ISSN No:-2456-2165

camPark: An Automated Car Parking Space Monitoring System using Image Analysis based on Ellipse Fitting Model

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Abstract:- Parking space availability monitoring problem has become prevalent nowadays. Most of the malls or public areas do not have an automated system for car park space monitoring, which causes drivers to spend more time and effort circling around just to check by inspection the parking space availability. Moreover, drivers may resort to nearby illegal area for parking. In order to mitigate problems such as these, camPark, an automated car parking space detection system, is proposed in this study. The study lays emphasis on parking cars in a mall's parking area. In the proposed system, the availability of parking spaces is recognized or detected through image analysis leveraging the advantage of ellipse fitting model. This also includes specifying number of available spaces for car parking. Upon receipt of request, the system searches for an available space through image capture and analysis. Experiments reveal that our proposed approach demonstrates efficiency and can be very beneficial to the drivers.

***Keywords**:- Ellipse Fitting Model, Automatic Parking Space Detection, Parking Space Management, Parking Space Monitoring System.*

I. INTRODUCTION

Finding a parking space in a crowded parking area is often times a very long and frustrating task. This problem usually springs from being unable to find where the open spots are, which compels the drivers to roam around aimlessly until a vacant space is spotted. Clearly, the problem of finding vacant parking space extends beyond just the time wasted by the driver getting inside the parking area and only to realize that there is no available parking space. Hence, car parking space availability monitoring system has become invaluable for drivers.

While there are already significant body of work that have been made to install parking space monitoring systems to perform function of identifying vacant lots, similar systems have yet to be implemented in other urban areas. Furthermore, most of the works used sensors-based systems [1][2]; and integrating image analysis are yet underway. Most of the malls or public areas do not have an automated system for car park space availability, which causes drivers to spend more time and effort to roam around just to check by inspection the parking space availability. Hence, monitoring inbound and outbound cars requires load of work due to limited automated system in detecting car parking area availability. This may sometimes lead the drivers to resort to nearby illegal area for parking. Some of the malls' Parking Management system regulate the number of cars that can be parked at any given time by manually monitoring parking space availability; and by using a green light as an indicator that there is an available space; and red light, for unavailable spaces.

In order to mitigate problems such as these, camPark, an automated car parking space detection system, is proposed in this study. The study lays emphasis on parking cars or vehicles inside a mall so that drivers do not need to get into the parking area and later realized that there is no available space. In the proposed system, the availability of parking spaces is recognized or detected through image analysis leveraging the advantage of ellipse fitting model. Such monitoring will be displayed at the entrance gate. This also includes specifying number of available spaces for car parking. Upon receipt of request, the system searches for an available space through image capture and analysis. In this work, we do not use a sensor to count the number of cars which are parked at the parking space, but instead we use a camera to capture an image of the parking area and automatically determine the availability of parking space based on the concept of ellipse detection.

Image processing has already gained popularity in solving problems in different areas such as car surveillance [3][4]. For example, ellipse detection and a fast and robust ellipse-detection method based on sorted merging have contributed a lot in the society in helping the drivers to reduce problems in finding parking areas but there are drawbacks and limitations of the current study, which include the following: (a) manual labor cost; (b) proper management of the parking facility; and (c) lack of efficiency and reliability of a system. In this study, the drivers can easily determine the availability of the parking space and can park their vehicles accordingly because the status of the parking spaces is already displayed at the entrance using a monitor. In image analysis field, exhaustive study of Median filter plays the important role in image processing applications and also in image edge preservation because it removes noise, sharpens contrast, it highlights contours, and detects edges. It sorts pixels value in the neighborhood and the replaces the central pixel with median value in the sorted group. Median filter plays the important role in image processing applications and also in image edge preservation [5][6][7]

Empirical results [8][9] show that ellipse fitting model was tested to be superior in detecting elliptical shape, which is also the subject of this study. Barbosa et al. [9] leveraged the advantage of the Collective Animal Behavior (CAB) algorithm introduced by Cuevas et al. [8], extracted multiple ellipses from an image. In their work, an evolutionary algorithm is employed to mimic the way animals collectively behave. The CAB algorithm performs tasks under the assumption that the set of operations having similarities with the rules of interaction that models the collective behavior of animals do exist. We use a yellow ellipse-shape marker at every parking space for a specific vehicle in order for the web camera to capture. The camera will only detect yellow ellipse shape at each parking area to determine available parking spaces. Each yellow ellipse shape that is detected by the web camera is equivalent to 1 available parking space. If there are still available spaces the security personnel will get the car's plate number and store car's parking information in the database.

