Developing a Parking Monitoring System using Mask-RCNN

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Abstract

In this paper, we present a technique for monitoring of parking spaces availability in unorganized parking spaces and organized parking spaces. It enables user to detect vehicles in a dedicated parking lot or in any unorganized parking space. The collected historical data helps us predict real time availability of parking at any given point in time based on these predictions we can also determine which areas can be converted to organized and legal parking spaces with help of efficient data mining techniques. Parking Monitoring System determines availability of parking space based on analysis of images obtained from video surveillance cameras. The system is developed to determine the best suitable and accessible parking location, and notify the users. We provide a system based on Mask-RCNN for analyzing the images and determining the availability of parking spaces in parking lots.

1. INTRODUCTION

The exponential and continuous growth of population in major cities and the availability of vehicles suiting all budget range has led to the issue of traffic jams and has eventually led to shortage of parking spaces. Both, public and private transport sector of mainly all major metropolitan cities is enormous and keeps growing with time, as a result of which constant monitoring, timely expansion and modernization is required. Without the use of intelligent and efficient information systems it is very difficult to efficiently organize and monitor such big sector. Intelligent monitoring systems are systems which carry out collection and preprocessing of data at low level[1]. To efficiently determine parking availability, intelligent monitoring of parking zone and efficient tracking of cars is required. Variety of sensors are available to gather information on movement of the vehicle for example : video directors, radars, infrared sensors and many more[2][3]. Selection of sensors is very critical, as each sensor has its own advantages and disadvantages. In today's times, CCTV cameras are deployed almost everywhere, are being efficiently used for security purposes. One major problem to be solved is the problem of motion detection. Multiple inductive sensors can be replaced by one effective video detector. One notable aspect here is the computer vision algorithms have significant limitations in the accuracy of detection of the vehicle. Weather changes, the day night cycle, overlapping objects at times result in image distortion[4]. Monitoring the status of parking in real time and providing appropriate results to the users is of utmost importance. Efficient parking information when delivered on correct time will help drivers find best suited parking spots and will eventually lead to reduction in traffic congestion caused by irresponsible parking [1] [4].

2. LITERATURE REVIEW

"Yandex Traffic" is a service developed by Yandex which does task of optimizing traffic flow. "Yandex Traffic" service shows user a picture of traffic congestion. To attain this service knowledge is collected from various sources and displays them on the app "Yandex traffic" after analysis. [5]. In places where traffic congestion is a significant issue, the service expects to score jams - the typical level of congestion. The service expects user to participate in data gathering by enabling certain permissions. Every few seconds, the user's device transmits its geographical position, direction and speed of the computer system computed to Yandex.Traffic. Only relevant data is collected meaning that users sensitive data is safe and remains untouched. Additionally drivers can report more information about service failures, repairs or other road troubles. "Yandex" has released the "Yandex. Parking" service to solve the issue of finding parking space. This is a dedicated service for searching, reserving and paying for a parking slot [6]. Integration of this program into the application "Yandex" has enabled users to see nearest parking spaces on the map and find an optimal route to the desired parking space. The program notifies users by raising a warning when parking time is about to end. The service updates status on utilization of parking spots at various parking lots. The service also contains other necessary information for the user like cost per hour for the parking space[7].

TSGS-30 is a parking guidance system created by TIBA. TSGS-30 system guides drivers in searching a parking spot easily and quickly in the parking lot. The TSGS-30 makes use of a sophisticated technology, based on using Ultra-Sonic wave detector with Red-Green lights on top of each parking space. The TSGS-10 makes use of directional arrows which are electronic in guiding the driver to nearest low occupancy zone. The electronic signage is updated according to commands received from the management server. The driver will be guided at the appropriate zone and the driver will have a green light indicating the available parking space [8]. Because of its complicated structure, it is not feasible to use TSGS-30 system in small spaces.

3. METHODOLOGY

Mask R-CNN is a model created to detects objects across the complete image in a computationally feasible manner while not making use of the traditional sliding window approach used in most object detection techniques. It runs fairly quickly as compared to traditional sliding window techniques. When a contemporary GPU is used, Mask-RCNN is always able to recognize objects in high-res videos at many frames per second. Adding to the benefits, Mask R-CNN offers ample info concerning every detected object. Mainly object detection algorithms solely return the bounding box of every object, however Mask R-CNN solely doesn't offer the placement of every object, it will conjointly offer a object bound (or mask) around the identified objects.

There are many datasets available for object detection problems on the internet. There's a well-liked dataset and very popular dataset named COCO (Common Objects In Context) that has pictures commented with object masks. In COCO dataset, there are more than 12,000 pictures with cars already in bounds. This information is ideal for training purpose of a Mask R-CNN model.

For each object detected within the image, it is necessary to revisit the following things from the Mask-RCNN model:

1. The category of an object detected(as an integer). The COCO model is pretrained to detect 80 completely different common objects which are easily seen in the neighborhood including cars, trains and buses.
2. Confidence score of the object detection. The higher the number, more accurately has the model identified the object.
3. Bounding box of the object within the image, represented as X/Y pixel locations.
4. A bitmap mask identifying pixels inside the bounding box as a part of the object or not. With the data from the mast it is possible to conjointly calculate the bound of the article.

