Smart Vehicle Parking Management System using Image Processing

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Summary

The term parking management system usually refers to the custom built hardware intensive systems installed in building and malls. However, there are many places where such expensive solutions cannot be installed due to various reasons, like cost and urgent/temporary setup requirements. This project focuses on developing a parking management system based on image processing to detect vacant parking slot in an area where automated systems are not installed. Camera images of the parking area are subjected to image processing algorithm which marks virtual slots in the area and extracts occupancy information to guide the incoming drivers about availability and position of vacant spaces. The application consists of two interfaces: one for the guidance of the incoming drivers and the other one for the administrator. The later interface also informs the administrator if a car is not parked properly in the virtual slot. This parking system would reduce the stress and time wastage associated with car parking and would make the management of such areas less costly.

Key words: *MaskRCNN, temporary parking space detection, firebase, real-time car detection.*

1. Introduction

With the continuous development of economy, personal vehicles have become an indispensable part of our daily lives. The commodity has become affordable to most working class providing comfortable way of life; however on the other hand multiple problems strike back which need to be solved. One problem is of parking spaces.

A variety of sophisticated car parking systems are in use nowadays; however they all require a considerable design time, installation and maintenance cost. In many parking areas the management uses the counter at the checkpoint in order to track the number of vehicle that enter and exit the parking area. More sophisticated systems detect the exact location of the empty spaces and guide the incoming drivers accordingly. Some advanced vehicles have their own parking systems installed but still hard for the system itself to confirm whether a vacant parking area truly exists or not. Despite of all these systems, there are still places where parking facilities need to be set up on temporary or urgent bases; this application provides a cost effective, image proceeding based solution for such scenarios. It just need to mount cameras on the location to take images at regular intervals. Images are then processed to mark virtual parking slots of appropriate sizes, which are then used to keep track of the vacant spaces and can guide the incoming drivers accordingly through a mobile app. Another software interface notifies the administrator or manager of the area of the same, also indicating if any cars are misplaced in the parking area blocking any routes.

Parking management system using image processing provides a modern & Innovative solution for temporary parking places; where no specific approach is used to park a car, reducing the hustle at the peak time, helping the users to park their cars easily and properly.

2. Literature Review

With the continuous development of the economy, vehicles have become an indispensable tool in people's daily life. However, solving the 'difficult parking' task is now an emergent issue. Detecting the status of parking spaces in a parking lot is the most fundamental prerequisite in modern intelligent parking management and guidance systems. Many researchers have been trying to develop automated parking availability system which detects the available space with certain area of interest. The following text gives a brief overview.

Numerous systems have been developed on number plate recognition and radio frequency identification (RFID) detections, used for counting and issuing tickets to vehicles [1], [2], [3], [4]. [5] uses wireless sensor network to guide vehicles to available parking slots. Other significant work based on Internet-of-things (IoT) sensors include [6], [7], [8] [9], [10], [11] and [12]. [13] and [14] presents camera based systems where images are being used to detect empty parking space, but it does not manage the area intelligently. It does not make any markings of its own. The authors of On-vehicle video-based parking lot recognition with fisheye

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optics [15] proposed a visual-based free parking space detecting method. However, they only focused on the simplest situations with only white parallel lines on the ground and without mentioning the image stitching approach. The authors of [16] proposed a surrounding view-based parking area detection and tracking algorithm, but the method only works when the ground is clean without too many sundries or too much reflection of light like underground garages. In addition, the algorithm does not distinguish a vacancy, which will cause problems in practice. [17] introduced a complete system of using both a surround-view system and an ultrasonic method to obtain parking spaces and their availability. They paid more attention to the detection problem but neglected the image stitching part. In addition, the paper only focused on an indoor environment without demonstrating any results on the special ground with much linear texture like brick stone ground. In this work we have tried to overcome these issues to provide a robust solution at low cost.

3. Methodology

This project, vehicle parking management system using image processing aims to create a better environment for a vision-based vacancy parking area detection; providing a modern and innovative solution for temporary parking places. For example, dust ground, cemented flooring where no specific parking systems are used. The prime objective is to have maximum number of cars which can be parked in an organized manner into the temporary lot.

This project's aim is to detect and recognize the real time vacant parking space. The process has been summarized in Fig. 1. It comprises of a camera mounted on roof top of any nearby building or some supporting pole at certain angle where it covers the maximum area of parking lot which is being used for taking the input. The images obtained from the live stream are then fed to the processing module, which detects the region of interest (ROI) consisting of the area to be covered for parking spaces. A car detection Module is used to detect the cars within ROI using Neural Network. This module tracks and detects the parking space in an image. The parking space detection module generates the virtual lines for parking which will be visible to user on an app assisting in vehicle parking. Due to human error if someone parked the vehicle between the lines or parked the vehicle in wrong manner, the output will be shown at the admin side of Application with the count of wronged parked Car. Two application interfaces have been developed, the user interface and the admin interface. Whenever the user opens the application, he will be able to see the image of the parking lot and number of vacant spaces into the parking lot.

