Applied Integral Intensity Projection To Find The Numbers Of The Parking Spots

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Abstract— **The automatic parking system using an integral intensity projection is important in order to reduce the time spend for finding an available parking space. We applied the intensity projection and peak detection approaches to find the number and location of the parking space from a parking lot image. The parking lot image is firstly applied the integral projection in order to sum and smooth intensity projection of this image in a horizontal direction. After that the image is segmented into the region of interest (ROI) image by using the location object's edges derived from a derivative method. Then the integral intensity projection is again utilized the maximum points in vertical direction of the image intensity summation. Finally, the number of parking spots were counted by using peak detection approach. In the experimental results, the accuracy for counting the number of cars in the parking lot image is 53.03%.**

Keywords-component; Automatic Parking System; Intensity Projection ; Peak Detection; 1-D First-Order Derivative

I. INTRODUCTION

Over the past decades, research on air pollution and issue to solve this problem has gained increasing relevance. The use of fossil fuels which is usually in vehicle engines is one of the cause of the air pollution. Nowadays the number of vehicles is dramatically increased [1], the following problem is a time consuming during searching an available parking space especially in the indoor garage. The air pollutants which are from an incomplete combustion of the fuel in car engines will then occur in limited area. Therefore, the automatic system that can support to reduce the wasting time for finding an available parking space in the indoor garage is required. Now, the parking system for the indoor garage has been developing for improving the better performance of counting the numbers of car in the parking lot. Most of system will count the available parking space one by one. Then, this system utilizes machine to detect and to count the available parking space [2], [3], [4]. Since the indoor garage normally has security cameras which also provides the image of parking lot, it might be interesting to apply image processing method for detecting and counting an available parking space in the indoor garage [5], [6]. In this paper, we will focus on applying an integral intensity projection and the First-Order derivative method to the parking lot image.

II. BASIC IDEA

Generally, the parking lot image is consisted of an image of cars which were arranged in series. To obtain the boundaries of car heights in the image, it can be determined by using the different values of the adjacent data of the cumulative intensity values of the image in horizontal direction. The transitions of the values can utilize to demonstrate the positions of edges object in the signal data. While to obtain the number of parking spots, we can then determine by using the location of each maximum cumulative intensity values of the image in vertical direction. The number of car is then counted in order to check the rest of the number of parking spots. Therefore, Intensity Projection and the First-Order derivative method are applied to detect the boundaries of car heights in this study. Fig. 1 illustrates an example of our basic idea. The peak detection method is then utilized to detect the number of car in the image. The idea for finding the numbers of the parking spots by using peak detection approach is represented in Fig. 2.

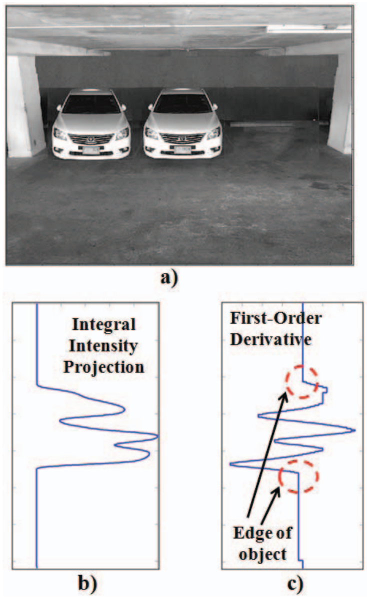

Figure 1. The basic idea to find the boundaries of car heights in the image by using the intensity projection and the first-order derivative method

III. PROPOSED METHOD

In this section, the details of our proposed method are explained based on the approaches for finding the boundaries of car heights in the image and for finding the maximum points in vertical direction of the image intensity summation. All processes of our approach are shown in Fig. 3. Firstly, an enhanced image was converted to a binary image.

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Mathematical morphology approaches, opening, closing, and dilation, were then applied for expanding the shape of objects in the binary image. Secondly, we applied the integral intensity projection and smoothing filter approaches to a binary image in order to sum and smooth the values of image intensity in horizontal direction and then found the boundaries of car heights in the image by the first-order derivative method. Subsequently, the binary image was operated with Mathematical Morphology approaches, the integral intensity projection, and smoothing filter again for finding the maximum points in vertical direction of the image intensity summation. Finally, peak detection approach was utilized to detect the maximum points in order to find the numbers of the parking spots in the garage.