Upon training a discovery was made that the bounding boxes of the cars in the image partly overlap in some scenerios. To solve this issue Intersection over Union Method (IOU) is used. IoU is obtained by using the following formula :

$$\text{IoU} = \text{Area of overlap/Area of union.} \qquad (1)$$

Calculating IoU gives the measure of what quantity a car's bounding box is overlapping a parking spot's bounding box. These calculations are made to determine if an automobile is occupying a parking space or not. If the calculated value of IoU is low, for example : 0.15 it indicated that the automobile is not occupying a lot of parking space. But, if the calculated value is high, for example :0.6 it means that the automobile is occupying majority of the parking space indicating that the parking space is occupied.

4. RESULT AND ANALYSIS

The system was tested using footages of parking spaces from various cities at different times. These videos were run through the proposed system based on outputs the following were calculated

4.1. Confusion Matrix

The rows in a confusion matrix correspond to what the machine learning algorithm predicted and the columns correspond to the known truth. As there are only two categories to choose from which in our case are Parking Available and Parking Unavailable, the top left corner contains true positives(TP), these are parking spaces that are correctly identifies by the algorithm, the bottom right corner of the table has true negative values(TN) which indicate the parking spaces that were occupied and were correctly identified by the algorithm, above true negative cells is the cell for false positives(FP), these include count of times when the algorithm showed available parking spaces when there actually were not, and below true positive cell is the false negative(FN) cell which includes count of when the algorithm parking space unavailable when it actually was available.

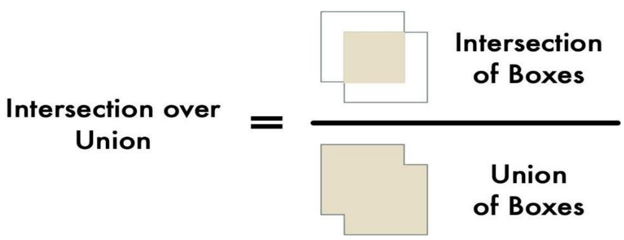

Fig. 1: Intersection Over Union or IoU

Table 2: Confusion Matrix of proposed system

	Available (No)	*Available (Yes)*	
True (No)	TN = 108	FP = 26	134
True (Yes)	FN = 14	TP = 117	131
	122	143	265

Fig. 2: Detecting Cars from Images

Fig. 3: Image with default COCO objects identified – cars, people, traffic lights and a tree

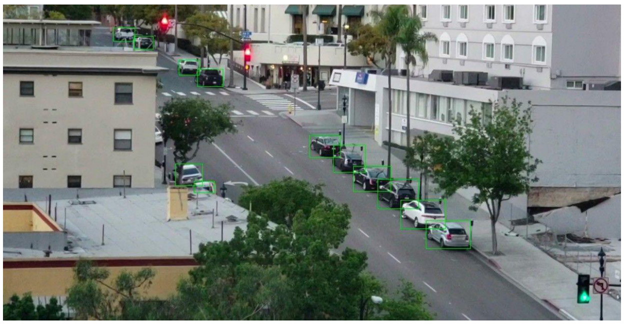

Fig. 4: Image depicting every car identified, marked by a green color box around it.

4.2. Precision

Precision is a measure that is used to determine if the algorithm returned more relevant results that irreverent, it is calculated using the below given formula:

$$\text{Precision} = \frac{True\ Positive}{True\ Positive + False\ Positive} \quad (2)$$

Precision of system = TP / Predicted Yes = 117 / 143 = 0.818 ~ 81.8% (3)

4.3. Recall

Recall means ratio of the total number of correctly identified parking spaces divided to the total number of

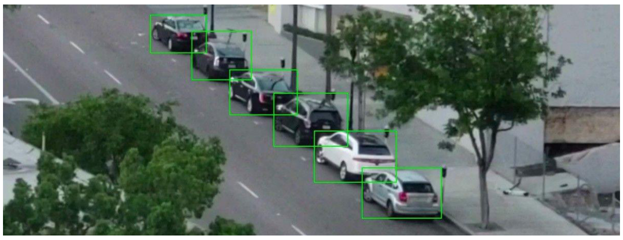

Fig. 5: Image depicting that cars parked in different parking spaces also overlap

actual available parking spaces. Recall is calculated using the formula:

$$\text{Recall} = \frac{True\ Positive}{True\ Positive + False\ Negative} \quad (4)$$

Recall = TP / Actual Yes = 117 / 131 = 0.893 ~ 89.3 (5)

4.4. Accuracy

Accuracy is the number of correctly predicted status of parking spaces, out of all situations tested. It is calculated using the formula:

Accuracy = TN + TP / N = (108 + 117) / 265 = 0.849 ~ 84.9% (6)

Error rate = 1 - accuracy = 1 - 0.849 = 0.151 ~ 15.1% (7)

4.5. F1 Score

The F1 score or the F measure is the harmonic mean between precision and recoil and is calculated using the formula:

$$\text{F1} = 2 \times \frac{Precision * Recall}{Precision + Recall} \quad (8)$$

F1 = 2 * (0.81*0.89)/0.81+0.89 = 0.848 ~ 84.8 % (9)

5. CONCLUSION

This paper presents the design and implementation of a Web based system that analyzes the state of parking lot according to videos fed from a surveillance video camera in real time. The system developed has been tested on real time data from various surveillance camera footage digital images taken with cameras placed on streets and parking lots. Testing showed that the results of the proposed system were considerably good.

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