II. METHODOLOGY

A. *camPark: an Overview*

Our system performs monitoring of parking space availability by doing automatic detection of markers and counting as a prerequisite task. We capture images (i.e. still photos) of the parking space located in each area with appropriate light illumination in order to acquire similar amount of lighting. The camera captures the parking area image in a top view position. Such position is very convenient as it covers the entire area and it can visibly capture the marker with an elliptical shape located in each parking space. Images captured are stored in the image database. Fig. 1 shows the proposed framework for automatic car parking space monitoring system.

To begin the process, raw images from the image database is extracted or retrieved. It is followed by the definition of HSV range for the color yellow. Then followed by the pre-processing of images to enhance contrast and remove undesirable image noise. This is done by applying filtering technique to the captured image. With filters, the central element is a newly calculated value which may be a pixel value in the image or a new value. It reduces the noise effectively. We then apply bilateral filter, which is a non-linear, edge-preserving, and noise-reducing smoothing filter for images. It replaces the intensity of each pixel with a weighted average of intensity values from nearby pixels. To further remove noise in the image, median filter is applied. This is highly effective against salt-and-pepper noise in the images. After which, we check contours and count those that are qualified. Ellipse images are then detected using the ellipse fitting model algorithm [6], a computational procedure for accurately fitting an ellipse to extracted edge points by considering the statistical properties of image noise.

