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Estimation of Available Parking Spots in Surveillance Scenes Based On Deep Convolutional Network

Kruthi S[1], Aditya Narayan[2], B S Smruthi Shreeya[3], Madhuvanthi R[4], Sreenivasa B C[5]

[1234]–*Student, Department of Computer Science Engineering, Sir M Visvesvaraya Institute of Technology, Bangalore-562157*

[5]–*Associate Professor, Department of Computer Science Engineering, Sir M Visvesvaraya Institute of Technology, Bangalore-562157*

Abstract - *In fast-growing cities, the number of vehicle users increases exponentially every day, demanding more parking space. Not finding a parking space is indeed a critical issue. And not finding a suitable parking space at a given time in such cities, especially during peak hours, is a real problem. Even if a parking space is found, many vehicles may try to go after the same parking spot, which in turn leads to traffic congestion. And as we know, traffic is a major concern in many of the cities. Such problems can be avoided by continuous monitoring of parking spaces. Many new technologies have been developed that help in solving parking problems to a great extent. In this paper, we have suggested a novel method to detect cars in an image or a video, in turn, yielding the vacant parking spaces using a single deep neural network. The Single Shot Multibox Detector method used here is a popular object detection method and is designed for object detection in real-time. We describe how this model is utilized in detail and how it outperforms other technologies used earlier. This technique effectively solves the problem of parking and reduces the stress undergone while searching for a parking space and takes away the unpredictability of finding a parking spot and also saves time and fuel. The proposed system of object detection using SSD is a very efficient and fast prediction method identifying vacant parking spots.*

Key Words: Convolutional neural networks, Single Shot Multibox Detector, Non-maximum Suppression, Tensorflow, Keras

1.INTRODUCTION

Nowadays, with the increase in population all over the world, we are experiencing a lot of complex problems which require efficient solutions. Deep Learning tackles a lot of such modern age problems. A novel method has been proposed in this paper with the use of deep learning to overcome one such modern problem. Traffic in recent times has a direct relation to population increase with development. The sheer amount of vehicles used draws attention to the need for an immediate, efficient, and thrifting way for the management of vehicles. The parking of vehicles is a big domain of that problem in desperate need of an efficient system. Drivers face major time-consuming issues in parking their vehicles in a parking lot, the process of allocating a spot is usually too lengthy and unreliable. The management system could be very costly. The value of money for the service provided is hence unfair. The increase in vehicles on the roads needs an efficient and fast system. The system for parking is supposed to provide a driver with a spot as soon as possible. In this paper, we propose a method to find the nearest parking spot for the customer with minimal or no installation expenses.

1.1 Problem Formulation

With the increase in traffic and vehicles, the allotment of parking spots for each vehicle in any amenity becomes a dreadful problem. There are at times when this leads to overcrowding in a particular amenity. This causes a major disturbance in the working of many communities. To manage the vehicle crowd and parking spots for them, we need to develop a system that provides a correct count and display of the number of parking spots taken and the number of parking spots available in a systematic manner. So, any disturbance pertaining to this should be avoided. Providing a proper parking system to control these large numbers of vehicles prevents blockage of roads, overcrowding, and traffic jams. Our approach focuses on developing a clean system for the parking spots to overcome all the issues faced in the current scenario. In our model, we need to identify cars to allocate a vacant spot. Nowadays, deep convolutional neural networks are found to be very effective in the classification of images, which predict image labels based on the various class scores obtained, and then the network tends to determine the strongest class in the image [1]. Here we have used one such network called the Single Shot Multibox Detector.

1.2 Objective

An efficient parking system is a dire need of the modern world. But legacy methods in this field requiring heavy installation and maintenance has yet to meet up to the expectations. The need for a fast system to manage the fast traffic and quick allocation of spots for the drivers, while keeping the installation and maintenance cost is required. To fulfill this, the system proposed here makes use of the pre-installed CCTV cameras in the parking lot resulting in

minimal or no installation expenses. Also, by the usage of this system, the vehicle drivers will have the benefit of being allocated the nearest parking spot from them, resulting in lesser time and fuel consumption. The system uses a single deep neural network, to get the feed from the CCTV cameras and analyze it frame by frame to access all empty parking spots at the moment. The model proposed also returns the closest parking spot to the driver entering the parking garage. This helps in improving the efficiency of the whole parking system. The allocation of the nearest empty spot to each driver helps minimize fuel and time consumption making the entire process much more efficient and user-friendly. This paper aims to replace the legacy methods of parking management with the proposed system and make the process of parking as efficient as possible.