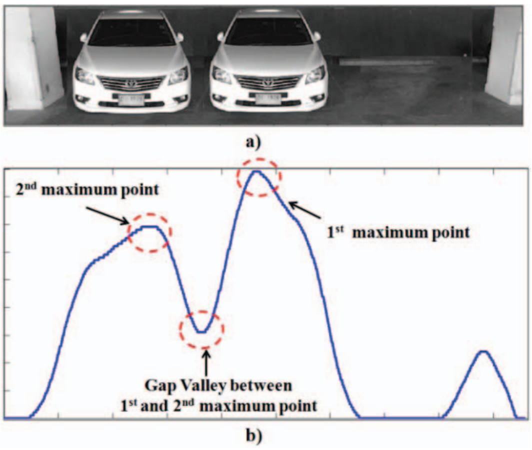

Figure 2. The basic idea to find the numbers of the parking spots byusing intensity projection and peak detection approach.

A. Binary Mathematical Morphology

In our proposed method, an enhanced image was an image which was already adjusted image intensity and has been already improved objects' edges of image by the Laplacian operator [7]. Then, an enhanced image was converted to a binary image. In order to expand the shape of objects in the binary image, Mathematical Morphology approaches [8] were then applied. Before applying the Integral Intensity Projection approach, the opening, closing, and dilation method were utilized to reduce noise, to fill the hole inside the object and to spread the objects' size in the image, respectively.

B. Integral Intensity Projection and Smoothing Filter

In our proposed, Integral Intensity Projection method [9] was utilized to sum the values of each pixel in each axis. The summation of each axis showed the shape of the cumulative intensity values of the image. In this case, the shape was demonstrated the position of object in the image from the summation results. However, the values in this summation results were still different. Therefore, the Smoothing Filter approach was required in order to smooth the values of these results before applying the next approach. In this paper, the 1-D triangular smoothing filter [10] was applied for flattening the individual data values in the vector of the summation results. The average of adjacent data values was then computed for either 1) reducing the summation values that were higher than the adjacent data or 2) increasing the summation values that were lower than the adjacent data values. Consequently, the average values were replaced each data value in the vector. In this method, Integral Intensity Projection and Smoothing Filter approaches were done twice. First, the approaches were applied to sum the values of each pixel and to smooth the summation results in horizontal axis. Second, the approaches were applied in vertical axis.

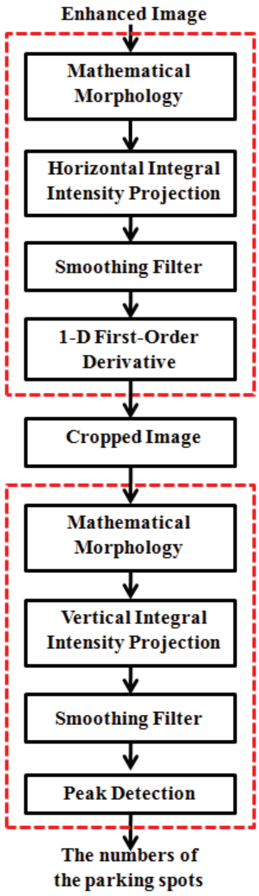

Figure 3. Processing flow of proposed method .

C. First-Order Derivative

The positions of the transition value in one-dimension signal data are generally defined as edge of object. Normally, noises which are the effect for detecting the positions of edge are mostly contained in the signal data. Then, it is difficult to detect the positions of edge in the signal data correctly. One-dimension first-order derivative [11] is utilized in order to compute the different values of the adjacent data. The transitions of the values can utilize to demonstrate the positions of edges object in the signal data. Therefore, a first derivative is applied to characterize the edge of object. In this paper, first-order derivative method was applied into the Integral Intensity Projection results in order to find the boundaries of car heights on y-axis in the parking lot image. In this case, we utilized the transitions of the first-order derivative result. This changed the values from the negative values to the positive values for checking and detecting the positions of the boundaries of car heights (Fig.4(a-b) and Fig.5(a-b)). The image was then segmented into the region of interest (ROI) image (Fig.4c and Fig.5c).

