Automated Car Parking Occupancy Detection using Computer Vision Techniques

Abhigna Narra, Jwalana Ravi, Upasana Bhandari

ABV-IIITM, Gwalior, India

bcs_2021048@iiitm.ac.in, bcs_2021056@iiitm.ac.in, bcs_2021067@iiitm.ac.in

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 re- port presents an automated car parking occupancy detection system that utilizes com- puter vision techniques to detect vacant and occupied parking spots in a video stream. The proposed system employs the widely-used OpenCV library for image process- ing 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.

Index Terms—Computer Vision, Vehicle Detection, Parking Lot Management

I. INTRODUCTION

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

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 system's main goal is to correctly identify parking

spot occupancy so that parking spaces may 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.

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 may then count the number of automobiles in each 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.

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.

II. 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).
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.
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.
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).
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.

III. METHODOLOGY

A. Objective

The following are the specific goals and objectives for creating a vehicle parking system in universities:

Create a centralised parking management system:Create a centralised database or system to store and handle real-time information about available parking spaces .

Implement parking slot monitoring technology: Integrate sensors(cc camera footage) or other technologies to monitor parking space occupancy and update the system in real-time.

Implement a communication system that allows vehicles to get real-time updates on parking availability, allowing drivers to navigate straight to available parking places.

Ensure parking information correctness and reliability: Implement procedures to ensure the accuracy and reliability of parking slot information transmitted to users and cars, minimising instances of erroneous or outdated information.

Optimise parking utilisation: Consider measures such as assigning priority parking to specific user groups or adopting dynamic pricing depending on demand to encourage effective parking space distribution.

Establish metrics and assessment criteria to measure the parking system's effectiveness in terms of lowering congestion, improving the parking experience, and minimising the environmental impact of parking-related activities.

Consider legal and regulatory aspects, such as data privacy, user permission, and compliance with local parking legislation, to ensure that the parking system is implemented in accordance with appropriate guidelines and requirements.

B. System overview

We will be having a cc camera observing vehicles movement over the parking area and the software will work as a sensor to detect the empty status of parking slots and display no of empty parking slots on monitor screen and update corresponding details in database. This whole model needs continuous power and internet connectivity access to ensure real time working of the software and cc camera.

C. Data collection

Using the dataset that has been acquired we have collected the data related to the parking such as total parking area and the number of parking slots available. We use the cleaned and preprocessed data to keep a count of the number of empty slots by detecting whether a car is present in the slot or not.

D. 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:

1) **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.

2) **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.

E. Impelmentation 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.

a) 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.

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

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

d) 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.

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

f) 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.

g) 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.

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

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

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

IV. RESULT

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.

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.

V. 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.

VI. 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 great 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.

References

[1] 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).
[2] 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.
[3] 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.
[4] 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).