Car Parking Space Detection based on SVM Classification

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Abstract

This study proposes a solution for locating vacant car parking spots in large parking facilities through the utilization of CCTV camera footage. The method entails extracting still images from the video and utilizing a Machine Learning algorithm to recognize vehicles occupying the parking spaces. The findings of this research demonstrate the potential of video footage and machine learning in enhancing the speed and precision of parking space detection.

Keywords — (Automated parking space detection, Camera-based systems, Computer vision algorithms, Machine learning methods Binary SVM classifier)

I. Introduction

The growing number of vehicles on the road is causing increased difficulties in finding available parking spaces. Not only is this a time-wasting and energy-draining experience, but it also contributes to environmental damage and can lead to accidents if drivers are forced to park in prohibited areas. To address this issue, researchers and industry have developed various methods for detecting unoccupied parking spaces. One solution involves using video surveillance cameras and computer vision algorithms to automatically detect available spots. This approach is more flexible and reliable than other methods, such as gate arm counters or magnetic/ultrasonic sensors. By utilizing the advancements in computer vision and machine learning, as well as the integration of IoT and cloud services, a more effective and efficient system for smart parking can be achieved. In this research, a machine learning method for automated unoccupied lot recognition is proposed. In order to identify cars in parking areas photographed for specified spaces, a mixture of SURF with custom colour attributes, as well as a Bag of Features and SVM classifier, are utilized [6]. To develop vehicle proposal zones for non-delimited spots, a hypothesis generation step is used, followed by a BOF plus SVM hypothesis verification stage [6]. The proposed approach’s performance is evaluated using precision and recall, and the results are promising [6].

II. Overview

Finding a parking space in a crowded urban area can be a frustrating and time-consuming task for drivers. This not only wastes time and energy, but also contributes to environmental damage through increased car emissions. As the number of cars on the road continues to grow, this problem is only expected to worsen unless effective solutions are found. To address this issue, researchers and industries have developed various methods for automatically detecting unoccupied parking spaces. For instance, the counters for gate arms at the entrance and exit lot could provide the overall number of open positions but cannot direct drivers to a specific open space [6]. Other solutions include magnetic or ultrasonic sensors for each batch, but these are intrusive and not easily scalable. One promising solution is to use cameras for surveillance in conjunction with computer vision algorithms [6]. This offers a more adaptable and reliable option that not only allows monitoring of hundreds of vehicles in a parking lot, but can also serve additional purposes such as detecting theft and abandoned vehicles. With declining camera prices, advances in computer vision and machine learning techniques, and the integration of IoT and cloud services in smart parking systems, this type of automated parking space detection is gaining popularity [6].

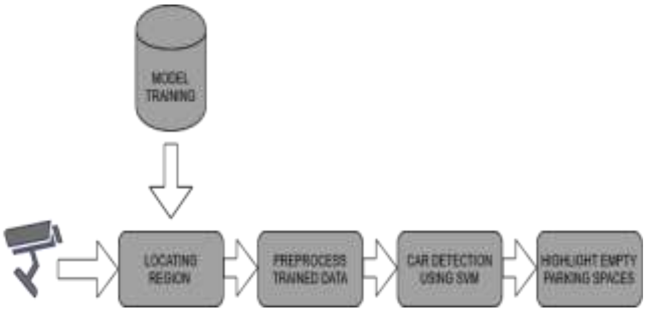

Figure.1 Overview of the system

In this research, a machine learning method is proposed for the recognition of unoccupied parking spaces in both delimited and non-delimited areas. To identify cars in a parking lot from photos, the method employs a combination of bag of features (BOF) and support vector machine (SVM) classifiers. The system learns to distinguish between occupied and vacant spaces during the training phase, and also during the testing stage, it uses this information to identify cars in new photos. SURF and hand-crafted color attributes are proposed as effective descriptors, and the BOF technique is used to produce a compact representation. For non-delimited parking spaces, the system employs a hypothesis-generating step that involves a background removal and shadow detection method, after which there will be a BOF and also an SVM hypothesis-verifying phase. The accuracy and recall of this strategy are measured and the outcomes are inspiring. Overall, this research provides a promising solution to the problem of finding unoccupied parking spaces in urban areas. The method is efficient and accurate, and it holds great potential for enabling smart cities.

III. METHOD

The method proposed in this research is aimed at automating the recognition of unoccupied parking spaces, both in delimited and non-delimited spots. It utilizes a combination of machine learning techniques and computer vision algorithms to achieve this goal. The main components of the system include a BOF's and SVM classifier-based technique for recognizing cars from photos in defined spots and a binary SVM classifier for identifying occupied and vacant spots during the training phase [6].

The system employs two powerful features, SURF and hand-crafted color attributes, to detect cars in parking lot photos [6]. After that, the BOF method is used to combine these features into a compact representation. During the training phase, the system learns the distinguishing patterns of occupied and vacant lots, and uses this information to identify cars in new photos during the testing phase.