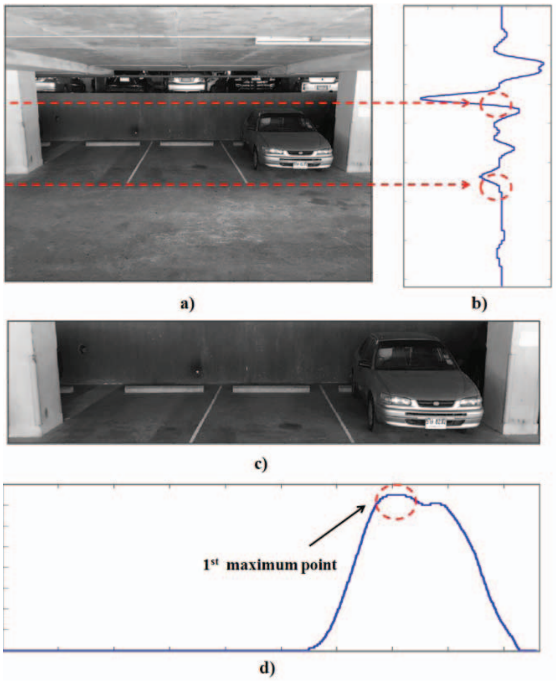

Figure 4. An example of image of 1 car, processes of the approach for finding the boundaries of car heights in the image by first-order derivative method and the approach finding the maximum points of the summation of image intensity in vertical direction.

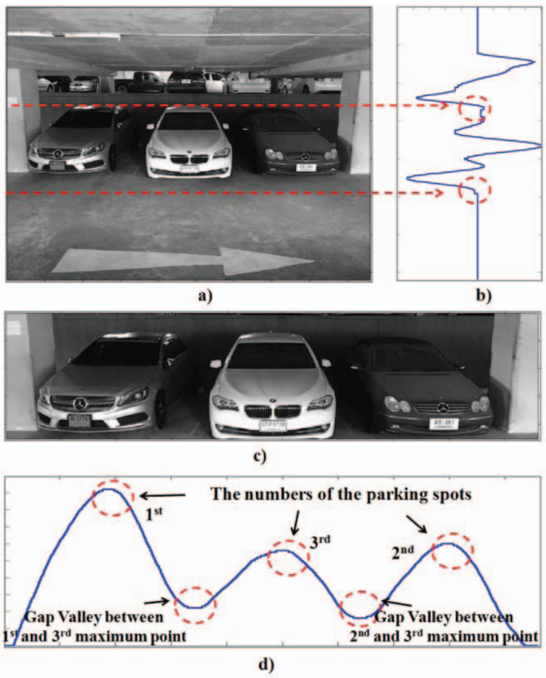

Figure 5. An example of image of 3 cars, processes of the approach for finding the boundaries of car heights in the image by first-order derivative method and the approach finding the maximum points of the summation of image intensity in vertical direction.

D. Peak Detection

The peak detection approach [12] is the method that is utilized in order to find the maximum value in the signal data. In our approach, the peak detection method was applied to find and locate the positions of maximum value on x-axis of the ROI image. The maximum value of projected intensity was then utilized to detect and count the number of car in the image. The positions of gap valley between each position of the maximum value were applied to check the difference between maximum values for reducing the errors of detecting the positions of maximum value. The example of peak detection results when the positions of gap valley were applied in the projected intensity on x-axis of the ROI image to reduce the errors for detecting the positions of maximum value are shown in Fig.4(d) and Fig.5(d).

IV. EXPERIMENTAL RESULTS AND DISCUSSIONS

In order to test the accuracy of our method, experiments have been done in55parking lot images which were consisted of 17 images of 1 car, 25 images of 2 cars and 13 images of 3 cars. The accuracy for detecting the car height's boundaries and the accuracy for counting the number of cars were estimated which are demonstrated in Table 1 and Table 2, respectively.

