PARKING SLOT DETECTION

A MINI PROJECT REPORT

18CSC305J - ARTIFICIAL INTELLIGENCE

Submitted by

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BONAFIDE CERTIFICATE

Certified that Mini Project report titled **“PARKING SLOT DETECTION"** is the bonafide work of **ALOK PRASAD (RA2111003010245), JIIYAA JAISWAL (RA2111003010244), YALAVARTHI JASWANTH (RA2111003010238),** who carried out the minor project under my supervision. Certified further that to the best of my knowledge, the work reported herein does not form any other project report or dissertation on the basis of which a degree or award was conferred on an earlier occasion on this or any other candidate.

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ABSTRACT

As urban populations burgeon, parking management becomes increasingly challenging, necessitating innovative solutions to optimize space use and ameliorate congestion. Artificial intelligence (AI) offers a promising avenue for addressing these challenges, particularly in the domain of parking slot detection. This report provides a comprehensive examination of AI applications in parking slot detection, elucidating the technological framework, methodologies, and implications.

The report begins by outlining the significance of automated parking systems and the pivotal role of parking slot detection within this context. Traditional methods of manual slot detection are labor-intensive and prone to errors, underscoring the need for automated, AI-driven solutions. Leveraging AI technologies, such as computer vision and machine learning, enables real-time analysis of visual data from cameras or sensors to identify vacant parking spaces with precision and efficiency. A detailed exploration of the technological framework underpinning AI-driven parking slot detection follows, encompassing image acquisition, preprocessing techniques, feature extraction, and machine learning algorithms. Image preprocessing improves the quality of the input data, while feature extraction algorithms isolate relevant patterns that indicate parking spaces. Machine learning models, notably convolutional neural networks (CNNs), are then trained on labeled data to recognize and classify parking slots accurately.

The report further evaluates state-of-the-art approaches in parking slot detection, considering factors such as accuracy, speed, scalability, and robustness. Recent advancements in research, commercial solutions, and practical implementations are analyzed to discern trends and best practices. Despite progress, challenges persist, including environmental factors, such as varying lighting conditions, and the need for continuous model optimization and adaptation. Ethical and societal implications are also scrutinized, encompassing privacy concerns, data security, and equitable access to parking resources. As AI-driven parking slot detection systems proliferate, ethical considerations become increasingly paramount to ensure responsible deployment and mitigate potential biases or privacy infringements. In conclusion, this report underscores the transformative potential of AI in revolutionizing parking management through advanced slot detection techniques. By elucidating the technological landscape, challenges, and ethical considerations, it provides valuable insights into the current state and future directions of AI-powered parking slot detection.

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CHAPTER 1
INTRODUCTION

The "Parking Slot Detection" is a crucial component of modern smart parking systems, facilitating efficient utilization of parking spaces and enhancing the overall parking experience. With the rapid urbanization and increasing number of vehicles on roads, efficient parking management has become a pressing concern for both municipalities and private establishments. Traditional parking management methods often lead to congestion, wastage of time, and unnecessary fuel consumption.

Parking management in urban areas poses significant challenges due to the increasing number of vehicles and limited parking spaces. Conventional parking systems often result in congestion, inefficiency, and frustration among drivers. In response, innovative technologies such as parking slot detection have emerged to revolutionize parking management.

Parking slot detection utilizes advanced computer vision, machine learning algorithms, and sensor technologies to automatically identify available parking spaces in real-time. By providing drivers with accurate information about parking availability, these systems aim to optimize space utilization, reduce traffic congestion, and enhance the overall parking experience..

This project report aims to explore the concept of parking slot detection, its underlying technologies, applications, and implications for urban parking management. Through a comprehensive examination of existing literature, case studies, and technological frameworks, this report seeks to provide insights into the potential benefits and challenges of implementing parking slot detection systems. Additionally, it aims to offer recommendations for the effective deployment and optimization of such systems in diverse urban environments. By shedding light on the transformative potential of parking slot detection, this report aims to contribute to the advancement of smart parking solutions and sustainable urban development, the system's user-friendly interface allows for easy customization, enabling users to tailor settings related to transcription accuracy, language support, and output format to suit their specific needs. This flexibility ensures that the generated meeting minutes align precisely with the requirements of each user, enhancing the overall efficiency and effectiveness of the system.

CHAPTER 2

LITERATURE SURVEY

Literature Survey on Parking Slot Detection has garnered significant attention from researchers and practitioners alike due to its potential to alleviate parking-related challenges in urban areas. This literature survey provides an overview of key studies, methodologies, and advancements in the field of parking slot detection.