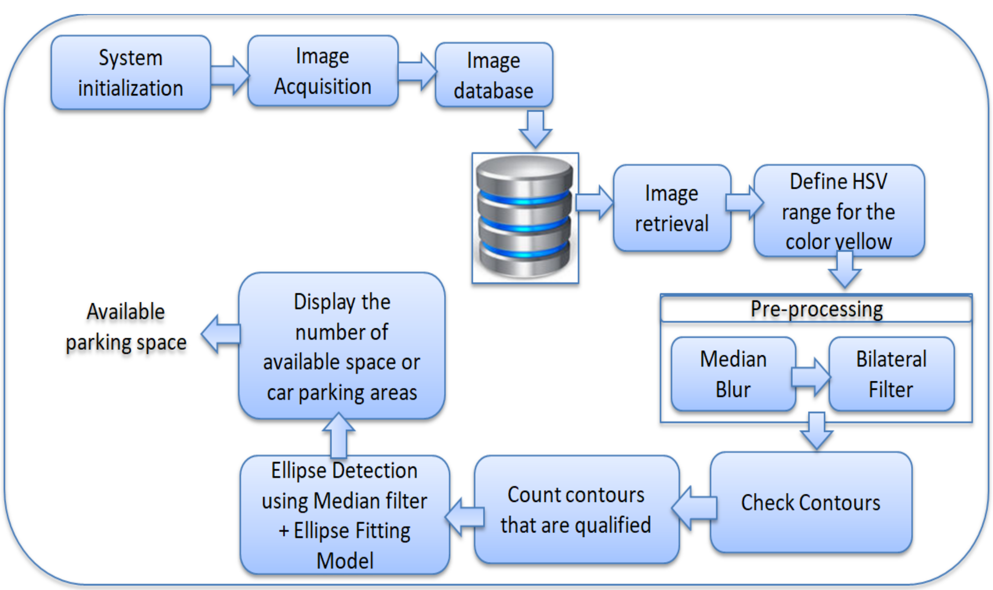

Fig 1:- Proposed Framework of camPark

B. Context and Data Flow Diagram of the Proposed System

Figure 2 shows the context-diagram or the bird's eye view of the entire system. It shows the process of three (3) entities involved in the system, which include the driver; admin; and car entity. The driver entity received parking area availability information, which contains the number of available parking spaces, parking are number, etc. The user on the other hand, is the source of the data requesting to check for the availability of a parking space and the receiver of the details of the available space, while admin receives both all information it needs such as the license plate number of parked cars and periodic reports. The car entity is source of data such as, plate number, model, color, etc. On the other hand, the Data Flow Diagram in Figure 3 show how the data runs and presents the data flow and the processes of the whole system. This includes capturing parking area image upon receipt of the request to check for parking space availability. The processes involved in the system are: (a) user registration; (b) displaying of parking space information; (c) recording of transactions; (d) displaying of the details of car parked; and (e) generating of reports.

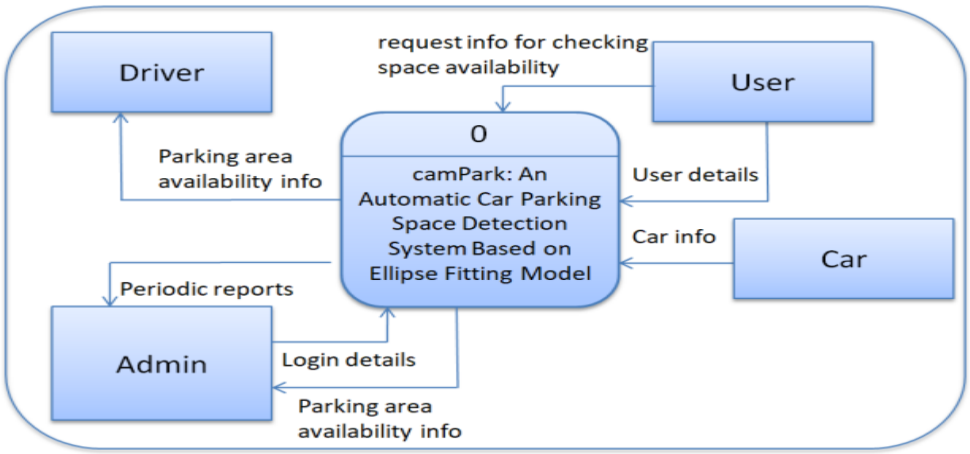

Fig 2:- Context Diagram of CamPark

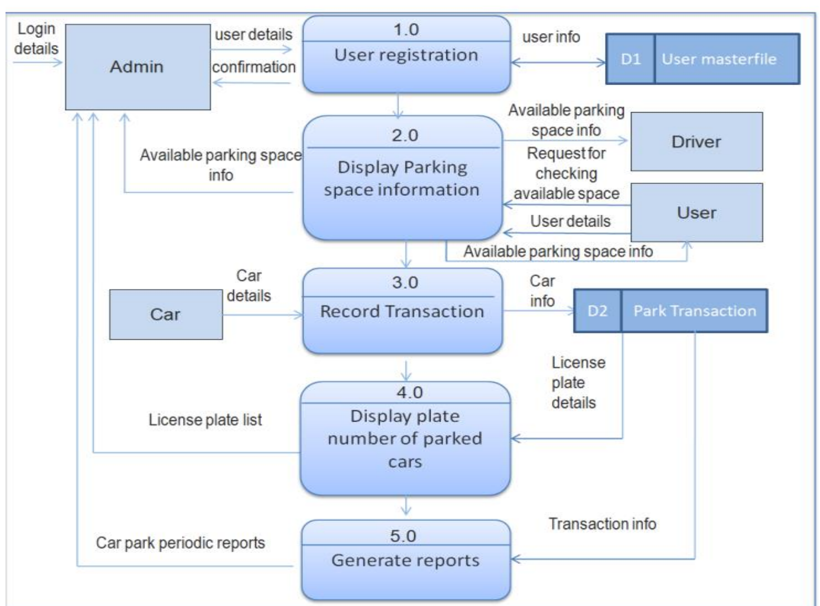

Fig 3:- Data Flow Diagram of the Proposed System

C. Use Case Diagram of CamPark

A USE case as presented in Figure 4 represents each user's (e.g. driver; use or employee; and admin) interaction with the system. In this figure, the function and transactions that can be performed by the user are presented. The driver, for example, can only view the available space. On the other hand, the user and the admin can both do the login and viewing of the system. Clearly, the admin is capable of managing the entire system (e.g. viewing of reports, requesting space availability and adding of new users), while the user or employee can only perform request, insert or add the car info, view and generate reports.