In order to provide ease to the user; help screen is provided which tell the user how to check the status of the parking lot. The Admin application have an extensive data where the admin can see total number of parking slots, total number of cars, vacant space, occupied space as well as No. of Incorrectly parked cars.

Python Programming language is used to train the models and do processing. Android Studio is used to develop the mobile applications for user and admin. Firebase is the real-time database where images are stored along with other information like total number of parking slots, vacant parking slots, occupied slots, number of cars correctly or wrongly parked. Annotation are done using Vgg Annotator.

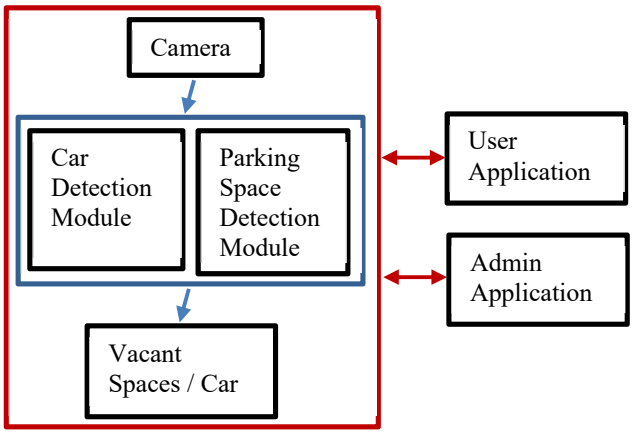

Fig. 1 Block diagram summarizing the overall process and working modules

3.1. ROI Detection

The camera has been mounted on roof top of a building from where the parking lot is completely visible. First challenge is to detect the ROI in the image obtained from camera. For this purpose markers are placed on the image corners using distinguishing colour. All images are resized to consistent dimensions and are then passed through two convoluting filters. The convoluted image is then made to pass through Gaussian blur, where the image is made slightly blurred. This process converts the original image to filtered image. The smooth and unique colour of markers is then detected using masking technique, based on the range of pixel values in the HSV colour space. In order to find out the coordinates of the mask, contours are located, which can be defined as the line of pixels whose values are same or in other word the edges in image are found. Since the camera is mounted on to roof top at some Angle, the ROI obtained is not a square, so the perspective of the image needs to be changed, to make it square because the car near to the camera is of different size as compare to the car placed far to the camera. Once ROI has been marked properly, the

image data is labelled for supervised machine learning algorithm; labelled data set is required so that the machine can easily understand the input patterns. To train the model to detect the car annotation of the data set is needed. Till now the data has been collected, recreated, filtered and annotated, now it is ready for training the neural network.

3.2. Car Detection

Once the model being trained the weights are being saved in H5 format that can be used for detecting a car in an image. The prepared images are fed to the neural network. The chosen model architecture for training is Mask RCNN. The resulting model detects the boundary of every car. While defining the architecture to load the weights, the confidence value is set to 0.9 that means an object which have 90% confidence to be a car is detected while objects having lesser confidence values are rejected. Fig. 2 shows the results.

Fig. 2 Car Detection

3.3. Drawing Virtual Parking Lines

After detecting the cars, next virtual parking lines are drawn in the image. Since in the image the unit of distance measurement is a pixel whereas actual distances are in the unit of feet, Eq.1 is used as the conversion formula to find the number of pixels per metric, p.

$$p = \frac{distance\ in\ the\ image}{actual\ physical\ diustance} \quad (1)$$

Using this information, imaginary lines are drawn on the image to mark the parking slots of appropriate sizes. Fig. 3 shows the results.

Fig. 3 Drawing Imaginary Parking lines

3.4. Finding Car Intersection

The imaginary parking lines are made to achieve maximum parking, since the cars are not parked in correct way, car area needs to be calculated which resides inside a proper parking slot. To handle with this, three classes have been defined, namely, the car class, the parking class and the intersect class. The car class contain the coordinate of car, the boolean either car is corrected parked or not and all value of all slot that car had occupied. The parking class contains the coordinate of the parking lot, boolean value either the parking slot is empty or not and the percentage intersection of all the car in that slot. The intersection class contain the coordinate of intersection between any car and parking lot and the number of car and parking lot that are intersecting. After calculating the area covered by the cars, the intersecting area percentage, i_area of car and the parking slot is calculated using Eq. 2.

$$i_{area} = \frac{intersection\ area}{car\ area} \times 100 \quad (2)$$

Finally, after all calculations the following perspectives are checked.

- Car correctly parked or not: Once i_area has been found, a rule needs to be defined which decides whether the car is parked correctly or not. Whenever the intersection of the car with parking slot is more than or equal to eighty-five percent of it will be marked as correctly parked otherwise wrongly parked.

- Parking space is vacant or occupied: To make sure which parking slots are being utilized and which slots are still vacant, another rule is defined that if a slot is occupied by more than or equal to fifteen percent then the parking slot is considered occupied otherwise

vacant. This is shown in Fig. 4. The red Color defines occupancy while the green color represents the vacant space.