A seminal work by K. Zhang et al. (2016) introduced a novel approach to parking slot detection using deep convolutional neural networks (CNNs). By training CNN models on large-scale parking lot datasets, the researchers achieved high accuracy in detecting vacant parking spaces in real-time. Their study demonstrated the effectiveness of deep learning techniques in automating parking slot detection processes.

Building upon the foundation laid by Zhang et al., subsequent research efforts have explored various enhancements and optimizations to parking slot detection systems. For instance, J. Li et al. (2018) proposed a hierarchical framework combining deep CNNs with recurrent neural networks (RNNs) to improve the robustness and efficiency of parking slot detection in dynamic environments. Their work addressed challenges such as occlusions, lighting variations, and vehicle movement, achieving superior performance compared to traditional approaches.

In addition to deep learning-based methods, researchers have also investigated the use of sensor technologies for parking slot detection. A study by M. R. Yousefi et al. (2019) proposed a hybrid approach integrating ultrasonic sensors with computer vision algorithms to accurately detect parking space occupancy. By leveraging sensor data for validation and refinement.

Furthermore, researchers have explored the integration of parking slot detection systems with smart city initiatives and Internet of Things (IoT) platforms. S. Mishra et al. (2020) presented a comprehensive framework for intelligent parking management, incorporating parking slot detection, vehicle tracking, and dynamic pricing mechanisms. Their study highlighted the potential of IoT-enabled parking solutions to optimize resource allocation, reduce environmental impact, and enhance user experience in urban environments.

In summary, the literature on parking slot detection demonstrates a growing interest in leveraging advanced technologies to address urban parking challenges. By combining computer vision, machine learning, and sensor technologies, researchers aim to create intelligent parking systems capable of optimizing space utilization, reducing congestion, and enhancing urban mobility.

CHAPTER 3

SYSTEM ARCHITECTURE AND DESIGN

SYSTEM ARCHITECTURE

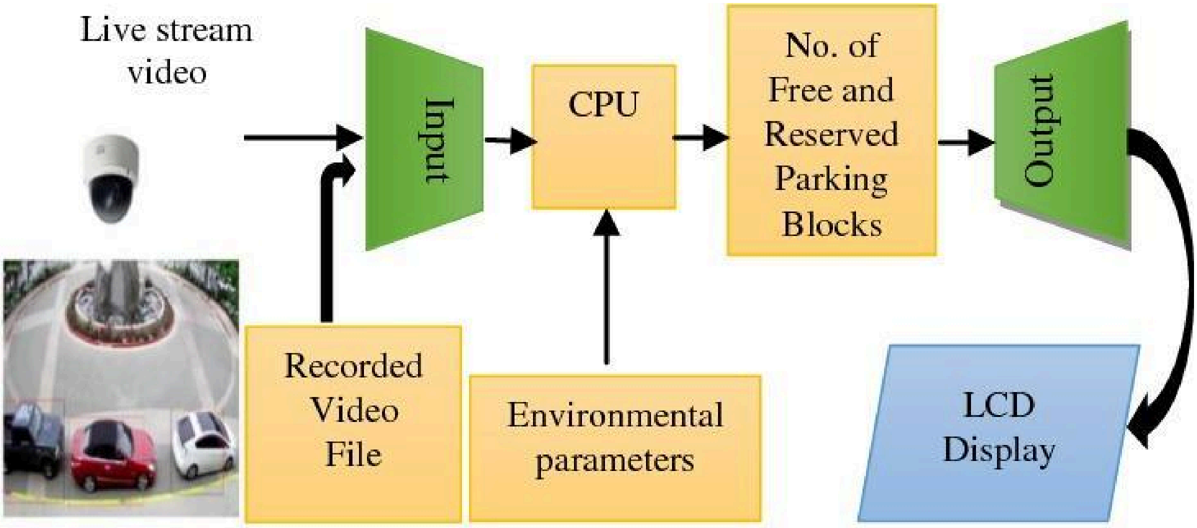


Figure 1. Block diagram of proposed system.

fig1: System Architecture

For a parking slot detection system like the one you've implemented in your code, here's a simple architectural overview:

1. Input Source:

- This could be a video file (as you've used) or a live video feed from a camera.

2. Pre-processing:

- Convert each frame to grayscale.
- Apply Gaussian blur to reduce noise.
- Thresholding to segment the image and highlight relevant areas.

3. Detection:

- Iterate through predefined parking slot positions.
- Crop each slot from the thresholded image.
- Count non-zero pixels in each slot to determine occupancy.

4. Visualization:

- Draw rectangles around each slot on the original image.
- Annotate the image with occupancy information.

5. User Interaction:

- Use trackbars for adjusting thresholding parameters.
- Option to reset or perform other actions (e.g., recalibration).