ISSN No:-2456-2165

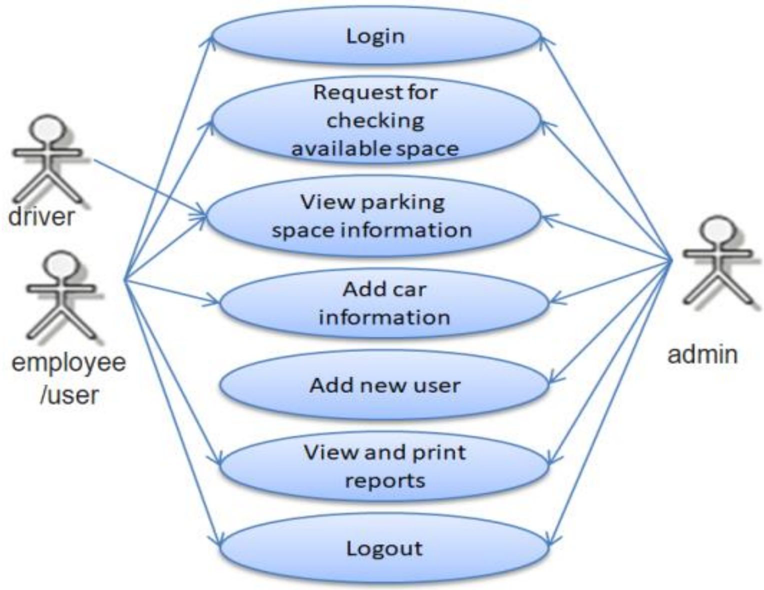

Fig 4:- Use Case Diagram

D. Overview of Ellipse Fitting Model

In the field of imaging, elliptical shape is one of the most widely used geometric shapes. Specifically, in pattern recognition, the ellipse extraction from the given images has been considered an interesting task. While attempts to detect ellipses efficiently have been made, most of these methods, however, are computationally expensive and require hug amount of memory in order to obtain a sub-pixel resolution [6]. In this study, we leverage the advantage of the Collective Animal Behavior (CAB) algorithm introduced by Cuevas et al. [6] for extracting multiple ellipses from an image. In their work, an evolutionary algorithm is employed to mimic the way animals collectively behave with the assumption of having the general detection process being a multimodal optimization problem. Additionally, in their proposed approach, the search agents perform emulation of a group of animals that interact with one another using the biological rules modeled as evolutionary set of operators. This detector uses parameters that combine five edge points to identify the optimum solutions for extracting ellipse candidates, while a matching function is used for determining if the ellipse candidates being identified are found in an image. Leveraging evolutionary technique or algorithm, the set of ellipse candidates are then evolved, based on the values of the matching functions so that the best candidates can be fitted into the actual ellipses found within the actual image. Analysis is then performed to search for the best ellipse and the significant minima or ellipses [6].

III. RESULTS AND DISCUSSION

In our experiments, we performed simulation of 50 still images of parking area with varied number of available parking spaces. Thorough experiments and quantitative analysis was conducted to test and evaluate the efficiency proposed method in automatic car parking space detection and counting. In particular, we evaluated the system using the three performance measures, such as accuracy, precision and recall of the two methods (i.e. using Canny and our proposed approach). Like any other research areas particularly in information retrieval and pattern recognition, we use precision performance measure as this gets the part of the instances being retrieved, which are relevant. We also use recall or sensitivity measure to get the par of relevant instances or cases which are retrieved. Above all, we get the accuracy rate to test the efficiency of the proposed approach. Figure 5 shows user or admin's interface showing 8 available parking spaces. On the other hand, Figure 6 shows the results of the experiments we performed using Canny and our proposed approach for detecting markers, thereby determining available parking space. Notice that our approach provides a more accurate result in detecting markings in elliptical shape. In Figure 6a, the image at the left shows actual number of ellipses to be detected and it has ten (10) ellipses, while the image at the right shows the number of ellipses being detected using Canny algorithm. The system failed to detect the correct number of ellipses based on the image at right as it only detected nine (9) ellipses. However, Figure 6b presents the results using our approach, which leverages ellipse fitting model in detecting markers. As presented, our approach appears to be better than Canny approach.

