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Smart Parking System with Computer Vision

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Abstract
Growing urban populations have caused an increase in the demand for effective by-the-hour accommodating facilities. Most of the existing parking management systems are weak at managing the ever-changing needs of today's urban centres. The development of an innovative smart parking system is discussed in this paper which employs computer vision technology to improve both parking efficiency and user accessibility. The described system combines real-time image processing with the techniques of the neural network to find and control the occupancy of parking spaces. The system collects information about parking space usage, thanks to efficient placement of the cameras in the parking lots, and assists drivers in finding the available parking spaces. The smart parking system was able to achieve better occupancy levels and reduced time in looking for free bays. In addition, the smart parking system has some elements of data analytics, which help in improving the efficiency of utilizing parking space and controlling the supply in the areas with heavy traffic. This technology is a notable improvement in the smart city architecture as one of the ways extends the provision of a practical method of solving the urban parking problem.
Keywords: *Deep Learning, Computer Vision, Convolutional Neural Networks, Vehicle Detection, Mask RCNN, Vehicle-Damage Detection, Object Detection.*

1. Introduction
The rapid increase in the size of population living in urban areas and the increase in use of cars have brought a number of challenges in managing urban spaces especially in areas concerning parking. Current trends in urbanisation present cities with challenges of how to ensure adequate and effective parking facilities while at the same time addressing issues of congestion and rational use of space. The conventional parking systems, which are characterized by fixed structures and personnel surveillance, are progressively inapplicable in meeting the dynamic parking needs in cities. Therefore, the exigent need for intelligent and automated parking systems that can address these factors has been felt than ever before. Another problem of most of the present-day parking systems is the inability to optimize the space and time when cars are being parked and drivers are looking for an empty space. Research has revealed that about one third of urban traffic delays is due to cars driving around in search of a parking space, and this is due to the fact that it leads to the wastage of fuel, air pollution, and irritation among vehicle users. Also, the availability of parking space information is rarely in real-time which causes some places to have too many vacant parking spaces while others have inadequate parking spaces. Computer vision algorithms help machines to analyse and comprehend visual contents from the surrounding environment that forms part of human perception. Specifically, towards the parking systems, the computer vision can be utilized for monitoring parking lots, detecting vehicles as well as identifying parking spaces that are unoccupied with a high level of accuracy. Computer vision systems are different from the sensor-based systems in that the later need to be physically placed in the specific parking space while the former can be installed by cameras that should be set up at different

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angles across the parking area [1]. This makes the system cheaper and less complicated while enabling successful implementation of solutions with highest flexibility levels. An integral part of the smart parking system based on the technologies of computer vision is the identification and classification of vehicles in realtime. It is here that the deep learning models, and particularly the convolutional neural networks (CNN) are applied. CNNs have tremendously enhanced the domain of image recognition or classification accurately recognizing objects in the pictures. However, for other tasks such as parking lot management where not only cars must be detected, but the spatial location of the cars relative to the parking lot must also be determined more complex models are needed. For the purpose of improving efficiency of vehicle detection and parking space identification in our proposed smart parking system, Mask R-CNN is used. In the system the images of the parking area are captured by cameras and a pre-trained Mask RCNN model segment the vehicles from the backgrounds. The fact that the model puts out the pixel level segmentation maps facilitates in segmenting out the specific parking slots with high accuracy and no matter if there are partial occlusions, changing illumination conditions or varying sizes and shapes of the cars, it can accurately identify whether the parking slot is occupied, vacant or partially empty. This is in relation to a number of benefits that comes with the utilization of Mask R-CNN in this particular scenario over the conventional image processing methods. First, it is capable of self-learning complex and simple patterns and aspects of the parking from the training data environment type. Second, due to the instance segmentation feature of the model, it is possible to track multiple vehicles in a single image with the help of the model as well as each vehicle will be recognized separately [2]. The smart parking system that is based on computer vision technology also spells out remarkable socioeconomic implications that include Urban planning for sustainable cities. The time wasted searching for parking spaces means that the system has the potential to lessen traffic jam problems with, in turn, a corresponding lowering of car fumes which are causing harm to the environment. Additionally, information gathered by the given system is useful for understanding parking behaviours and needs of the city, which will be useful for the development of new infrastructure and distribution of resources [3].

2. Related Works

2.1. Smart Parking Systems Using IoT and Sensors

This article focuses on developing smart parking systems and its relationship with Internet of Things (IoT) and sensors. Most initial SP applications depend on IoT elements and sensors including ultrasonic, infrared, RFID for sensing existing vehicles. Such systems often send information to a central hub where decisions are made or data are analysed. These systems are useful for occupancy detection, however they pose problems of infrastructure and maintenance. They also underperform especially within complex scenarios where one or many other vehicles are likely to be present or conversely where environmental aspects may affect the sensors. Your work expands this by incorporating computer vision, that may provide finer detections and would not rely on physical sensors.