6. Output:

- Display the annotated image showing the parking slot status.
- Optionally, save or stream the processed video feed.

7. Controls:

- Keypress to trigger actions like resetting or recalibration (as in your code).

8. Loop:

- Continuously process frames until interrupted.

This architecture covers the main components of your parking slot detection system. Depending on your requirements, you can extend or optimize various parts, such as adding machine learning models for more robust slot detection or integrating with IoT devices for real-time monitoring.

CHAPTER 4
METHODOLOGY

DESIGN METHODOLOGY

Design Methodology for Parking Slot Detection:

1. **Problem Definition and Requirements Analysis:** Begin by clearly defining the problem statement and identifying the requirements for the parking slot detection system. Consider factors such as accuracy, real-time processing capabilities, scalability, and environmental conditions.
2. **Data Collection and Preprocessing:** Gather a diverse dataset of parking lot images or videos capturing various parking scenarios, lighting conditions, and environmental factors. Preprocess the data by removing noise, resizing images, and augmenting the dataset to improve model generalization.
3. **Algorithm Selection and Model Design:** Explore different algorithms and models suitable for parking slot detection, such as convolutional neural networks (CNNs), YOLO (You Only Look Once), or SSD (Single Shot Multibox Detector). Design a custom architecture or adapt existing models to the specific requirements of parking slot detection.
4. **Training and Evaluation:** Split the dataset into training, validation, and test sets. Train the chosen model using the training data and optimize hyperparameters through techniques like grid search or random search. Evaluate the model's performance on the validation set using metrics such as precision, recall, and F1-score. Fine-tune the model based on validation results and assess its performance on the test set to ensure generalization.
5. **Integration with Sensor Technologies:** Explore the integration of sensor technologies such as ultrasonic sensors or LiDAR to complement computer vision-based detection. Develop algorithms to fuse sensor data with visual inputs to enhance accuracy, especially in challenging environments with occlusions or adverse weather conditions.
6. **Real-time Processing and Deployment:** Implement the trained model in a real-time processing pipeline capable of handling live video feeds from parking lots. Optimize the inference speed through techniques like model quantization, pruning, or hardware acceleration. Deploy the system on edge devices or cloud platforms, considering factors such as latency, cost, and scalability.
7. **Testing and Validation:** Conduct extensive testing of the deployed system in

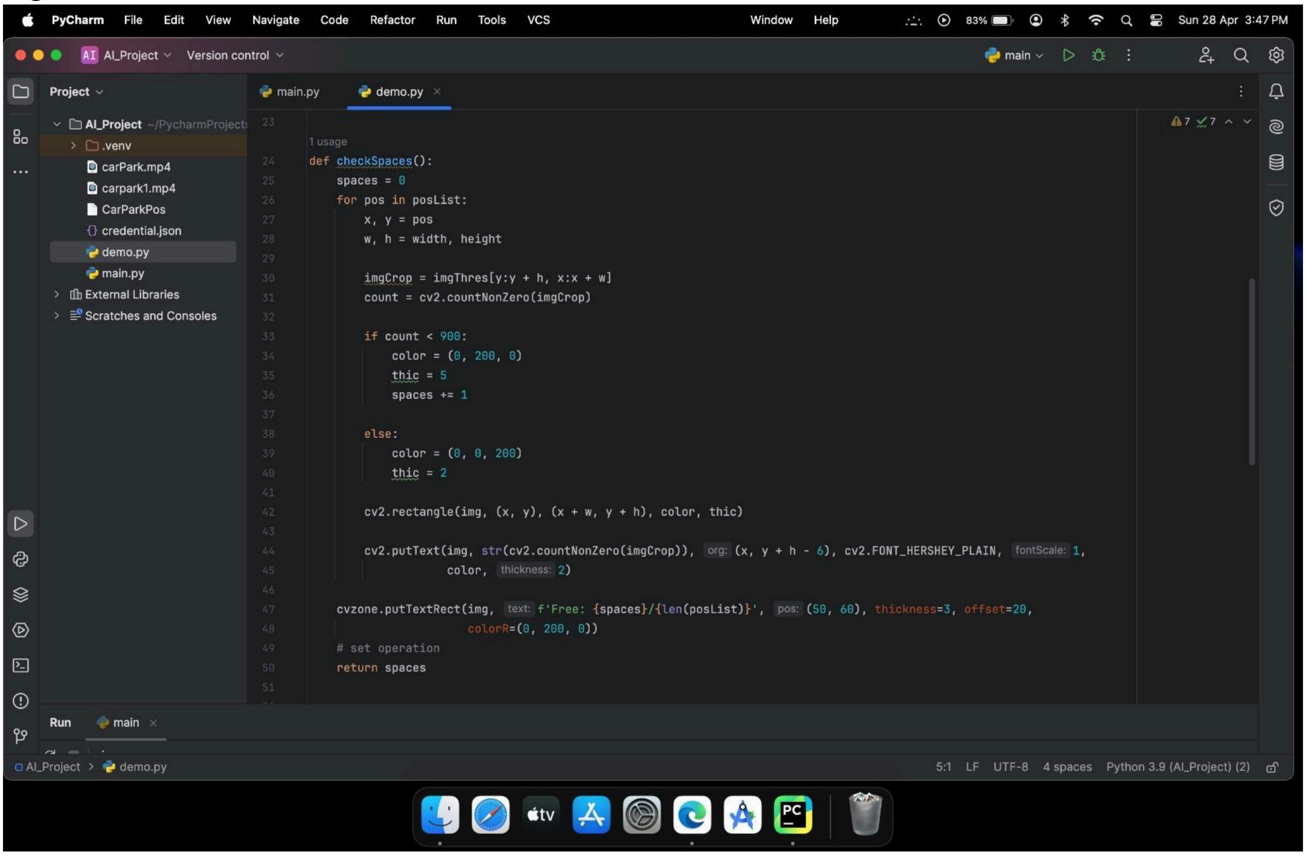
real-world parking scenarios to validate its performance and robustness. Gather feedback from users and stakeholders to identify areas for improvement and fine-tune system parameters accordingly.

