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Automatic Parking Space Detection System

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***Abstract*—Searching a suitable parking space in populated metropolitan city is extremely difficult for drivers. Serious traffic congestion may occur due to unavailable parking space. Automatic smart parking system is emerging field and attracted computer vision researchers to contribute in this arena of technology. In this paper, we have presented a vision based smart parking framework to assist the drivers in efficiently finding suitable parking slot and reserve it. Initially, we have segmented the parking area into blocks using calibration. Then, classify each block to identify car and intimate the driver about the status of parking either reserved or free. Potentially, the performance accuracy of recommended system is higher than state of the art hardware solutions, validating the supremacy of the proposed framework.**

Keywords-smart parking management; automatic parking; slot recognation; parking space detection; machine learning

I. INTRODUCTION

Now a day's most of the parking areas are manually managed by human manpower and there is no automatic system to manage the parking area in an efficient way. There is great analogy that when a driver enters any of the parking lot he must look for some kind of information board that tells him about the status of the parking lot that whether it is fully occupied, partly occupied or vacant. Most of the times the drivers have to circle around the parking area in search of the free parking space. This kind of problem mostly occur in cities near the shopping malls, hospitals etc., where the number of vehicles is greater as compared to the parking spaces.

The process for searching the free parking space is time consuming and also wastage of fuel. Most of the times the parking spaces remain unoccupied, however the total occupancy is low because of bad management of parking lot. This causes ineffective use of the parking area and also results in traffic jams and congestion near the parking lots.

To properly manage the parking lot and display each parking division's information to the drivers before entering the parking lot have become an important issue to be resolved. In this paper, a system is proposed that will detect the total number of available parking spaces and displays the information to the drivers so that they can easily parked their cars. A web camera is used to get the images of the parking area and image processing techniques are used to detect the presence or absence of cars to count and locate the available parking spaces .The status of the parking lot is updated whenever a car enters or leaves the parking lot.

II. LITERATURE SURVEY

Various methods and techniques have been proposed to overcome the problem of parking in the congested areas. Ming-Yee Chiu *et al.* proposed a method for counting the vehicles at the checkpoint from which the number of available parking spaces can be counted [1]. The counting is performed by installation of the induction loop sensors under the road surface. Although the usage of sensors was less costly, not easily affected by environmental conditions and it detects accurately however, it installation was difficult and cause damage to roads. It was also difficult to maintain it in case of malfunction [2]. Moreover, the exact locations of free parking area cannot be determined because the counting method is not able to give the detail information, it just records the number of vehicles passing the checkpoints [3].

The other detection methods were based on use of sensors like ultrasonic, infrared and microwave for the detection of vehicles [4]. These sensors are placed beneath every parking space. Wan-Joo Park *et al.* proposed the use of ultrasonic sensors mounted on the cars to search for a free parking space. The disadvantage of this method was that the sensors are easily affected by weather conditions like rain, temperature, snow and fast air breeze. Another method was presented by Vamsee K. Boda *et al.* based on wireless sensor nodes. This method was less costly and it uses the wireless sensor nodes implemented at the critical places like the lane turns, entrance and exit positions of the parking lot. The total number of cars in the parking area can be determined by the difference of incoming and outgoing cars [5].

The other kinds of detection methods are presented based on vision based methods. Through vision based methods, the whole parking area available for parking can be examined though the camera, the data is than processed and the result generated will determine the exact number and location of the free parking spaces. Zhang Bin *et al*. proposed that vision based parking space detection methods are very easy to install, low in cost and the detector can be easily adjusted according to requirements. Moreover, the data obtained from images is very rich. However, the defects in the vision method are that the accuracy is highly dependent upon the position of the camera.

Thomas Fabian proposed an unsupervised vision based system for parking space occupancy detection. The proposed system has low complexity in computation and needs less image frames per minutes. He claims that the major problem in images detection is the occlusions and shadows [6]. For unsupervised learning more advanced clustering algorithms

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are used. H. Ichihashi *et al.* proposed that the vision based parking space detection system are mostly affected by weather and lighting condition like the falling of rain drops on the lens of camera during heavy rainfall. Low and high lighting conditions. For this reason the cameras are mostly used for the detection of vehicles in the indoor parking areas not for the outdoor parking lots [7].