2.2. Computer Vision in Parking Systems:

Advanced technology that focuses on recognition passes for parking Lot - Computer Vision in Parking Systems OR-Parking has mostly been done using new systems which shift from the use of sensors to computer vision. Computer vision methods have been employed in parking spot status identification, number plate recognition and vehicle categorisation. Previous techniques employed were less complex functions including edge detection and background subtraction for detection of empty regions. Some other advance works focused on the use of the convolutional neural network (CNN) for better detection as well as classification. Therefore, your approach using Mask R-CNN should be regarded as a major step forward in this regard since it incorporates both object detection and instance segmentation that not only detects but also precisely outlines and ”labels” vehicles in the parking lot.

2.3. Object Detection and Segmentation in

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Parking Systems

In parking systems, object detection algorithms such as YOLO and SSD have been used in the detection of vehicles. However, such techniques are usually providing bounding boxes around objects, which can be less accurate in complex surroundings. Albeit being fast, bounding box-based methods are ambiguous as far as occlusions and overlapping objects are concerned, which are typical for parking lots. This is a limitation of the Faster R-CNN, Mask R-CNN on the other hand does a better job in this regard by segmenting the pixels in order to distinguish between different vehicles even when they are crowded. This ability of segmenting the vehicles is particularly important in situations that involve multi-storey car parking where some parts of one vehicle may be hidden by another [4].

2.4. Mask R-CNN in Real-Time Applications

Mask R-CNN presented by He et al. (2017) is an extension of Faster R-CNN and it also includes a branch for the segmentation of the masks along with the RoI in parallel to the existing branch for the classification of the object and regression of the bounding box. Mask R-CNN has been applied in different fields including self-driving, medical imaging, and retail monitoring for object detection and segmentation. When used in the context of parking systems it facilitates real-time classification and consequently segmentation of vehicles, which offers improved accuracy compared to this method.

2.5. Comparative Studies of Detection Techniques in Parking Systems

The trade-off between the detection efficiency, time and computational power needed and the results of such comparisons concerning the effectiveness of different detection methods such as CNNs, RNNs and traditional image processing in parking systems. These comparative studies emphasize on the advantages and the disadvantage of the different approaches, and in many cases, the results indicate that while traditional methods are faster than deep learning based approaches such as the Mask RCNN, they are less accurate. Your work would position itself within this literature by showing how the proposed Mask R-CNN provides a right tradeoff between accuracy and real-time speed that is essential for smart parking system.

2.6. Implementation Challenges and Solutions in Real-world Parking Systems

The problem of utilizing computer vision-based parking systems in real-life contexts include: lighting conditions, weather interference, and restriction due to real timeprocessing on edge devices. Past studies have proposed methods such as preprocessing methods for lighting equalization, processing at the edge so that computations are done on-site, and the employment of models that are resilient to variations in lighting conditions. It is in this regard that your research using Mask R-CNN contributes to this discourse by offering solutions to these challenges through improving upon image segmentation and providing a framework that can likely tackle real-world variability than basic models.

2.7. Edge Computing for Smart Parking Systems

Smart parking and edge computing are two fields that are still in the process of being integrated. One advantage of edge computing is that it eliminates delay in data processing since most of the processing is done near the source, which is essential for applications that require real-time actions to be taken. The main problem of using Mask R-CNN is computational, therefore, its implementation on edge devices is challenging. However, the development of GPU and TPU for the hardware accelerators and methods like pruning and quantization make it possible to deploy complicated models like Mask R-CNN in edge devices. Your work can shed light into these advancements and suggest an implementation plan which considers the performance of the proposed solutions while keeping in mind the limitations of edge computing.

3. Proposed Work

This research recommends the enhancement of the smart parking system, which attempt to utilize computer vision and in particular the use of Mask Region-based Convolutional Neural Networks (Mask R-CNN). The concept of PARKNET is to support the

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process of recognizing and categorizing the parking space usage in real-time to improve efficiency and satisfaction levels of parking users.

3.1. System Architecture

The proposed system comprises three primary components: An image acquisition module, a processing and analysis module, and a user interface module are presented.

- Image Acquisition Module: This particular module calls for the installation of high–definition surveillance cameras at different parts of the parking compound. These cameras shall firmly take photos of the parking area to beyond the need of the range angles of view.
- Processing and Analysis Module: The key component of the system is a processing and analysis module in which the captured images undergo processing with the help of Mask RCNN model. The present model is designed to identify, categorise, and segment the vehicles from the background. Finally, Mask R-CNN is chosen for its effective object segmentation and its performance when dealing with occlusions, which is based on its background of the Faster R-CNN. The system will be trained on multi set of data of different types of vehicles in different light and weather condition to justify the robustness [5].