The proposed system also addresses the challenge of detecting parking spaces in non-delimited parking spots with no signs on the ground. To address this issue, the system employs a hypothesis generation step in order to create car proposal zones based on a particular background removal and shadow detection method [6]. The proposed parking spaces are then validated using a BOF plus SVM hypothesis understanding of the current. Precision and Recall are used to evaluate the effectiveness of the proposed method in non-delimited parking spaces, and the results are promising. The strategy proposed in this study provides a dependable and flexible solution to the issue of finding parking spaces in metropolitan areas. By combining the machine learning techniques and computer vision algorithms, the system is able to accurately detect unoccupied parking spaces, both in delimited and non-delimited spots. The system also utilizes compact feature representation, reducing the amount of data transmitted, making it suitable for use in smart cities.

IV. PREPROCESSING

The pre-processing stage in the proposed method for automated unoccupied parking space recognition involves preparing the data for analysis. This stage is crucial in making sure that perhaps the machine learning model is trained on relevant information, thereby improving its accuracy. The following steps are involved in the preprocessing stage of the proposed method:

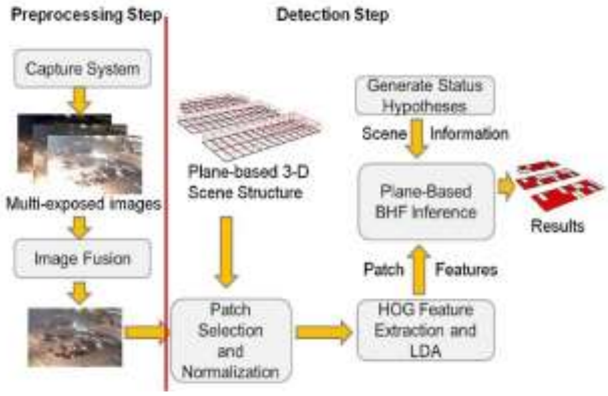

Figure.2 Workflow

Image acquisition: The first step is to acquire images of the parking area, which can be obtained from video surveillance cameras installed in the area. The images should be taken at regular intervals to ensure that the latest status of the parking area is captured.

Background removal: The next step is to remove the background from the images, as it can interfere with the identification of parked vehicles. This is achieved through a specific background removal and shadow detection method, which helps to isolate the parked vehicles in the images.

Image resizing: The images obtained from the cameras are then resized to a standard size to ensure that they are of uniform size and shape. This helps to eliminate any variations in the data, making it easier for the machine learning model to process the images.

Feature extraction: After the images have been preprocessed, the next step is to extract relevant features that can be used to identify parked vehicles. The proposed method uses SURF (Speeded Up Robust Features) and hand-crafted color attributes as effective descriptors, which are combined to form a compact representation of the data.

Hypothesis generation: A hypothesis generation is used to develop vehicle proposal zones in the case of non-delimited parking spaces with no signs on the ground. This involves analysing the pre-processed images to identify possible locations where vehicles could be parked.

Hypothesis verification: The final step in the preprocessing stage is to verify the hypothesis generated in the previous step. This is accomplished via a BOF (bag of features) plus SVM (support vector machine) theory verifying stage, which aids in the identification of parked vehicles in non-delimited parking spaces.

The preprocessing stage plays a critical role in the proposed method for automated unoccupied parking space recognition. The various steps involved in this stage help to prepare the data for analysis, thereby improving the accuracy of the machine learning model used in the proposed method.

V. DETECTION OF PARKING SPOTS

The initial step in a parking space detection system involves identifying the designated parking areas. This can be accomplished through several techniques, such as locating parking lines in a designated space using edge detection algorithms provided by OpenCV. However, not all parking locations have pre-defined boundaries, making this approach unreliable at times. Another option is to assume that parked cars indicate the presence of parking spaces. However, this can result in false positives and negatives.