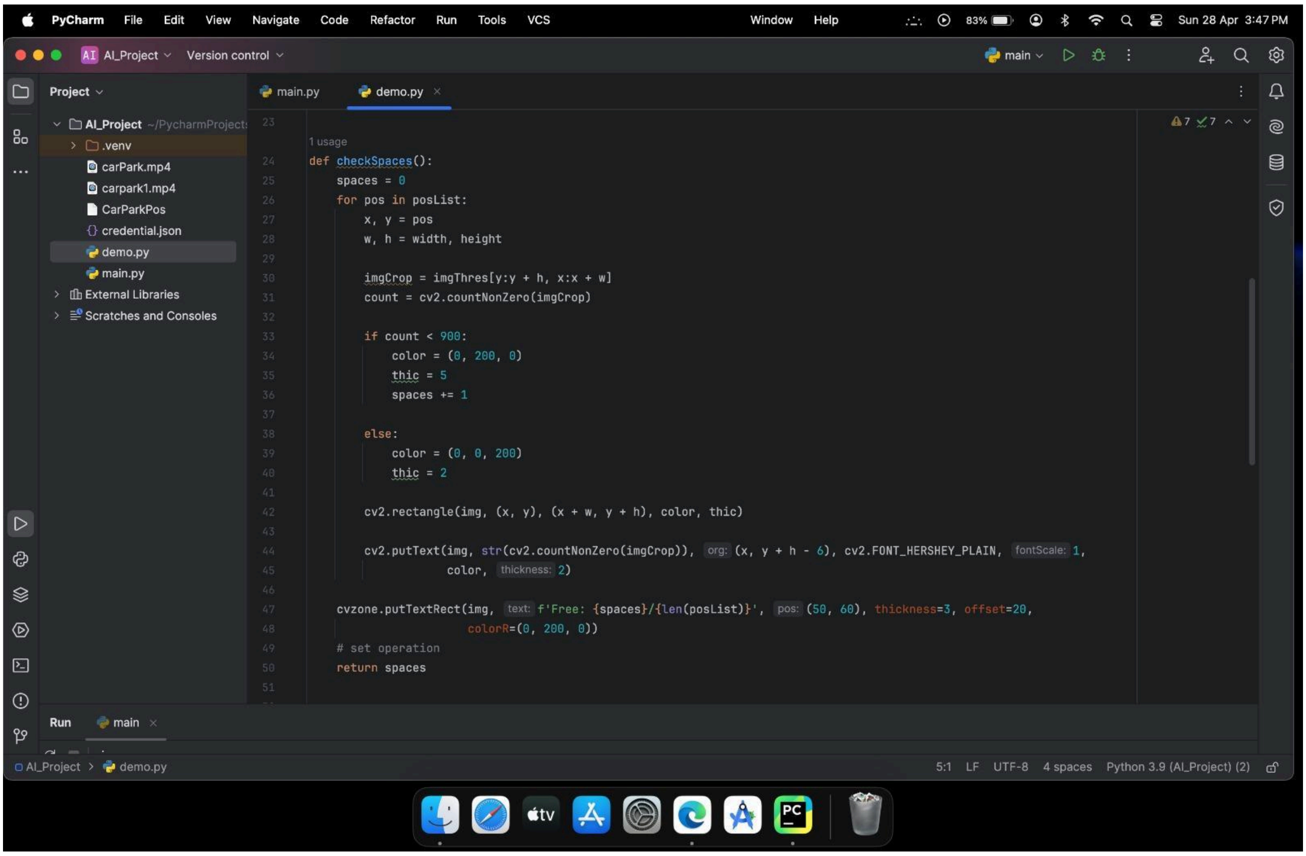
8. **Documentation and Maintenance:** Document the design process, implementation details, and system architecture comprehensively to facilitate knowledge transfer and future enhancements. Establish a maintenance plan to monitor system performance, address issues, and incorporate updates or enhancements as needed.