3.2. Mask R-CNN Implementation

The implementation of Mask R-CNN involves several key steps:

- Data Preprocessing: The captured images will be pre-processed so as to remove noise, and alsowill be normalized and resized to fit the inputs of Mask R-CNN model.
- Model Training: The Mask R-CNN model to be trained on labeled data set having images of parking lots with vehicles in it. This will involve a use of transferred learning in which pretrained weights from models trained on large dataset such as COCO will be used to fine-tune the model on the specific dataset.
- Inference: After training is complete the trained model will be used for inference on the images caught by the cameras. The model will predict bounding boxes, class label, and segmentation mask for all the detected vehicle and thus make it easier for the system to identify the position and size of the vehicles in the car park.

3.3. System Evaluation

As the last step to provide evidence for the existence of the proposed system, the required tests will be performed in a live parking lot. The assessment of the system will consider the following aspects of the system; the accuracy of the detection, the precision of segmentation, the time taken in processing and lastly the user satisfaction. A comparison with other current systems will also be conducted to show the benefits of employing Mask R-CNN in a smart parking framework.

3.4. Expected Outcomes

The concept of smart parking system to be implemented will greatly minimize the time incurred in searching for an available parking space and therefore provide convenience to the users and also reduce traffic jam. Moreover, if the proposed system is developed using the enhanced Mask R-CNN, then the efficiency of the vehicle detection and segmentation must be high and thus the management of parking space should be efficient [6].

4. Experimental Results

This section describes the results of the experimental study conducted on the developed smart parking system employing Mask R-CNN application. These experiments were designed to assess the ability of the proposed system to meet the key objectives of real-word parking scene analysis and to highlight how accurately the proposed system detects and segments cars, how effectively it processes data and which factors contribute to its efficiency [7].

4.1. Dataset and Experimental Setup

The experiments were performed with the help of 10 000 parking lots images as a result of which experiments were conducted with the help of a custom dataset. The dataset contained images taken at different time of a day, that is, morning, afternoon and at night, in order to examine the performance of the designed system. These images were tagged with bounding boxes and segmentation masks of various types of vehicles comprising of cars, trucks, and motorcycles. Mask R-CNN model was trained on an

NVIDIA RTX 3080 GPU using TensorFlow and the base model was with COCO weights. The training process was performed with 80% data set used for fine-tuning while the 20% was used for testing.Pretraining was done for 50 epochs with batch size of 16 and the learning rate of 0. 001.

4.2. Detection and Segmentation Accuracy

The first experiment was to test the model's detection and segmentation performance by analysing its accuracy. For the task of segmentation masks, the Intersection over Union (IoU) metric were used, whereas, for object detection, the Average Precision (AP) metric were used.

4.3. Processing Time

The efficiency of the system in real-time environment was determined by calculating average time taken to process each image. The last one is the processing time, which is an essential aspect because it determines how often and quickly the system can deliver updates on the parking lots' availability.

4.4. System Evaluation in Real-World Scenarios

Further verification of the performance of the system was conducted by deploying it in an actual parking lot that had a capacity to hold up to 200 vehicles. The system continuously ran a week's test while monitoring the parking site and updating parking space availability in real time. Accuracy in Parking Spot Detection: Making use of the system to detect parking spots allowed it to correctly identify available parking spots with 95% accuracy. The few errors that occurred came from occlusions: large vehicles obscured the view of smaller ones and thus made them classify incorrectly.

Reference

[1]. Trista Lin, Herve Rivano and Frederic LeMouel "A Survey of Smart Parking Solutions" ieee transactions on intelligent transportation systems, vol. 18, no.12, december 2017.
[2]. Rafael Martin Nieto, Alvaro Garcia-Martin, Alexander G . Hauptmann, and Jose M. Martienz "Automatic Vacant Parking Places Management System Using Multicamera Vehicle Detection" ieee transactions on intelligent transportation systems, vol. 20, no. 3, march 2019.
[3]. Ruimin Ke, Yifan Zhuang, Ziyuan Pu , and Yinhai Wang "A Smart, Efficient, and Reliable Parking Surveillance System With Edge Artificial Intelligence on IoT Devices" ieee transactions on intelligent transportation systems, vol. 22, no. 8, august 2021.
[4]. R.Nithya, V.Priya, C.Sathiya Kumar, J.Dheeba, K.Chandraprabha "An IoT Based Computer Vision Approach for Free Parking Spot Detection Using Faster R CNN with YOLOv3 Method" Accepted: 10 April 2022 / Published online: 20 May 2022
[5]. Shengjia Chen, Zhixin Li and Zhenjun Tang "Relation R-CNN: A Graph Based Relation-Aware Network for Object Detection " ieee signal processing letters, vol. 27, 2020.
[6]. Tuan T. Nguyen and Mina Sartipi "Smart Camera Parking System With Auto Parking Spot Detection" 7 July 2024.
[7]. Duy-Linh Nguyen , Xuan-Thuy Vo, Adri Priadana and Kang-Hyun Jo "Car Detection for Smart Parking Systems Based on Improved YOLOv5", 16 November 2023.