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Fig 5:- user or admin's interface showing 8 available spaces

(a) Sample results using Canny edge (b) Results using our approach

Fig 6:- Comparison of results using Canny and our Proposed Approach

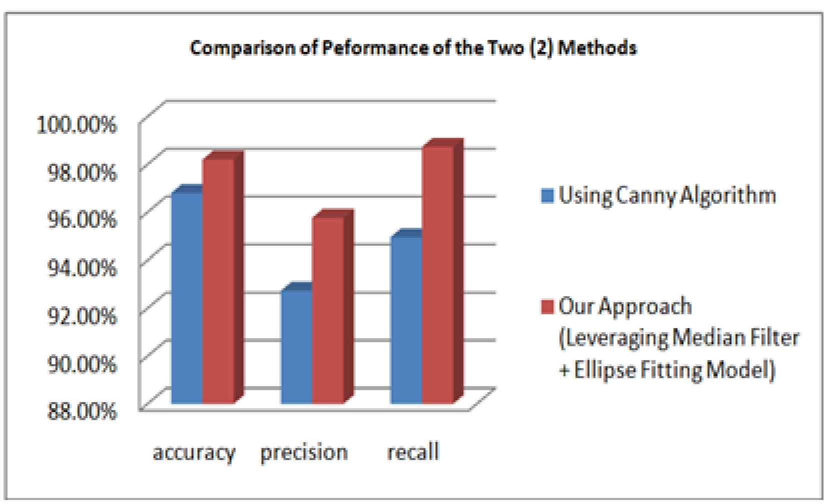

Fig 7:- Comparison of Performance of the Two (2) Approaches in Automatic Detection of Available Parking Space

Performance measures	Using Canny Algorithm	Our Approach (Leveraging Median Filter + Ellipse Fitting Model)
Accuracy	96.8%	98.2%
Precision	92.7%	95.8%
Recall	95.0%	98.7%

Table 1:- Comparison of the Performance of the Two (2) Approaches

Table 2 shows the evaluation of precision and recall using different approaches or tools prior to the proper detection markers, which are used to determine the parking space availability. From the captured images of parking area, the results reveal that our approach is better than using other method, which uses Canny as ellipse detection tool. Canny-based ellipse detection method yields good results with a precision and recall of 92.7% and 95%, respectively, while our approach (i.e. applying median blur and bilateral filter plus and ellipse fitting model) appears to be superior as it resulted to a precision and recall of 95.8% and 98.7%, respectively. For the accuracy measures, the table reveals that Canny has an accuracy rate of 96.8%, but our approach yields almost 99% accuracy rate. Thus, experiments reveal that our approach is superior than Canny edge detection methods prior to employing ellipse fitting model for available parking space. Tables 2, 3 and 4 present more detailed results of the experiments.

No. of parking areas represented by ellipses	Using Canny Algorithm			Our Approach (Leveraging Median Filter + Ellipse Fitting Model)		
	Accuracy	Precision	Recall	Accuracy	Precision	Recall
10	94.0%	100.0%	94.0%	98.0%	100%	98.0%
9	94.0%	98.0%	95.6%	100%	100%	100%
8	100.0%	100.0%	100.0%	100%	100%	100%
7	98.0%	97.5%	100.0%	100%	100%	100%
6	98.0%	97.1%	100.0%	100%	100%	100%
5	98.0%	96.7%	100.0%	98.0%	100%	96.0%
4	94.0%	88.0%	100.0%	98.0%	96.0%	100%
3	96.0%	90.0%	100.0%	96.0%	95.0%	93.3%
2	100.0%	100.0%	100.0%	96.0%	86.7%	100%
1	96.0%	60.0%	60.0%	96.0%	80.0%	100%
Average	**96.8%**	**92.7%**	**95.0%**	**98.2%**	**95.8%**	**98.7%**