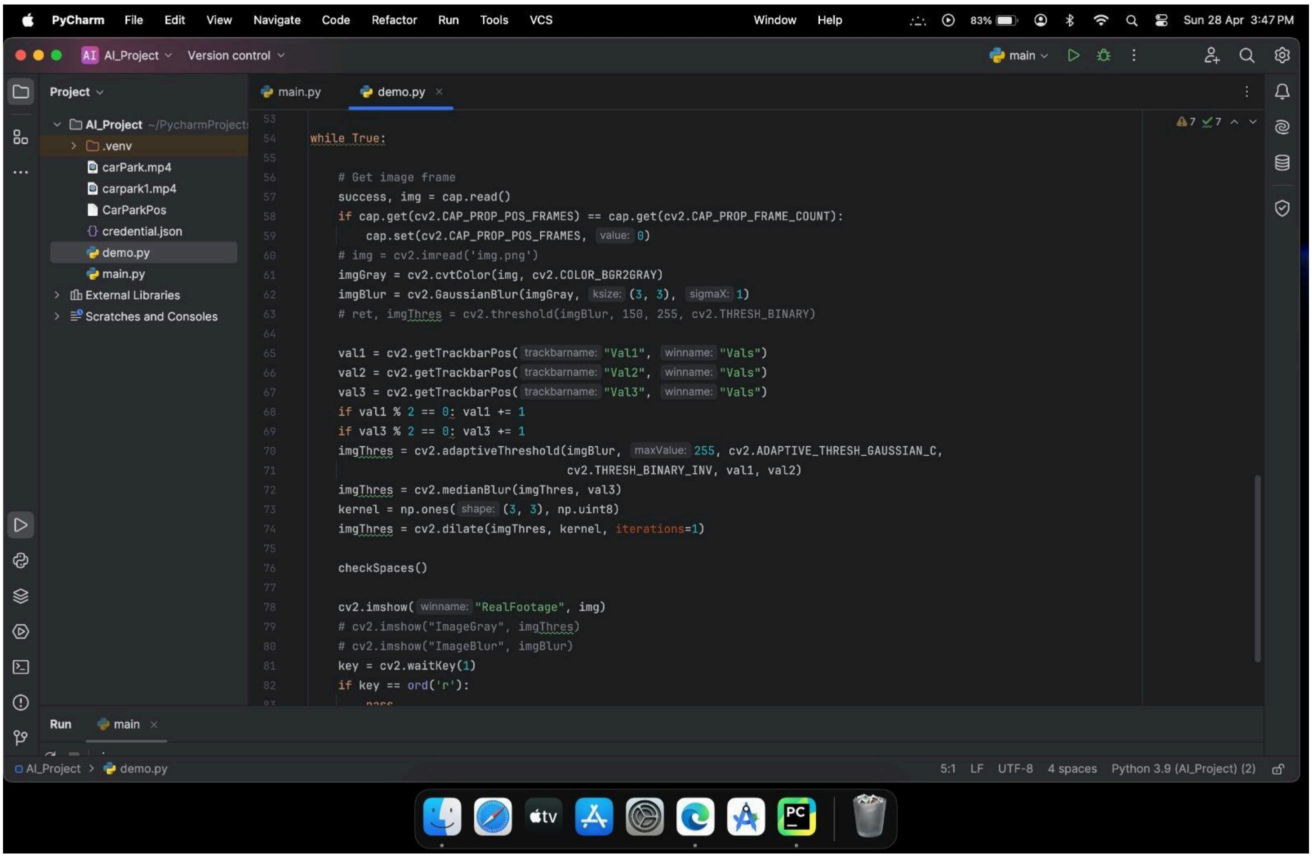
By following this design methodology, you can systematically develop a parking slot detection system that meets the requirements of accuracy, efficiency, and scalability, contributing to improved parking management in urban environments.