TABLE I. THE ACCURACY FOR DETECTING THE CAR HEIGHT'S BOUNDARIES

Type of images	**The car height's boundaries**		
	precise	***mistake***	***Accuracy(%)***
1 car	4	13	23.53
2 cars	14	11	56.00
3 cars	7	6	53.84
Average			44.45

TABLE II. THE ACCURACY FOR COUNTING THE NUMBER OF CARS

Type of images	**counting the number of cars**			
	All	***Correct***	***Mistake***	***Accuracy(%)***
1	17	9	8	52.94
2	25	15	10	60.00
3	13	6	7	46.15
Average				53.03

From the Table 1, the percentage values of accuracy for detecting the car height's boundaries by our proposed are 23.53% in case of 1 car, 56.00% in case of 2 cars and 53.48% in case of 3 cars in one image, respectively. Therefore, the average of all percentage values is 44.45%. In this case, we can report that the performance of our approach for detecting the car height’s boundaries is better in case of images of 2 and 3 cars than the image of 1 car.

In the Table 2, the average percentage values of accuracy for counting the number of cars by our proposed are 53.03%. The accuracy in case of1 car image is 52.94%. While the accuracy in case of 2 cars and 3 cars images are 60.00% and

46.15%, respectively. It could be claimed that the performance of our approach is sufficient enough for detecting the number of cars in the parking lot image. Fig.6a and Fig.6b are sample images that show the results for detecting the car height's boundaries and counting the number of cars in case of 1 and 2 cars images.

However, the errors for detecting the car height's boundaries and for counting the number of cars still occur in our experiment. There are two possible reasons that cause these errors. Firstly, the intensities of floor and intensities of background in back of cars in the parking lot image can be considered as the reasons of degradation. The floor intensities affect the detection of the positions of maximum value in the signal data. The cumulative intensity values of cars in the image will change when the floor in the image is wet or reflect the light of sun (Fig.7a). Secondly, intensities of background will effect to the results of peak detection when the most intensities of background are higher than the cumulative intensity values of cars in the image (Fig.7b).

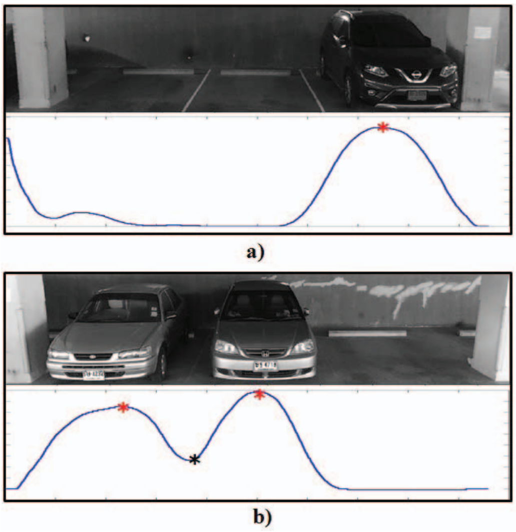

Figure 6. Example results of our method for counting the number of cars in the parking lot image

V. CONCLUSION AND FUTUREWORK

In the present study, we demonstrated an approach dedicated to count the number of cars in the parking lot image. The approach applied the integral intensity projection, smoothing filter, one-dimension first-order derivative and peak detection method in order to detect the position of maximum values in the cumulative intensity values in the image. The number of cars in the image are counted from the number of the position of the maximum values. In this experiment, the average accuracy for counting the number of cars are 53.03%. Further studies on a more sophisticated approach for detecting the car height's boundaries and for reducing the effect of intensities from the neighborhood area of car in the image are needed to develop this approach. For example, this parking lot image might be subtracted by emptying car's parking lot image.

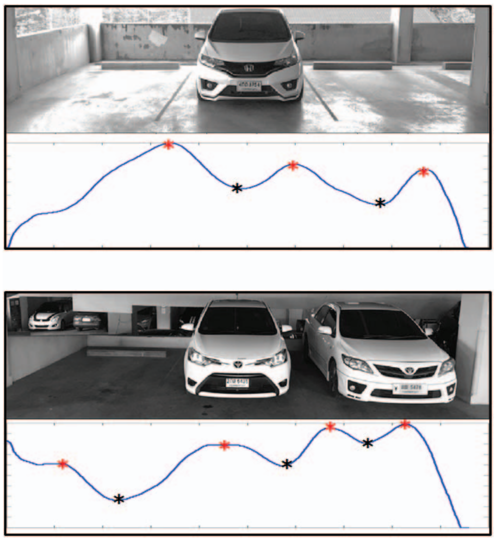

Figure 7. Example of error results for counting the number of cars in the parking lot image

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