R. Yusnita *et al.* presented a method in which a brown color round patch was drawn in each parking space manually. When the system is initialized it looks for the rounded shape in each space, if patch is detected that particular space is considered as free and will be displayed the driver [8]. When the patches are blocked by objects(vehicles) then the system assumes the particular spaces are filled by vehicles. The system was good enough for managing the parking lot, however it does not work well in heavy rainfall and snow. N. True proposed an efficient parking space detection by using the combinations of color histogram and vehicle features detection [9]. Najmi Hafizi proposed an image-based method for detection of free slots in the outdoor parking area. A low resolution web camera is utilized for acquiring images of the parking lot that reduces the cost greatly. The images acquired are preprocessed and then a pair of ROI is applied on every division of the parking lot, which increases the reliability of detecting vehicles [10].

In [11] an image processing technique was presented that captures the brown circle drawn on the parking area and process it to detect whether that parking division is free or reserved. In [12] an image of car is saved as reference and the other images are matched with the reference image by edge detection technique and information about free and reserved slots are displayed. There are number of methods has been proposed for the extraction of features from the images like [13] - [17].

In this paper, we have designed and implemented a framework for automatic parking system. The experimental results have shown the remarkable accuracy, achieved by proposed system as compared to state-of-the-art methodologies.

The proposed parking lot model is discussed in detail in Section 3. In Section 4 the proposed algorithm of the parking system is discussed in detail .Section 5 deals with experimental results. Conclusion is given in section 6.

III. Proposed Parking Model and Methodology

The main flow of framework is shown is Fig. 1. Videos were acquired from the top view of parking arena, from ten feet heighted camera. To strengthen the recognition capacity of system video data was captured at different environmental conditions and temporal shifts.

Video is segmented into frames. Then from each segment a key frame is extracted and further processing is applied on this key frame, to reduce computational complexity. When radio controlled toy car enter or leave the parking lot from parking arena, motion of car is estimated by key frame subtraction.

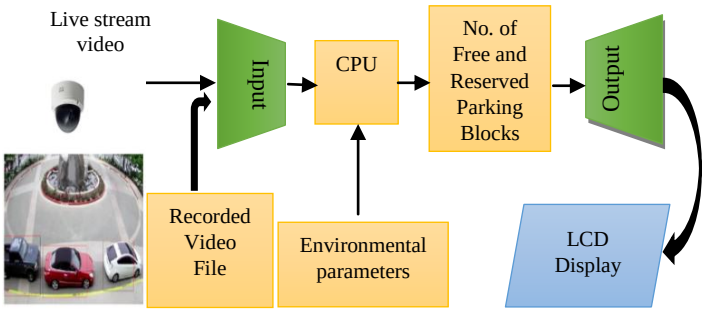

Figure 1. Block diagram of proposed system.

Initially, the parking arena have no parking lines. User will manually input the coordinates of parking area and vehicle intended to be parked. The system automatically generates virtual parking lines keeping in view the size of vehicle. The maximum capacity of parking slots in our training model is fourteen. A unique numeric label is assigned to each parking lot from 1-14.

After the parking arena is divided in the virtual blocks, our system will check the existence of car in each block. Binary filter is applied on image and then inverse binary to extract car as region of interest ROI. Computing the value of connected region in ROI and setting the threshold value greater then eighty as reserved parking slot. The number of the free blocks will be indicated to the divers in green and the reserved blocks will be indicated in red color.

IV. Algorithm of Proposed System

The main steps of the proposed algorithm for parking space detection are shown in Fig. 2

1. System will get Livestream video of the parking lot from camera.
2. Images are captured when a car enters or leaves the parking lot.
3. RGB Images are converted to grayscale images.
4. Do calibration
    - First select the coordinates of the parking lot. This will crop the extra space other than parking lot from the image.
    - Secondly select the coordinates of the single parking slot. This will divide the parking lot into equal size slots.
5. Each block is converted from grayscale to binary and then inverse binary to get the car in white color and parking area into black color.
6. Threshold value is calculated in every block to detect whether that block contain car or not.
7. If value is less than threshold value than that block is free and available for parking car and if value is greater than block is occupied.