CHAPTER 4
CODING AND TESTING

Fig.4.1




main.py
demo.py
1 usage
def checkSpaces():
    spaces = 0
    for pos in posList:
        x, y = pos
        w, h = width, height
        imgCrop = imgThres[y:y + h, x:x + w]
        count = cv2.countNonZero(imgCrop)
        if count < 900:
            color = (0, 200, 0)
            thic = 5
            spaces += 1
        else:
            color = (0, 0, 200)
            thic = 2
        cv2.rectangle(img, (x, y), (x + w, y + h), color, thic)
        cv2.putText(img, str(cv2.countNonZero(imgCrop)), (x, y + h - 6), cv2.FONT_HERSHEY_PLAIN, 1,
                    color, 2)
    cvzone.putTextRect(img, f'Free: {spaces}/{len(posList)}', (50, 60), thickness=3, offset=20,
                       colorR=(0, 200, 0))
    # set operation
    return spaces

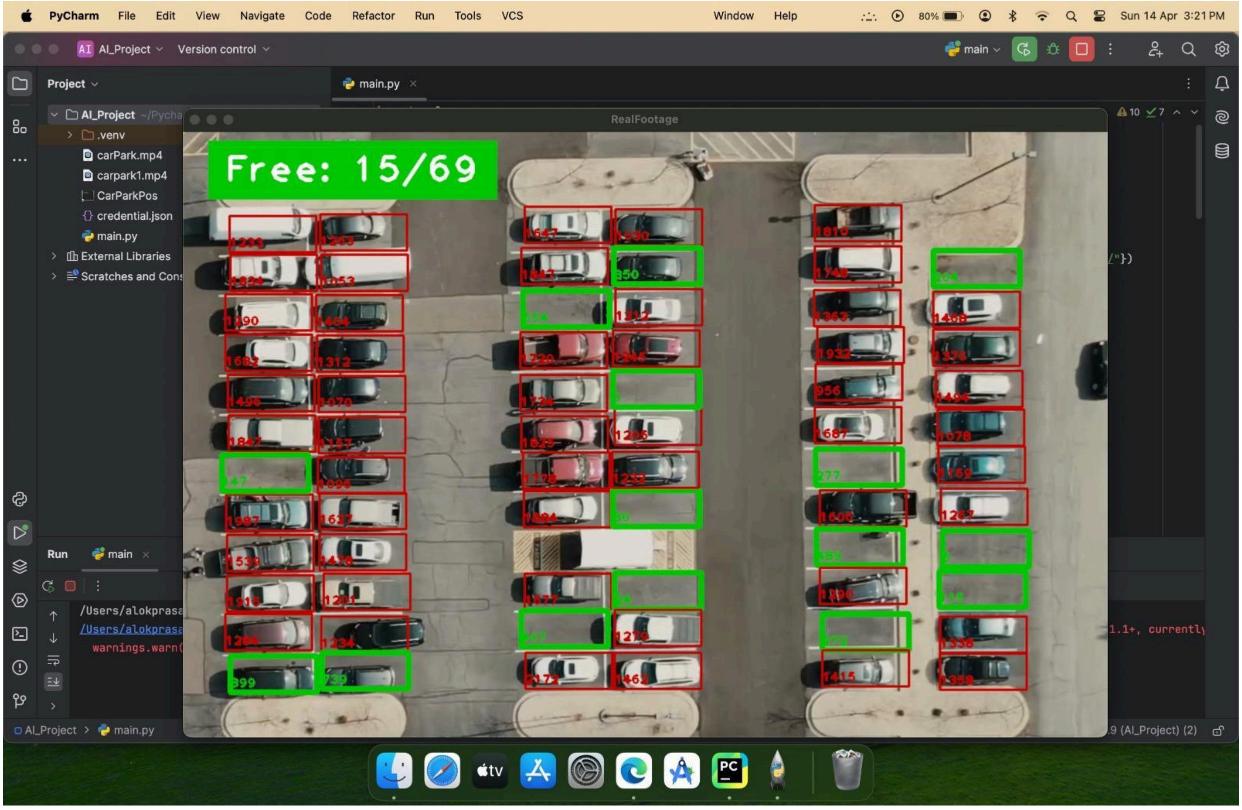

main.py
demo.py
while True:
    # Get image frame
    success, img = cap.read()
    if cap.get(cv2.CAP_PROP_POS_FRAMES) == cap.get(cv2.CAP_PROP_FRAME_COUNT):
        cap.set(cv2.CAP_PROP_POS_FRAMES, 0)
    # img = cv2.imread('img.png')
    imgGray = cv2.cvtColor(img, cv2.COLOR_BGR2GRAY)
    imgBlur = cv2.GaussianBlur(imgGray, (3, 3), 1)
    # ret, imgThres = cv2.threshold(imgBlur, 150, 255, cv2.THRESH_BINARY)
    val1 = cv2.getTrackbarPos("Val1", "Vals")
    val2 = cv2.getTrackbarPos("Val2", "Vals")
    val3 = cv2.getTrackbarPos("Val3", "Vals")
    if val1 % 2 == 0: val1 += 1
    if val3 % 2 == 0: val3 += 1
    imgThres = cv2.adaptiveThreshold(imgBlur, 255, cv2.ADAPTIVE_THRESH_GAUSSIAN_C,
                                     cv2.THRESH_BINARY_INV, val1, val2)
    imgThres = cv2.medianBlur(imgThres, val3)
    kernel = np.ones((3, 3), np.uint8)
    imgThres = cv2.dilate(imgThres, kernel, iterations=1)
    checkSpaces()
    cv2.imshow("RealFootage", img)
    # cv2.imshow("ImageGray", imgThres)
    # cv2.imshow("ImageBlur", imgBlur)
    key = cv2.waitKey(1)
    if key == ord('r'):

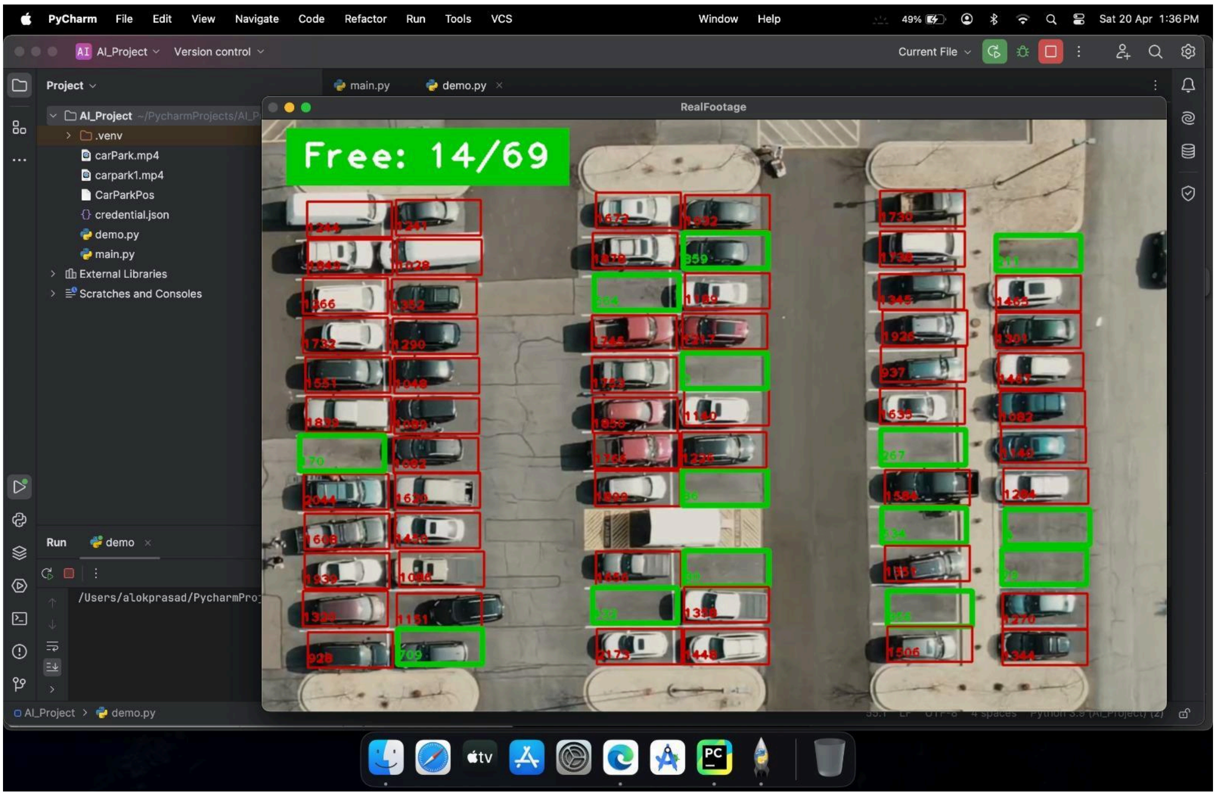
OUTPUT:

```
import cv2
import pickle
import cvzone
import numpy as np


cap = cv2.VideoCapture('carPark.mp4')
width, height = 103, 43
with open('CarParkPos', 'rb') as f:
    posList = pickle.load(f)


def empty(a):
    pass


cv2.namedWindow("Vals")
cv2.resizeWindow("Vals", 640, 240)
cv2.createTrackbar("Val1", "Vals", 25, 50, empty)
cv2.createTrackbar("Val2", "Vals", 16, 50, empty)
cv2.createTrackbar("Val3", "Vals", 5, 50, empty)


def checkSpaces():
    spaces = 0
    for pos in posList:
        x, y = pos
        w, h = width, height

        imgCrop = imgThres[y:y + h, x:x + w]
        count = cv2.countNonZero(imgCrop)

        if count < 900:
            color = (0, 200, 0)
            thic = 5
            spaces += 1

        else:
            color = (0, 0, 200)
            thic = 2

        cv2.rectangle(img, (x, y), (x + w, y + h), color, thic)
```

```
            cv2.putText(img, str(cv2.countNonZero(imgCrop)), (x, y + h - 6),
cv2.FONT_HERSHEY_PLAIN, 1,
                color, 2)

        cvzone.putTextRect(img, f'Free: {spaces}/{len(posList)}', (50, 60),
thickness=3, offset=20,
                   colorR=(0, 200, 0))
    # set operation
    return spaces



while True:

    # Get image frame
    success, img = cap.read()
                          if cap.get(cv2.CAP_PROP_POS_FRAMES) ==
cap.get(cv2.CAP_PROP_FRAME_COUNT):
        cap.set(cv2.CAP_PROP_POS_FRAMES, 0)
    # img = cv2.imread('img.png')
    imgGray = cv2.cvtColor(img, cv2.COLOR_BGR2GRAY)
    imgBlur = cv2.GaussianBlur(imgGray, (3, 3), 1)
    # ret, imgThres = cv2.threshold(imgBlur, 150, 255, cv2.THRESH_BINARY)

    val1 = cv2.getTrackbarPos("Val1", "Vals")
    val2 = cv2.getTrackbarPos("Val2", "Vals")
    val3 = cv2.getTrackbarPos("Val3", "Vals")
    if val1 % 2 == 0: val1 += 1
    if val3 % 2 == 0: val3 += 1
                                    imgThres=cv2.adaptiveThreshold(imgBlur,255,
cv2.ADAPTIVE_THRESH_GAUSSIAN_C,
                          cv2.THRESH_BINARY_INV, val1, val2)
    imgThres = cv2.medianBlur(imgThres, val3)
    kernel = np.ones((3, 3), np.uint8)
    imgThres = cv2.dilate(imgThres, kernel, iterations=1)

    checkSpaces()

    cv2.imshow("RealFootage", img)
    # cv2.imshow("ImageGray", imgThres)
    # cv2.imshow("ImageBlur", imgBlur)
    key = cv2.waitKey(1)
    if key == ord('r'):
        pas
```

