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Enhancing Urban Mobil Image Driven Parking Space Optimization

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ABSTRACT:

A parking spot detection system using classical computer vision techniques. It processes a video feed, identifying parking spots based on pre-defined coordinates stored in a YAML file. The algorithm analyzes each frame, determining spot occupancy by examining grayscale intensity statistics within defined regions. If the standard deviation of intensity falls below a threshold and the mean intensity exceeds a specified value, the spot is considered occupied. The system overlays visual indicators on the video frames, distinguishing between occupied and vacant spots and providing real-time feedback on the number of available spaces. Users can interact with the system by pausing the video, capturing frames, or quitting the application using keyboard commands. While the code does not involve deep learning or traditional machine learning approaches, it demonstrates a practical application of image processing and computer vision techniques for parking spot detection and occupancy monitoring in real-world scenarios..

1. Introduction

Parking space management is a critical issue in urban areas, where the demand for parking spaces often exceeds the available supply. This can lead to traffic congestion, increased pollution, and a negative impact on the quality of life for residents and visitors. To address this challenge, we propose a project focused on optimizing parking space utilization through a comprehensive approach that combines technology, data analysis, and policy interventions. By leveraging advanced technologies such as smart sensors, machine learning algorithms, and real- time data analytics, we aim to develop a parking management system that can efficiently allocate parking spaces, reduce congestion, and improve the overall parking experience for drivers. This project will also explore the potential of policy interventions such as dynamic pricing, shared parking, and incentives for alternative modes of transportation to further optimize parking space utilization. Through a combination of technical innovation and policy interventions, we hope to create a more sustainable and efficient parking system that can benefit both drivers and the environment.

2. Literature Review

In the research paper titled as "Technological improvement rate predictions for all technologies: Use of patent data and an extended domain description,2021" Anuraag Singh,

Giorgio Triulzi, Christopher L. Magee, the researchers used Classifiaction Overlap Method(COM).The classification overlap method is a technique used in object detection to refine the classification results by considering the overlap between bounding boxes. It involves comparing the confidence scores of overlapping bounding boxes and selecting the one with the highest confidence as the final prediction. This approach helps reduce duplicate detections and improve the accuracy of object localization and classification in scenarios where multiple bounding boxes are generated for the same object.

In the research paper titled as " A Smart, Efficient, and Reliabl Parking Surveillance System With Edge Artificial Intelligence on IoT Devices, 2020" by R. Ke, Y. Zhuang, Z. Pu and Y. Wang,they used Single Shot Multibox Detector (SSD) for for the detection of vehicles and objects.Single Shot Multibox Detector (SSD) can enhance parking surveillance by efficiently detecting vehicles and objects. It operates by generating a set of default bounding boxes with varying aspect ratios and scales across feature maps, predicting class scores and offsets for each box. In a parking surveillance system, SSD can rapidly identify vehicles and potential obstructions, aiding in monitoring parking space occupancy and detecting unauthorized vehicles or safety hazards.

In the research paper titled as "An Image Feature-Based Method or Parking Lot Occupancy, 2019" by Tatulea, Paula, Florina Calin, Remus Brad, Lucian Brancovean and Mircea Greavu, used Histogram of Oriented Gradients (HOG) for background substraction which is very important in computer vision applications.Prior to applying the algorithm, the edges in the images must be detected and the image resized. The edge detection is done using the Canny algorithm, while the image is resized to 64× 128 pixels.

In the research paper titled as "A Smart Image Processing- based System for Parking Space Vacancy Management,July 2018" by Kommey, Benjamin & Addo, Ernest & Agbemenu, Andrew, they used The Canny Edge Detection Algorithm which is commonly used in parking spot vacancy systems to identify edges of vehicles within parking spots.Implementing Canny edge detection in a parking spot vacancy system can be effective for detecting empty parking spaces.It helps detect the boundaries of vehicles, allowing the system to determine whether a spot is occupied or vacant based on the presence or absence of edges within predefined regions.

In the research paper titled as " Computer Vision Based Parking Optimization System,2021" by Siddharth Chandrasekaran, Jeffrey Matthew Reginald, Wei Wang, Ting Zhu , they used Space Identification Algorithm. Space identification algorithms are pivotal in parking space optimization projects by efficiently determining vacant parking spots. These algorithms utilize sensor data and image processing techniques to detect unoccupied spaces in real-time. By analyzing sensor readings or images captured by cameras installed in parking lots, the algorithm identifies available spots and updates the parking database accordingly. This information is then relayed to drivers through mobile applications or electronic signage, streamlining the parking process and maximizing utilization of parking resources. Ultimately, space identification algorithms play a crucial role in enhancing the efficiency and effectiveness of parking management systems, leading to improved user experiences and reduced congestion.

