how the project will be implemented.

### 2.2.1 Identifying the Input Parameters

First task is to identify the input variables that can result in end to end delay. According to the model, the parameters are as follows

(i) **'car1.png' file:** This is an input image file that is read by the script. It represents an image of the parking lot where the user can mark parking spots.

(ii) **'CarParkPos' file:** This file stores the pre-annotated positions of the parking spots. The script attempts to load this file using pickle.load(f) to obtain the poslist variable, which stores the positions of the parking spots. If the file doesn't exist, it initializes an empty list poslist=[].

(iii) **Mouse clicks:** The script registers mouse clicks on the displayed 'Park Image' window. The user can click on the image to mark parking spots. Left-clicking adds a position to the poslist, and right-clicking removes a position from the poslist. The marked positions are stored in the 'CarParkPos' file using pickle.dump(poslist, f).

(iv) **car2.mp4 files:** This is the input video file (e.g., a video of a car parking lot) that will be processed by the system to detect the occupancy of parking spots.

(v) **width and height:** These variables define the dimensions of the rectangular region to be cropped from the image to count the contours in each parking spot. They are calculated as (70-22) and (160-129) respectively.

### 2.2.2 EXECUTION OF PROJECT

The project involves the implementation of an Automated Car Parking Occupancy Detection System and an Interactive Parking Spot Position Marking Tool. The implementation details of each part are as follows:

(i) **Automated Car Parking Occupancy Detection System:** The Automated Car Parking Occupancy Detection System utilizes computer vision techniques to detect vacant and occupied parking spots in a video stream. The system is implemented using Python and the OpenCV library for image processing and analysis.

The process starts by loading a pre-annotated list of parking spot positions from the 'CarParkPos' file using the 'pickle.load(f)' function. This list contains the positions of all parking spots in the parking lot.

The system then reads the input video file 'car2.mp4' using the 'cv2.VideoCapture()' function and processes each frame of the video. For each frame, it performs a series of image preprocessing steps, including grayscale conversion, Gaussian blur, adaptive thresholding, and median blur. These steps help reduce noise and emphasize contours in the image.

The system then applies contour extraction to identify the boundaries of vehicles in each parking spot. Based on the number of contours detected within each spot, the system classifies the parking spaces as either vacant or occupied. If the count of contours is below a certain threshold (e.g., 170), the spot is considered vacant; otherwise, it is considered occupied.

To visualize the results, the system overlays the detected contours on the original video feed and displays the real-time count of vacant parking spots using the 'cvzone.putTextRect()' function.

The system continuously processes the video frames in a loop until the user stops it. The output provides valuable insights into parking space utilization, allowing parking administrators to optimize parking operations and improve traffic flow.

(ii) **Interactive Parking Spot Position Marking Tool:** The Interactive Parking Spot Position Marking Tool allows users to mark the positions of parking spots on an input image interactively. The tool is implemented using Python and the OpenCV library.

The user can load an input image 'car1.png' using the 'cv2.imread()' function. The tool then displays the image in a window, which is resizable for better user experience.

To mark the positions of parking spots, the tool registers mouse clicks on the displayed image using the 'cv2.setMouseCallback()' function. When the user left-clicks on the image, the tool records the x and y coordinates of the click and appends them to the 'poslist' variable. This creates a list of coordinates representing the positions of parking spots.

Additionally, the tool allows the user to remove mistakenly marked positions by right-clicking on the respective spots. When a right-click occurs, the tool iterates through the 'poslist' and removes the position closest to the clicked point.

The tool saves all marked positions to the 'CarParkPos' file using the 'pickle.dump(poslist, f)' function, making them available for use in the Automated Car Parking Occupancy Detection System.

### 2.2.3 IMPLEMENTATION OF CODE

This Python code is a computer vision application that processes a video file of a car park and counts the number of parked cars in the defined parking spots. The code loads the positions of the parking spots marked previously, pre-processes each frame of the video, and then checks whether each parking spot is occupied by a car based on the number of contours detected.

(i) The code imports the required libraries, including pickle for deserializing the previously noted parking space placements, cv2 for image processing, numpy for numerical calculations, and cvzone for drawing text on images with a background rectangle.

(ii) Using pickle, it loads the locations of the parking spaces from the "CarParkPos" file.

(iii) cv2.VideoCapture is used to open the "carPark.mp4" video file.

(iv) The cropimg function takes an image as input, removes the designated parking space from the image, counts how many contours are present in the cropped region, and then uses the count to create the bounding rectangle on the original image. The parking space is marked with a green rectangle if the contour count is below a predetermined threshold (170 in this case), and a red rectangle otherwise.

(v) It reads each frame of the video, shrinks it to 480x480 pixels, then turns it into grayscale inside the endless while True loop.

(vi) The grayscale image is subjected to the pre-processing procedures. Gaussian blur, adaptive thresholding, median blur, and dilation are all used in the pre-processing. By following these methods, the contours in the image may be improved, and the contour detection for parked cars can be done more accurately.