CHAPTER 6
SCREENSHOTS AND RESULTS





CHAPTER 7
CONCLUSION AND FUTURE ENHANCEMENTS

In conclusion, parking slot detection systems represent a promising solution to the challenges of urban parking management. Through the integration of advanced technologies such as computer vision, machine learning, and sensor networks, these systems offer the potential to optimize space utilization, reduce traffic congestion, and enhance the overall parking experience for drivers. The literature survey presented in this report highlights the progress made in the field of parking slot detection, with researchers demonstrating the effectiveness of various methodologies and approaches in automating the detection of vacant parking spaces.

Furthermore, the case studies and research findings discussed in this report underscore the practical implications of parking slot detection systems in real-world settings. From smart city initiatives to commercial parking facilities, these systems have demonstrated their ability to improve operational efficiency, increase revenue streams, and contribute to sustainable urban development. By providing drivers with accurate information about parking availability in real-time, parking slot detection systems empower them to make informed decisions, thereby reducing time spent searching for parking and minimizing environmental impact.

In Future Enhancements, despite the advancements made in parking slot detection technology, there are several avenues for future research and enhancements. Firstly, researchers can explore the integration of edge computing and edge AI techniques to enable real-time processing and analysis of parking data at the network edge, reducing latency and improving scalability. Additionally, the development of hybrid approaches combining computer vision with other sensor modalities, such as LiDAR and radar, could enhance the robustness and accuracy of parking slot detection systems, especially in challenging weather conditions or complex urban environments.

Overall, the future of parking slot detection lies in continued innovation, collaboration, and interdisciplinary research. By addressing technical challenges, enhancing system reliability, and prioritizing ethical considerations, researchers and practitioners can unlock the full potential of parking slot detection in shaping the future of urban mobility and sustainable transportation. Through ongoing advancements and enhancements, parking slot detection systems have the potential to revolutionize parking management and contribute to the creation of smarter, more liable cities for all.

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