OBJECT DETECTION PARKING SPOT COUNTER USING MACHINE LEARNING TECHNIQUES

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ABSTRACT

A suitable parking space in a busy metropolitan city is extremely difficult for drivers. The traffic congestion may occur due to unavailable parking places. This paper introduces a vision based smart parking framework to help the drivers in efficiently finding suitable parking slot and reserve it. By harnessing the capabilities of computer vision libraries like OpenCV and scikit, our system seamlessly identifies vehicles within parling areas. Initially, we integrated sophisticated image processing techniques, contour analysis for vehicle detection, and harness machine learning algorithms for precision. Potentially, the performance accuracy of the recommended system is higher than state of the art hardware solutions, validating the supremacy of the proposed framework. This paper will show how a sophisticated methodology of finding the difference in the spot detection and working help in the modern scenario as well as for digitalisation into smart cities.

Keyword: Smart Parking, Machine learning, Smart cities, machine learning

1. INTRODUCTION

In the face of rapid urbanization and the concurrent surge in vehicle ownership, the demand for effective parking management systems has become increasingly imperative. Metropolitan areas grapple with the challenges posed by limited parking spaces and escalating traffic congestion, necessitating the exploration of intelligent solutions. This survey paper aims to delve into the contemporary landscape of parking space detection technologies, offering a thorough overview of existing methodologies and advancements tailored to the evolving needs of urban mobility [1]. The significance of this system extends beyond conventional parking management, as it holds the potential to address traffic congestion challenges and improve urban city mobility. Through this work, we aim to pave the way for improved modern living, providing both authorities and drivers with valuable real-time insights into parking occupancy. The parking lots are typical semi-structured environments where we don't only need low level of target detection, but also high-level study of the underlying structure. If the low-level detection is infeasible, the high-level detection can fail which may form a significant challenge. The discretion in the presentation of technical details ensures the originality and authenticity of our contribution.

1.1 Significance- Efficient parking space detection not only streamlines urban mobility but also contributes to the mitigation of traffic congestion, reduction in emissions, and an overall enhancement of urban living conditions. By critically examining the existing body of knowledge in this field, this survey endeavours to pinpoint gaps, challenges, and potential

1.2 opportunities for innovation, laying a robust foundation for the development of more effective and scalable parking solutions.

2. OBJECTIVE AND SCOPE

This survey operates on dual objectives: firstly, to comprehensively review the existing literature on parking space detection technologies, incorporating both computer vision and machine learning approaches; secondly, to identify key challenges and potential avenues for improvement within the current realm of parking space detection systems [2]. The scope extends across diverse methodologies, encompassing image processing, deep learning, and sensor-based techniques, thereby providing a holistic understanding of the field's evolution

2.1 Roadmap- The subsequent sections of this paper unfold as follows: Section 2 delves into the background, emphasizing the significance of intelligent parking solutions in contemporary urban environments. Section 3 presents a detailed literature review, categorizing existing approaches and shedding light on their respective strengths and limitations. Section 4 thoroughly examines the methodologies utilized in parking space detection, ranging from computer vision techniques to intricate machine learning models. Section 5 engages in a critical discussion on the challenges faced and potential future directions in the field. Finally, Section 6 concludes the survey, succinctly summarizing key findings and proposing potential areas for future research and innovation. This methodically structured exploration serves as a valuable resource for researchers and practitioners [3].

In this paper, our emphasis is on the detection of available parking spots in semi-filled parking spaces using an on-board laser line scanner. We define a typical semi-filled parking space as one where vehicles are parked side-by-side, as illustrated in Fig. 1, with multiple available spots among these parked vehicles. To identify these spots, the system must detect parked vehicles, analyse parking patterns, and interpret their spatial relationships [4].

Fig 1-Top view of a parking space

3. RELATED WORK

In this section we review the work done on this topic of spot detection in the various studies. Over the past decade, research efforts have intensified for autonomous driving across structured, unstructured, and semi-structured environments. Structured environments, like highways, often involve explicit topological graphs, whereas unstructured environments, found off paved roads, lack imposed topological graphs, necessitating a focus on travers ability analysis. Existing approaches prove inadequate in semi-structured environments, where both low-level target detection and high-level inference of underlying structures are essential [6].