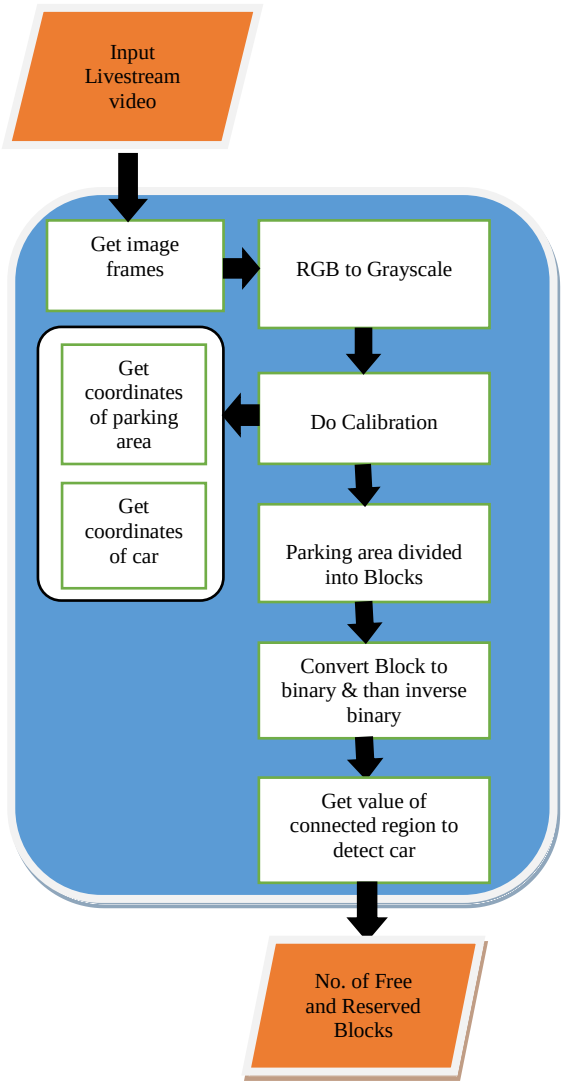

Figure 2. Algorithm of proposed system.

V. RESULTS AND DISCUSSION

The proposed method is implemented in MATLAB. The online system is getting images from the camera while offline system is getting images from a video file. The result of the online system shows that the proposed algorithms has efficiently detected the available parking slots and notify the drivers. The proposed algorithm is implemented on the model parking lot having space for 14 cars. The Slots having no car are shown as free while the Slots having car in it are shown as reserved to drivers as shown in Fig. 3.

To test the performance of our proposed algorithm, the accuracy of the system is measured with images taken at different time intervals. The performance is calculated by comparing the results of occupancy to the ground truth after every 5 sec. The performance of the proposed system is measured by the using the equation (1)

TPS = Total Parking slots
ANC = Actual Number of Cars
PNC = Predicted Number of Cars

$$\text{Performance} = 1 - ((|ANC - PNC|)/TPS) * 100 \quad (1)$$

The percentage of error in the proposed system will be find by using the equation (2)

$$\text{Percentage Error} = ((|ANC - PNC|)/TPS) * 100 \quad (2)$$

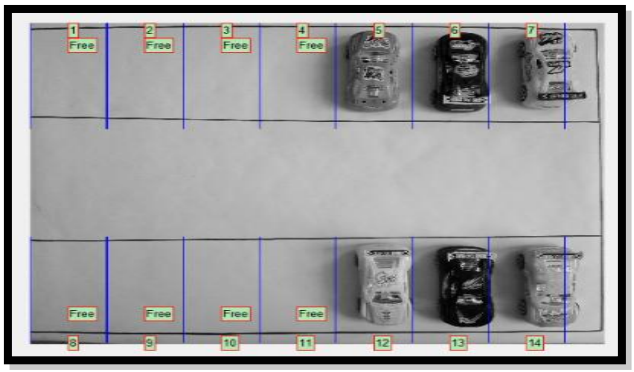

Figure 3. Free slots detection.

The testing of the proposed methodology is performed on the model parking lot having total parking slots TPS= 14.The test are performed in different weather conditions as shown in Table 1.

TABLE I. ACCURACY OF PROPOSED METHOD.