3. Modules:

OpenCV (cv2): OpenCV is a computer vision library used for image and video processing tasks such as reading, processing, and displaying video frames, as well as performing operations like Gaussian blurring, color conversion, contour detection, and drawing shapes on images.

NumPy (np): NumPy is a library used for numerical computing with Python. It provides support for large, multi-dimensional arrays and matrices, along with a collection of mathematical functions to operate on these arrays efficiently. In the provided code, NumPy is used for array manipulation and mathematical operations.

YAML: YAML is a human-readable data serialization format commonly used for configuration files. In the code, YAML is used for reading parking spot coordinates from a YAML file.

VideoCapture: VideoCapture is a class provided by OpenCV for capturing video from files or camera devices. It's used to read frames from the input video file.

cv2.imshow() and cv2.waitKey(): These functions are used for displaying images or videos in windows and waiting for keyboard input, respectively. They enable the interactive display of processed video frames and handling of user input for controlling the application.

cv2.imwrite(): This function is used to save frames as images. In the script, it's invoked when the user presses the 'c' key to capture frames

4. Architecture

Input: The system takes a video file (video.mp4) as input, which contains footage of parking spots.

Video Capture: The video file is read frame by frame using OpenCV's VideoCapture class.

Preprocessing: Each frame undergoes preprocessing steps, including Gaussian blurring and conversion to grayscale (cv2.GaussianBlur(), cv2.cvtColor()).

Parking Detection Algorithm: The core of the system involves detecting parking spots and determining their occupancy status. This process includes Loading parking spot coordinates from a YAML file. Calculating regions of interest (ROIs) for each parking spot.

Analyzing the pixel values within ROIs to detect changes indicative of vehicle presence.

Visualization: Detected parking spots and their occupancy status are visualized on the frames using contours, bounding rectangles, and text overlays. This step provides visual feedback to users about parking availability and occupancy.

User Interface: The processed frames with parking spot overlays are displayed in a window using cv2.imshow(). The system waits for user input using cv2.waitKey() to control functionalities such as quitting the application or capturing frames.

Image Capture: Optionally, users can capture frames by pressing the 'c' key, which triggers the saving of frames as images using cv2.imwrite().

Output: The system outputs the processed video frames with parking spot overlays and occupancy information displayed. Additionally, users can capture frames as images for further analysisor documentation.

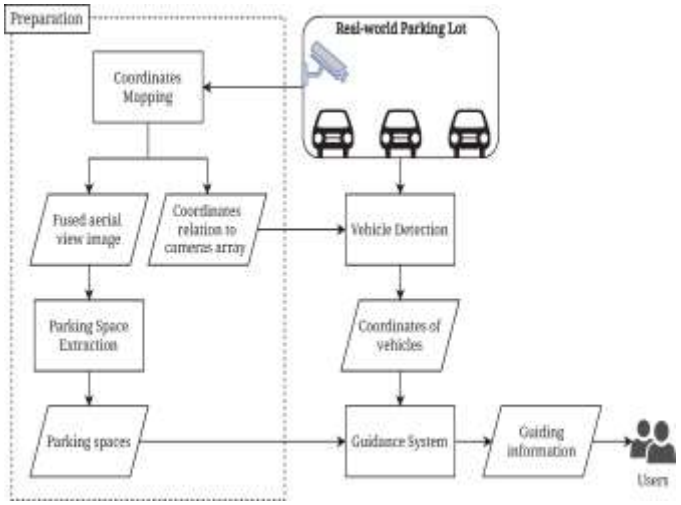

Fig 1. Architecture

5. Conclusion

In conclusion, the image-driven parking space optimization project successfully utilized advanced computer vision techniques to analyze and optimize parking lot efficiency. Through the implementation of image processing algorithms, the project accurately identified available parking spaces, reducing congestion and improving overall parking management. Real- time monitoring and data analysis provided valuable insights for better resource allocation and enhanced user experience. By leveraging technology to streamline parking operations, the project demonstrates the potential for intelligent solutions to address urban mobility challenges effectively.

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