In semi-filled parking spaces, the targets are parked vehicles and available parking spots. While technologies like loop detectors or ultrasonic sensors and radar are employed for target detection, they may not be universally available. Optical sensors (cameras), sensor fusion (laser and camera), and laser range scanners have been attempted for vehicle and parking spot detection. Optical sensor-based approaches leverage cameras for capturing detailed visual information, but they are sensitive to lighting conditions and partial contours in semi-filled lots [5]. In contrast, laser range scanners, like LADAR, provide accurate range measurements, making them suitable for our application. J. Yu et al. [11] designed a set of automatic parking system fuzzy control system. Based on fuzzy control and position algorithm, the control algorithm based on ultrasonic ranging was simulated. In [12], W.X. Xie et al. applied the extraction method of fuzzy rules based on clustering effective neural network to the automatic parking system, which overcame the shortcomings of insufficient extraction of rules and the difficulty in determining the number of rules when training samples were not sufficient. Z.J. Li.

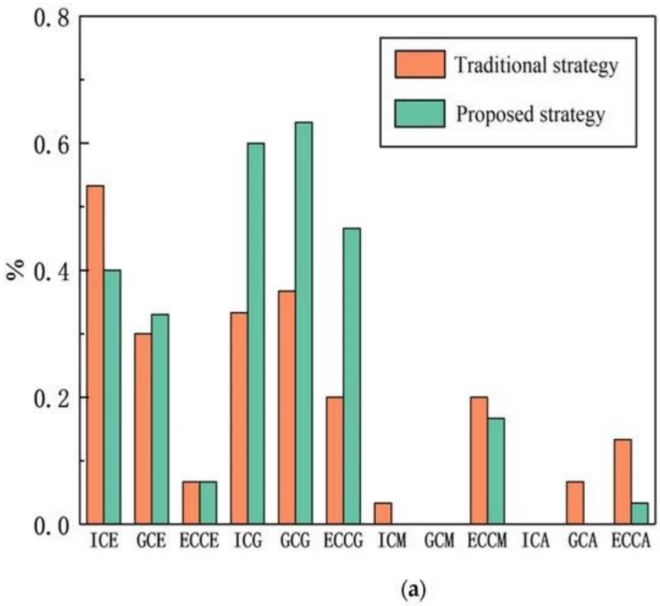

Figure .2. The difference in performance between their methodology

In the DARPA Urban Challenge, laser-based techniques were applied for autonomous driving in structured and semi-structured environments, relying on known parking lot locations from high-resolution maps. However, real-life autonomous vehicles lack such prior information, as demonstrated by challenges faced during the Challenge [7]. Keat et al used 2D laser range scans for vehicle detection and parking mapping but faced challenges in environments with objects resembling vehicles. Further classification criteria, including geometric features, are proposed for reliable detection. Jung et al introduced a laser-based system but assumed sufficient prior knowledge, limiting its applicability to autonomous driving scenarios. In [13] paper proposes parking space detection and path planning based on the VIDAR method (vision-IMU-based detection and range method) to solve the problem. In the parking space detection stage, the generalized obstacles are detected based on VIDAR to determine the obstacle areas, and then parking lines are detected by the Hough transform to determine the empty parking space. Compared with the parking detection method based on YOLO v5, the experimental results demonstrate that the proposed

In the paper of Automatic parking system strategy, the system used breadth-first search algorithm along with the modified Bellman–Ford algorithm, which successfully overcomes the shortcomings of the existing traditional methods. Firstly, according to the characteristics of grid map, the calibration of vehicle position, obstacle and parking space was completed. The motion model was studied, the motion space constraints were generated, and the parking end conditions were given according to the relative positions of vehicles and parking spaces. Finally, the Bellman–Ford algorithm was improved to integrate the bidirectional breadth-first search algorithm to optimize the previous parking path and obtain the shortest parking path. The results show that the path planning scheme designed in this paper has the characteristics of higher parking success rate [8].

Park Hop is a sensor less mobile crowd-sensing device that collects and makes information about on-street, retail centers, parking spaces, and roadside parking spaces available to urban cars in a reliable manner [14]

Unlike previous work of focusing on navigation and motion planning, our algorithm concentrates on detecting available parking spots in semi-filled parking lots. By interpreting the spatial distribution of vehicle hypotheses, our algorithm constructs a topological graph, enabling the identification and maintenance of available spots using probabilistic methods [10].