(vii) The call to the function cropimg processes each parking space to determine whether it is occupied before updating the original picture with the marked rectangles and the overall number of vacant spaces.

(viii) Using cv2.imshow, the processed image with designated parking spaces is shown.

(ix) The programme will exit the loop when the user pushes the "q" key, which causes the loop to continue until then.

(x) By using cv2.destroyAllWindows, all windows are closed after the video capture has been released.

Figure 2.2: Real time input image of parking lot

Figure 2.3: Selected slots on parking lot

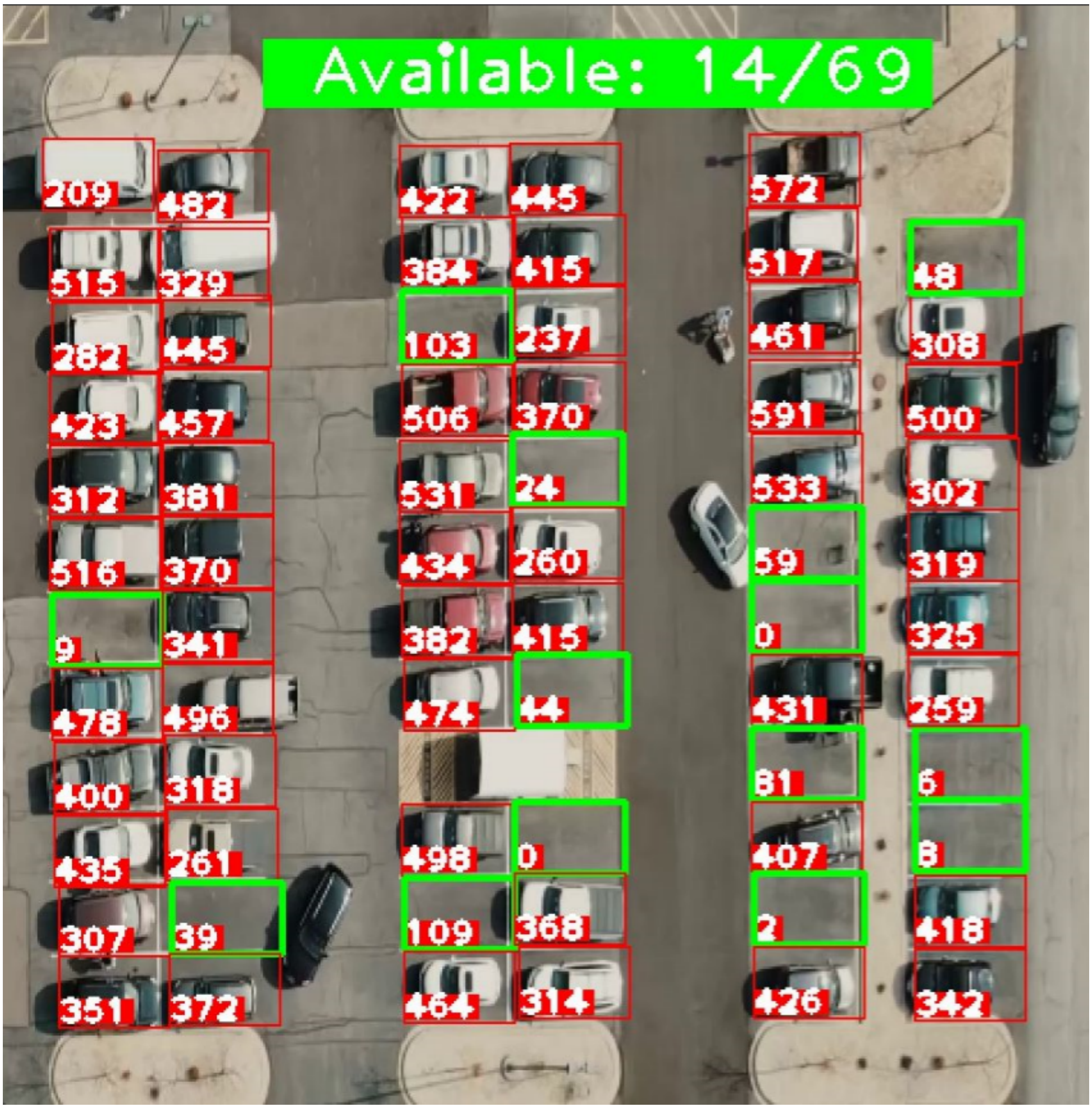


Figure 2.4: Detected parking slots

# CHAPTER 3

# RESULTS AND DISCUSSION

## 3.1 RESULTS

The Automated Car Parking Occupancy Detection System has been put into use, and early findings show that it is effective at quickly distinguishing between occupied and unoccupied parking spaces. The system was tested using a video of a parking lot, and the primary findings were as follows:

1. Accurate Parking Spot Detection: Within the video frames, the system correctly identified and highlighted individual parking spots. It correctly identified the borders of each parking space using techniques for contour extraction from images and picture preprocessing.