	Vehicle Appearance	*Number of tests*	*Correct detection*	*False detection*	*Accuracy*
Sunny day	Clear	50	50	0	100%
	Occluded	50	48	2	96%
Cloudy day	Clear	50	49	1	98%
	Occluded	50	46	4	94%

The accuracy of the proposed algorithm is found to be 100%, 98% 96% and 94%.The results shows that when the captured images of the parking lot are not clear because of less lighting or occlusions, the efficiency decreases and the accuracy for detection's reduces. It is observed that the average performance is 99.5 % and is very high as compared with other parking lot detections applications. The performance of the proposed algorithm in some cases drops down because of the strong shadows. The accuracy of

the proposed work also depends on the type of camera used for monitoring the parking lot. The output accuracy is shown below in Fig. 4. The correct detection of the cars is shown in chart in blue color and the false detection of cars is shown in orange color.

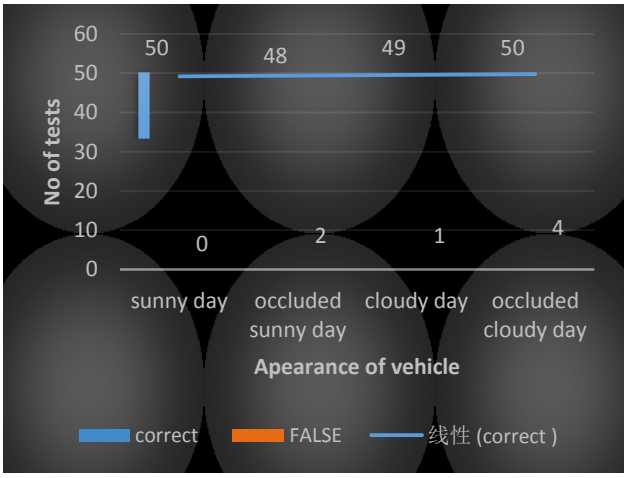

Figure 4. Vehicle detection in different conditions.

The results of the system proposed are compared with already implemented systems. The average detection rates of our system is compared with the two techniques used in existing parking systems for detection of free parking slots as shown in Table 2.

TABLE II. COMPARISON OF PROPOSED METHOD WITH TWIN ROI BASED DETECTION TECHNIQUE [10],EDGE BASED DETECTION TECHNIQUE[12].

	Twin ROI detection method	***Edge based detection method***	***Proposed approach***
Average detection Rate (car)	95%	97%	98%

The graph showing the accuracy of different parking system is given below in Fig. 5.

The accuracy of our proposed system is better than the Color based twin ROI detection technique [10], Edge based detection technique [12] used in existing parking systems.In color based detection system and Twin ROI based system ,the efficiency goes down when the car and parking area is of the same color.. Our proposed method will automatically divide the parking area in multiple blocks by drawing virtual lines on the parking lot and efficiently detect the cars in these virtual parking blocks and notify the drivers about the available parking blocks.

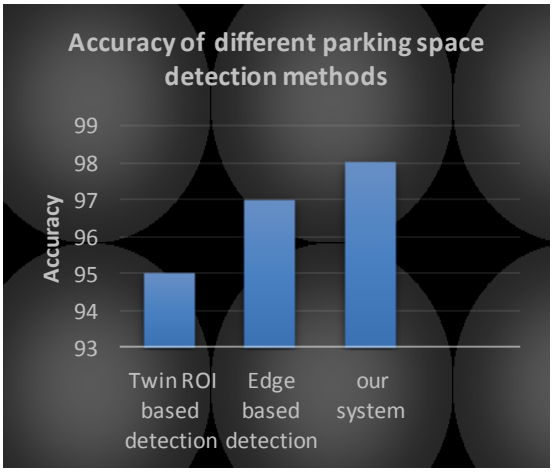

Figure 5. Accuracy of different parking system.

VI. CONCLUSION

The main contribution of this study is to optimize the identification of available parking slots to possibly reduce the congestion in parking arena. Due to advancement in machine learning and vision base technology cost effective automatic parking systems facilitate the drivers to locate available spaces at parking arena. Future researchers can focus on allocation specific location to customers already registered from online parking management system.

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