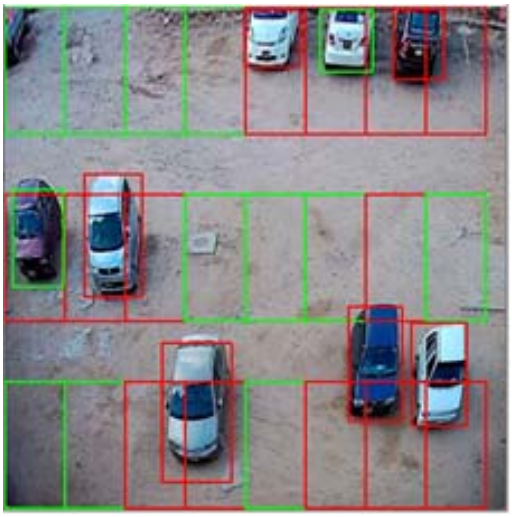

Fig. 4 Parking Lot Status

After all the calculations and changing the perspective of the image to bring back into the original look. The processed image and data related to it will be uploaded into the Real-time Firebase database, which can be seen by the user or the admin via Android mobile application.

3.5. User Interface

The user interface is the most important aspect for which the mobile application is used to provide a real-time parking space detection to facilitate the users. Fig. 5 shows the flow of the user application interface.

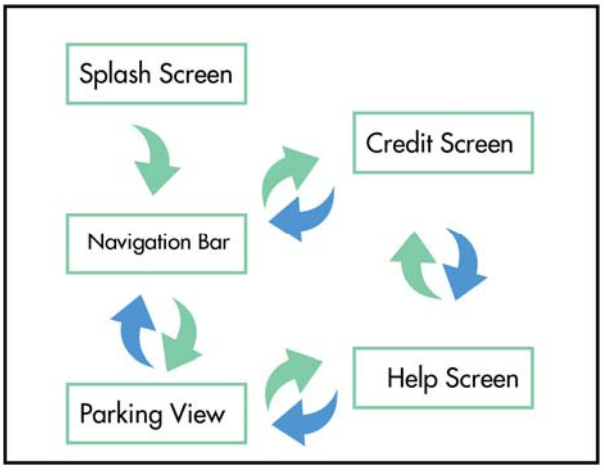

Fig. 5 User Application Flowchart

On home screen user will be able to see the parking lot with Imaginary lines through which the user will be able to determine whether any slot is vacant or not and also the total number of empty parking slots. The red box indicates the parking slot is occupied; if green then the parking slot is vacant. A view is shown in Fig. 6.

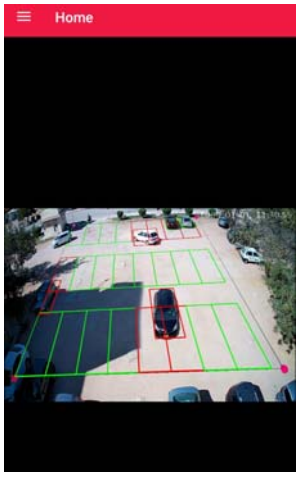

Fig. 6 User Application home screen

3.6. Admin Interface

In order to provide an ease to the parking management and admin personals at the parking lot, an admin application interface has been provided. Fig. 7 shown the flow of this interface.

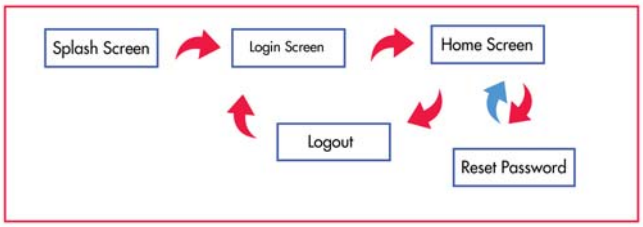

Fig. 7 Admin Application Flowchart

The admin application interface provides extensive data related to the parking lot, containing information like total number of car parking slots, number of the cars parked, number of correctly and incorrectly parked cars. To check an extensive report, the admin has to insert credentials to log into the application. Fig. 8 shows a view of the interface.

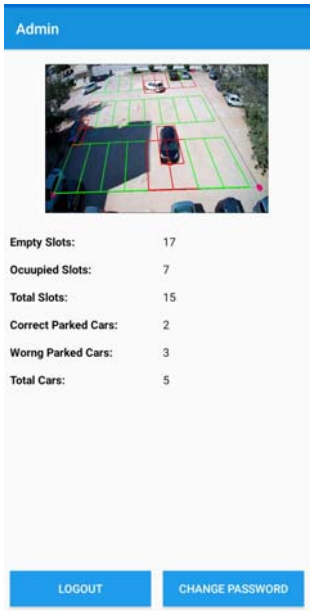

Figure 8: Admin Application

4. Conclusion

The Final Version of our Project is a mobile Application offering a start-up product in management sector that aims to address the parking difficulty issues at some mega-events where vehicles have to be parked in temporary parking area. The vision-based parking management system features to have maximum parking within the ROI and to facilitate the user with the best. The user can have a real-time parking lot update in order to see if there any vacant space available to park the car or not. Since most people are in hurry and park the car in the wrong way. In order to track it out, we have an admin application where the admin can check into the system for any wrong parking, the total number of vacant spaces, the number of correctly parked cars, and other details.

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