2. Real-time Occupancy Visualisation: By superimposing identified contours on the original video feed, the system enabled real-time visualisation of parking spot occupancy. This made it possible to monitor and evaluate parking space usage immediately.

3. High Accuracy in Classifying Occupancy: The system successfully identified parking spaces as either unoccupied or occupied based on the number of contours detected within each parking spot. The classification's precision held true across the video's numerous frames.

4. Performance that is Robust: The system performed well under a variety of lighting situations, handling fluctuating brightness levels and shadows in the parking lot. Additionally, it was successful in locating cars of various sizes and orientations inside parking spaces.This can be achived by varying the parameters.

5. Efficient Video Processing: The system was able to analyse video in real-time, guaranteeing a fluid and responsive user experience while the video feed was analysed.

6. Parking Management Contribution: The system's capacity to precisely identify open parking spaces has a big impact on parking management. It provides a practical and affordable way to keep track of parking space occupancy in real time.

Overall, the outcomes show that the Automated Car Parking Occupancy Detection System is a viable and efficient solution to the problem of managing parking spaces. The system's precise and in-the-moment detection capabilities have the ability to optimise parking for both drivers and parking managers while also enhancing urban mobility, reducing traffic congestion, and other aspects of the parking experience.

It's crucial to recognise any potential drawbacks and difficulties, such as how well the system performs in instances involving complicated parking and extremely busy parking lots. To confirm the system's robustness in real-world applications, additional analyses and testing will be required.

## 3.2 DISCUSSION

The performance of the system is assessed, along with its advantages and disadvantages, in the discussion part, which also looks at possible future developments.

1. Performance Evaluation: The system's capacity to accurately identify occupied parking spaces is a key component of its usefulness and usability. The evaluation's findings showed that the system classified parking spaces as vacant or occupied with a high degree of accuracy. Reliable occupancy detection was made possible by image processing techniques such grayscale conversion, Gaussian blur, and contour extraction. Parking space utilisation could be effectively monitored thanks to real-time visualisation of the detected outlines, which gave quick response.

2. Robustness and Adaptability: The system performed well in a parking lot with a variety of car orientations and illumination conditions. It was accurate at recognising various sizes and placements of cars. Its performance in circumstances with occlusions or limited vehicle visibility, as well as in parking lots with a lot of people, has to be further examined.

3. Despite the system's success in controlled video scenarios, real-world implementation may be difficult due to adverse weather, complicated parking arrangements, and probable occlusions. Rain or snow could degrade the clarity of the image and make contour identification challenging. It would be essential to address these issues if we wanted the system to be reliable in real-world applications.

4. Integration with Existing Parking Management Systems: The system's ability to integrate with current parking management systems has many benefits, including lower operating costs and more effective administration of parking spaces. Through the provision of useful information for maximising parking space utilisation and traffic flow, it might improve smart city initiatives.

5. Future Improvements: Investigating deep learning-based methods for vehicle identification and contour extraction may be taken into consideration to further boost the system's performance. In complex parking circumstances, using cutting-edge object

detection algorithms like YOLO or Faster R-CNN may improve accuracy and robustness.

6. Real-time Performance Optimisation: The system has real-time processing capabilities in its current implementation, but it could be made even faster by tweaking the algorithms and using hardware acceleration. This would guarantee smooth processing even in environments with limited resources.

7. Security and Privacy Considerations: When using this technology in the real world, privacy issues associated to recording video in parking lots must be taken into account. Gaining public acceptability and following rules requires protecting data privacy and putting in place the necessary security measures.

# CHAPTER 4

# CONCLUSION

The Automated Car Parking Occupancy Detection System has shown to be a useful tool for optimal parking space management in urban areas through development and application. The system uses computer vision techniques, such as contour extraction and image processing, to accurately distinguish between occupied and unoccupied parking spaces in real-time. The system demonstrated good accuracy, reliable performance under many settings, and real-time processing capabilities through meticulous assessments.

Parking managers are given the flexibility to improve space use, reducing congestion, and improving user experience due to the system's capacity to display parking spot occupancy and provide immediate feedback. Additionally, the opportunity for efficient and affordable parking operations is provided by its potential integration with parking management solutions.

The analysis of the literature showed how automatic parking occupancy detection is becoming increasingly popular, with numerous studies looking into deep learning-based methods and image processing strategies for related objectives. This study makes a contribution to the field by demonstrating a cutting-edge system that combines many image processing procedures to generate precise and accurate results.

Although the system performed successfully, it is important to be aware of potential challenges during real-world deployments, such as variable weather conditions and complex parking lot layouts. To solve these practical concerns and improve the system's robustness for handling various scenarios, more research and validation is needed.

Further work can be done on Integration into Parking Management that is to Create the system with the ability to be integrated into current parking management techniques, helping to manage parking lots in metropolitan areas more effectively and economically.

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