4. METHODOLOGY

Creating an Object Detection Parking Spot Counter involves a meticulous fusion of computer vision and machine learning methodologies, aiming to build a robust system for real-time detection and counting of parking spots. The following steps outline the procedural pathway for each frame of the input video, we will start by utilizing the technique Mask-RCNN object detection model to identify cars and their bounding boxes. Once we have these bounding boxes, we will compute the Intersection over Union (IoU) for each pair of bounding boxes and parking spot coordinates. If the IoU value for any parking spot exceeds a specified threshold, we will classify that parking spot as occupied.

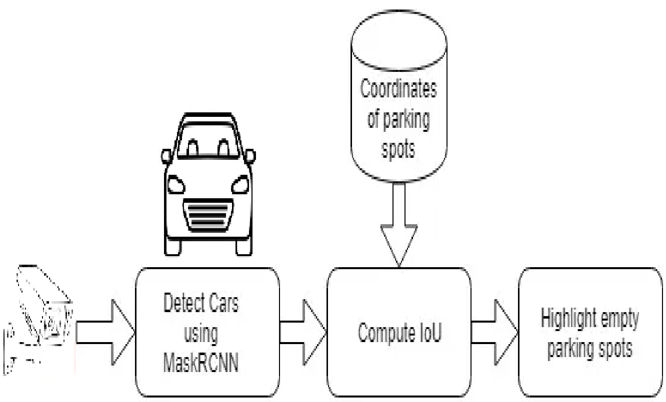

Figure .5. Detection of Parking Spots

The initial stage of a parking space detection system involves the identification of the parking slots. There are multiple methods to accomplish this. An approach entails the identification of parking locations by detecting parking lines, which can be achieved by utilizing edge detectors offered by OpenCV. Nevertheless, the reliability of this strategy is diminished when certain parking areas lack predetermined boundaries [9]. An alternative approach involves making the assumption that vehicles that remain immobile for an extended duration are in a parked state. Valid parking spaces, in this context, refer to designated zones where stationary vehicles are located. Nevertheless, this approach is also prone to being unreliable as it can yield both false positives and false negatives. When automation demonstrates its lack of reliability, it is frequently essential to resort to manual intervention. Shown in figure-5.

4.1 Problem Clarification:

Explicitly define the objectives, prerequisites, desired functionalities, precision benchmarks, and real-time processing capabilities of the parking spot counter system. Find other possibility to unorthodox method that are more practical in nowadays scenario.

4.2 Data Compilation:

Assembling a diverse dataset of images or videos that cover a range of parking scenarios, including variations in lighting conditions, weather scenarios, and vehicle types. This diverse dataset enhances the adaptability of the model. We have made use of TensorFlow to gather datasets for implementation and testing.

4.3 Data Refinement:

Refine the dataset to enhance input data quality. Standardize image sizes, normalize pixel values, and apply necessary transformations to ensure homogeneity.

4.4 Markup:

Annotate the dataset by meticulously labelling each parking spot and its occupancy status. This serves as the foundation for supervised learning, streamlining the model training process.

4.5 Model Selection:

Choosing a suitable object detection model architecture, such as Faster R-CNN, YOLO (You Only Look Once), or SSD (Single Shot Multi-Box Detector), based on unique project specifications.

4.6 Knowledge Transfer:

Leverage pre-trained models on extensive datasets like COCO (Common Object In Context) to harness acquired features. This dataset is used to detect, segment and caption models of object making it an excellent choice for dvelopers.. Fine-tune the model using the annotated parking spot dataset, tailoring it to the specific context.

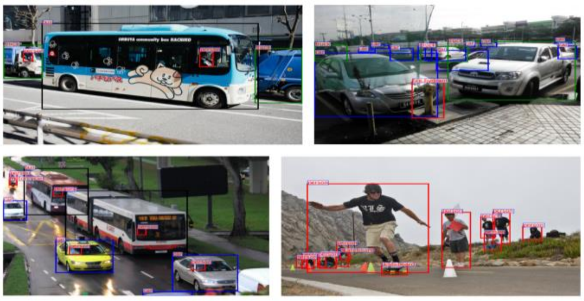

Figure .4. Object detection through COCO

4.7 Training Iterations:

Execute the model training process with the annotated dataset. Adjust hyperparameters, including learning rates and batch sizes, to optimize performance. Regularly monitor training dynamics to mitigate overfitting or underfitting.