2. MODEL

Here, we have used a method for detecting objects in images using a single deep neural network. Our approach, Single Shot Multibox Detector, is a popular algorithm for object detection [2] and is one of the best object detection algorithms with both fast speed and high accuracy [3]. Single-shot implies that the tasks of object localization and classification are done in a single forward pass of the network. The architecture of SSD is as shown in Fig1. SSD mainly consists of two parts: extracting feature maps and applying a convolution filter to detect objects. SSD uses VGG-16 as the base network because of its strong performance in high-quality image classification tasks and its popularity for problems where transfer learning helps in improving results. SSD uses default boundary boxes similar to anchors in Faster R-CNN. Default boundary boxes are chosen manually, having different scales and aspect ratios to ensure most objects could be captured.

A large number of boxes are generated during a forward pass of SSD at inference time. It is essential to prune most of the bounding box by applying a technique known as non-maximum suppression [10], this makes sure that the network retains only the most likely predictions and the noisier ones are removed.

We can begin the training phase soon after the image samples with ground truth boxes are loaded. For each default box, we predict both the shape offsets and the confidences for all object categories. During training time, the default boxes are matched with ground truth boxes, and the intersection over the union (IoU) ratio is obtained. If the IoU of the corresponding default boundary box is greater than 0.5 with the ground truth, the match is positive. Otherwise, it is negative.

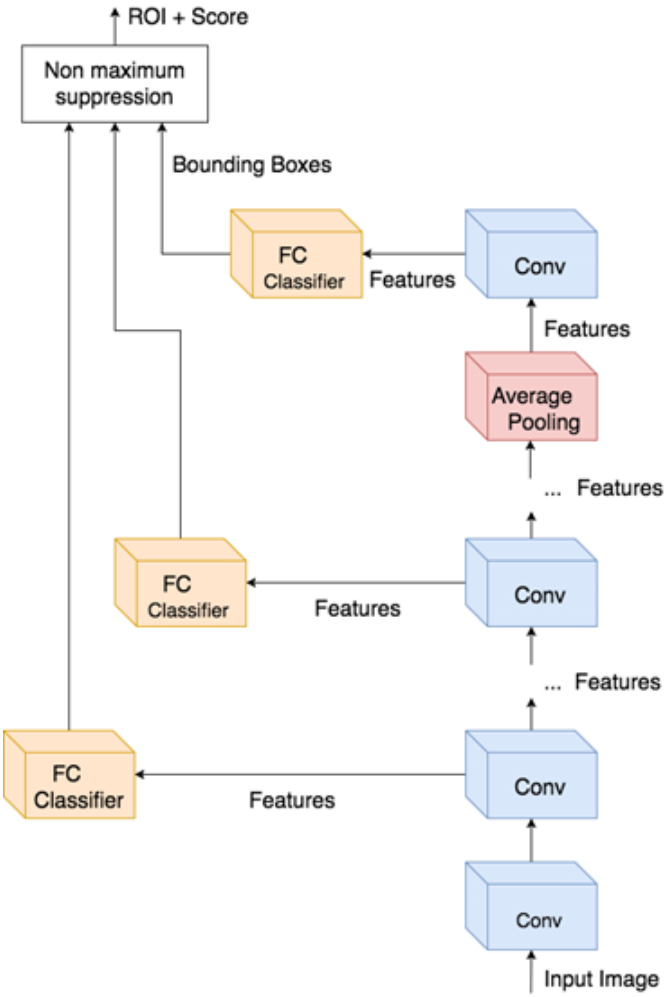

Fig-1: Architectural diagram of Single Shot Multibox Detector

We have used the PASCAL VOC dataset, which consists of twenty objects and one background, therefore 21 classes. Here we have restricted the object to cars. SSD300 provides an accuracy of 74.3% mean average precision (mAP), with 59 frames per second [8], which is much better than many other single-stage methods. It is one of the best object detection algorithms with both fast speed and high accuracy [9].

2.2 SOFTWARE COMPONENTS

Tensorflow

Tensorflow is a deep learning library offered by Google, which is in high demand. It is the best library of all because it is built to be accessible to everyone. It incorporates different API to build at scale deep learning architecture like CNN or RNN. TensorFlow includes graph computation, and it allows the developer to visualize the construction of the neural network with Tensorboard. This tool is also helpful to debug

the program. Here our model uses TensorFlow as the backend.