Table 2:- Comparison of Results using the Two Approaches for Car Parking Area Availability Verification

Table 2 shows that the average results of the experiments while performing 5 tests for varied number of available parking space (from 10 to 1 available parking space) using Canny edge and our approach. We use the results by eye inspection as our ground truth to compare with the results generated by the system. We started the experiment using the Canny tool. During the first test, we performed ten (10) different set ups starting from 10 available parking spaces to 1. It shows that the system detected {10,9,8,8,6,5,5,3,2,1} available parking spaces, respectively from 10-1 numbers of ellipses on the 1st test; {10,9,8,,7,6,5,4,4,2,1} on the 2nd test; {9,10,8,7,7,6,4,4,2,1} on the 3rd test; {9,8,8,7,6,5,5,3,2,0} on the 4th test; and {9,8,8,7,6,5,5,3,2,0} on the 5th test. Similarly, we apply the 5 tests to our approach, which shows that the system detected {10,9,8,7,6,5,4,3,2,2,}, from 10-1 numbers of ellipses on the 1st test; {10,9,8,7,6,5,4,2,2,1} on the 2nd test; {9,9,8,7,6,5,4,3,3,2} on the 3rd test; {10,9,8,7,6,5,5,3,3,1} on the 4th test; and finally {10,9,8,7,6,4,4,4,2,1} on the 5th test. Additional sample summary results of each trial conducted are presented in tables 3 and 4, where True Positive (TP), False Positve (FP), True Negative (TN) and False Negative (FN) are recorded in each trial using applying varied number of available spaces to compute the accuracy, precision and recall.

No. of parking areas represented by ellipses	TP	FP	TN	FN	Accuracy	Precision	Recall
10	9	0	0	1	90%	100%	90. 0%
9	8	0	1	1	90%	100%	88.9%
8	8	0	2	0	100%	100%	100.0%
7	7	0	3	0	100%	100%	100.0%
6	6	0	4	0	100%	100%	100.0%
5	5	0	5	0	100%	100%	100.0%
4	4	1	5	0	90%	80%	100.0%
3	3	0	7	0	100%	100%	100.0%
2	2	0	8	0	100%	100%	100.0%
1	0	0	9	1	90%	0%	0.00%
	Average				96.0%	88.0%	87.9%

Table 3:- Sample Results of a test using Canny Algorithm for Car Parking Area Availability Verification

No. of parking areas represented by ellipses	TP	FP	TN	FN	Accuracy	Precision	Recall
10	10	0	0	0	100%	100%	100%
9	9	0	1	0	100%	100%	100%
8	8	0	2	0	100%	100%	100%
7	7	0	3	0	100%	100%	100%
6	6	0	4	0	100%	100%	100%
5	4	0	5	1	90%	100%	80%
4	4	0	6	0	100%	100%	100%
3	3	1	6	0	90%	75%	100%
2	2	0	8	0	100%	100%	100%
1	1	0	9	0	100%	100%	100%
	Average				98.0%	97.5%	98.0%

Table 4:- Sample Results of a test using our Approach (Median Filter + Ellipse Fitting Model) for Car Parking Area Availability Verification

IV. CONCLUSION

In this study, we present an application using image analysis for automatic detection of markers in a parking area, thereby providing efficient monitoring of available parking space without necessarily going to the physical location to check by inspection. We model the system based on the needs of a parking area in a mall leveraging the advantages of ellipse fitting model. Experiments reveal that our approach provides efficient results of determining available parking space. One limiting factor, however, is that it requires marker of elliptical shape in each space in order to yield satisfactory results. Nevertheless, our system generally provides significant merit that can be used to real world application. It hastens the process of finding available parking space without wandering aimlessly until a vacant slot is spotted as it employs automatic detection and counting of space for parking.

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