4.8 Performance Evaluation:

Assess the trained model's efficacy using an independent validation dataset. Employ metrics such as precision, recall, and F1 score to gauge parking spot detection accuracy.

4.9 System Integration:

Integrate the trained model into a real-time system capable of processing video streams or images from a camera. Implement necessary algorithms for parking spot counting and occupancy tracking.

4.10 Rigorous Testing:

Subject the system to extensive testing within authentic parking environments to affirm accuracy and reliability. Identify and address any issues, refining the model iteratively.

4.11 Refinement Iterations:

Fine-tune parameters, augment algorithms, and optimize the system for operational efficiency. Explore hardware acceleration or parallel processing strategies for seamless real-time functionality.

4.12 User Interface Synthesis:

Developing an intuitive interface for end-users to interact effortlessly with the system. Present real-time parking spot counts and occupancy details in a user-friendly manner.

4.13 Documentation Protocols:

Chronicle the entire methodology, encapsulating model architecture, training nuances, and system implementation intricacies. This comprehensive documentation serves as a valuable resource for future maintenance and enhancements.

By following this tailored methodology, the systematic creation and deployment of an Object Detection Parking Spot Counter can significantly contribute to streamlined parking management and urban mobility solutions.

5. EXPERIMENTAL RESULTS

After implementation of the technology currently our project is able to categorize and identify the available space as well as the filled spaces in the parking lot of a particular location. This result demonstates the capability of computer vision and automation to efficiently detect the spaces.

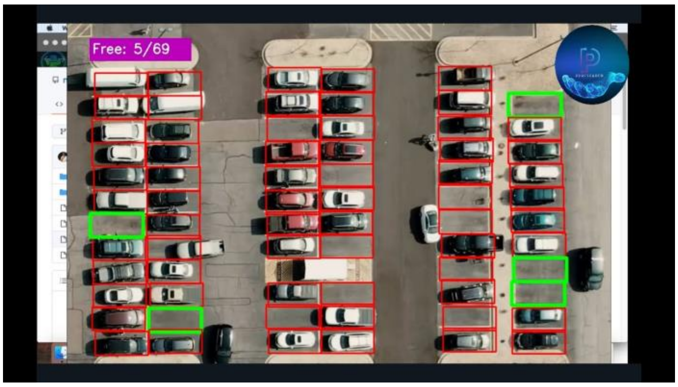

Fig 4- Identification of the free spots in a parking lot

BENEFITS FOR THE SOCIETY:

- Reduced Time Spent Searching: The tedious process of circling for an open place is eliminated by parking spot management systems. Drivers can save a lot of time by finding available parking immediately.
- Less Stress Levels: Finding parking can cause a lot of anxiety, particularly in crowded places. Driving can be more enjoyable and stress-free when you know a spot is reserved in advance.
- Enhanced Efficiency: Knowing precisely where and when to park makes it possible for drivers to arrange their excursions more efficiently when they reserve a parking space in advance. This might be especially helpful for time-sensitive appointments, meetings, or errands.
- Better Accessibility: Accessibility elements can be integrated into parking management systems. This makes it simple for drivers with impairments to find and book accessible parking spaces.

6. CONCLUSION

Smart city ecosystem needs a much more mobile, state of the art and progressive technology to make living more sustainable. The main intention of this research is to optimise and increase availability as well make use of the already available space. By making use of machine learning and real-time monitoring to revolunize the parking system. It will make easier and time saving to locate free space and will further enhance urban mobility. Our technique differs from space-based methods as it does not necessitate labeling and training for each individual parking facility. Instead, it simply requires the initial marking of parking lot boundaries and surrounding road areas for setup. Our method involves selecting a frame from the camera or stream of the parking area and manually indicating the parking regions. The Matplotlib module in Python provides a feature called `Polygon Selector`, which is well-suited for our requirements as it enables precise selection of polygonal regions..

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