Keras

Keras is known to be one of the leading high-level neural networks APIs. The language used to write Keras is python and provides support to multiple back-end neural network computation engines. It was developed to make the implementation of deep learning models as fast and as easy as possible for research and development. The primary back end is Tensorflow, and its principal supporter is Google. Keras is used to create models. It offers various standalone modules like neural layers, cost functions, optimizers, initialization schemes, activation functions, and regularization schemes that can be combined to create new models. The two main types of models in Keras are the Sequential model and the Model class. Here we have used both the classes to create our SSD model.

OpenCV

OpenCV is an open-source computer vision and machine learning software library. It was built to provide a common infrastructure for computer vision applications and to accelerate the use of machine perception in commercial products. It covers various image processing operations such as image filtering, geometrical image transformations, color space conversion, histograms and also explains the video capturing and video codecs. Here for edge detection, we have used the Canny edge detector of OpenCV, which is a popular noise reduction algorithm. For detecting the parking spots and the various clusters, we have used Hough Transform, which is a well-known technique to detect any shape if one can represent that shape in mathematical form.

3. IMPLEMENTATION

In recent times the more popular ways for parking management include sensor implemented systems. The advancement is brought in relation to the parking management system through the use of the SSD model [8]. This method makes the whole process much more efficient compared to all the legacy methods in the field, SSD applies neural networks in tackling the job of a smart parking management system. The legacy methods such as ZigBee [4], LIDAR, Optical Character resolution [7], and Ultrasonic waves technique employ sensors for finding empty spots in a parking lot. The model suggested in our research handles it by overcoming the challenges of such massive cost installation and maintenance, by using CCTV cameras available in the parking lot and using the efficient SSD model in-order to find all available parking spots.

The implementation can be described as follows :

Initially, when a driver enters the facility, he requests for a parking spot. Acting on the request, the CCTV cameras send the video feed, which is processed by the processor frame-by-frame. The frames are stored in a central server. From where further processing is carried out, to carry this out, we have used an SSD network as a base, and on top Google's TensorFlow package is used. The combination of both handles the image processing and detection of cars present on frames. Furthermore, the SSD network processes the image and outputs data by using predefined spaces of default boxes and handling the output space of bounding boxes by discretizing it. SSD handles it all through different aspect ratios and scales over feature map location [9]. This data is then updated in the central database system. The whole information about the location and number of cars present in the range of CCTV cameras is used to predict that for each car detected if it's location is on a parking spot or not. The new information generated is automatically updated in the central database. Concluding the whole process, the processing outputs the nearest parking spot, which will be allocated to the driver, and he can proceed to park his vehicle in the nearest spot. In the end, again, the data is uploaded to the central system.

The whole process can be thought to be broken down into the following three actions:

- **User Interaction**: As soon as the driver enters the facility in the vehicle, CCTV cameras collecting the feed of real-time location of vehicles while continuously updating data into the database comes into the picture, and the model implemented outputs the nearest parking spot for the driver.
- **Constant Feed:** The program keeps a continuous account of all parking spots checking if they are empty or occupied. This data is constantly uploaded to the database as the program has a straight connection with the database. Through this part, constant up-gradation of the database is handled, the data about details of a parking spot is empty or occupied is accounted for.

Model and Program: The Model and program after being loaded initially work on taking the frames from the CCTV feed and storing it in a folder. The model's Tensorflow then works on parsing the frames. The Parsing results in the detection of available spots for the next driver. The database is under constant update after the parsing of each frame and hence ready for usage by the next parsing cycle.

3. CONCLUSIONS

We have proposed a system in this paper to detect the available parking spot in any community. It is developed using the SSD technique of object detection. Here we fetch the coordinates of the vacant spot and allot it to the incoming cars. This saves time and fuel, especially in leveled

parking areas. Single-shot detectors have impressive frames per second (FPS) and are also relatively faster and have better mAP compared to other methods such as R-CNN and YOLO. SSDs are best suited for large object recognition and real-time processing, which in our case is parking spot detection. One of the advantages is that it doesn't require the use of bulky and expensive equipment such as big sensors and can be easily incorporated in the daily activities of the common user. Our model also provides the nearest parking spot available in any parking system along with the already parked spots to the customer with precision and accuracy. Hence, overcoming a lot of hurdles faced while managing a parking system with ease and accuracy.

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