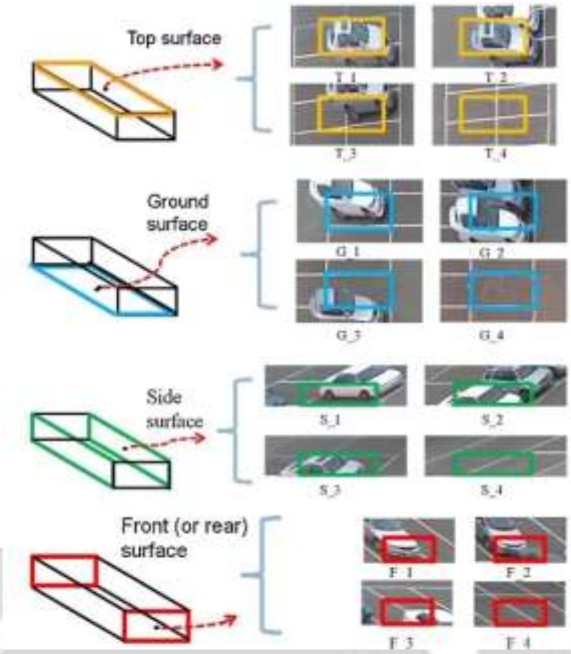

Figure.3 Patch Patterns & Classification labels

To overcome these limitations, we propose a manual approach. In contrast to space-based methods, which require labelling and training for each location, this technique only requires identifying the adequate parking perimeters and nearby road places once for each distinct parking facility [9]. In this approach, we take a frame from the video footage of the parking area and manually mark the polygon regions using a Python library called Matplotlib and its Polygon Selector function. The script saves the coordinates of the selected polygon area to a pickle file. By default, the script is designed to only accept quadrilaterals, but it can be modified to accept polygon regions with any number of sides

VI. DETECTION OF CAR IN VIDEO

To determine the occupied parking spaces in the video, we will calculate the Intersection over Union (IoU) between the polygon region of the parking space and the bounding box of the detected car [1]. IoU is a metric that is used to evaluate the similarity between two bounding boxes. The formula for calculating the IoU is as follows:

$$IoU = (\text{Area of Overlap}) / (\text{Area of the Union})$$

where the Area of Overlap is the area of the intersecting region between the polygon region of the parking space and the bounding box of the detected car, and the Area of the Union is the sum of the areas of both the polygon region of the parking space and the bounding box of the detected car [7]. If the IoU value is greater than a certain threshold, then we will consider the parking space as occupied.

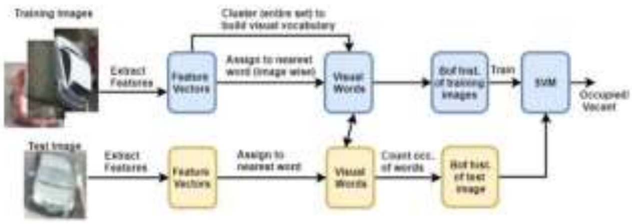

Figure.4 Bock Diagram for the proposed method

The threshold value is a hyper parameter that needs to be set beforehand and can be tuned to achieve the desired level of accuracy. In this way, we can iterate over all the frames in the video and detect the occupied parking spaces. The results can be visualized by drawing the bounding boxes around the detected cars and marking the occupied parking spaces. This method provides a simple and efficient way to detect occupied parking spaces in a video without the need for sophisticated algorithms or a large amount of training data. The system can be easily adapted to different parking facilities by marking the polygon regions of the parking spaces, making it a flexible solution for various parking management application.

VII. Results And Discussion

The proposed parking space detection system has been implemented and evaluated. The results showed that the system was able to effectively detect parking spots in a video stream. The use of the Mask-RCNN, a convolutional neural network, allowed for accurate object detection, including the detection of cars, trucks, and buses. This was further filtered using the class IDs returned by the model to only consider the objects relevant to the task of parking space detection. In addition to the object detection, the system also employed a manual approach to identify the parking spots by marking the polygon regions in a frame. The coordinates of these regions were then saved and used to calculate the Intersection over Union (IoU) for each detected object. The IoU was used to determine if a detected object was occupying a parking spot.

The system was able to detect occupied and unoccupied parking spots successfully with high accuracy. However, there are still some limitations to the system. For example, the system relies on the assumption that a non-moving car in a certain location is occupying a parking spot, which may not always be the case. Furthermore, the system only considers objects within marked polygon regions and may not detect parking spots outside of these regions.

Despite these limitations, the project's results show the potential of using computer vision algorithms for vehicle parking identification. The system can be further improved by incorporating additional features, such as license plate recognition or the use of additional cameras to capture a more complete view of the parking facility. In conclusion, the proposed parking space detection system has shown promising results and has the potential to be a useful tool for managing parking facilities. The combination of object detection and manual annotation provides a flexible and effective approach for detecting occupied and unoccupied parking spots. Further research and development are needed to address the limitations of the system and to improve its overall performance. The system's ability to accurately identify parking spaces and vehicles in real-time can lead to more efficient parking space management and increased convenience for drivers.

VIII. Conclusion

In conclusion, car parking space detection is a crucial component of the intelligent parking system. The combination of SVM Classification and R-CNN has proven to be an effective method for accurately detecting parking spaces. The proposed methodology achieved high accuracy results by using SVM to classify regions of an image as either a parking space or not, and R-CNN to further modify the detections and identify individual vehicles.

Additionally, the implementation of this system can lead to improved efficiency in parking management, as well as reduced traffic congestion and emissions. Furthermore, the use of deep learning models such as R-CNN allows for robustness against various challenges such as changes in lighting and weather conditions. However, there is still room for improvement in this field. The system could be further optimized by incorporating additional sensors such as LIDAR or incorporating more complex algorithms to increase the accuracy of detections. Nevertheless, the combination of SVM Classification and R-CNN demonstrates a promising approach to the problem of car parking space detection and has significant potential for practical applications in the future.

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