Vision Based Parking Space Classification

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***Abstract*— The problem of Vacant Parking space detection from static images using computer vision based algorithms such as color histogram classification, car feature point detection has been recently proposed by a few researchers. In this project we implement some of the suggested approaches and also use additional techniques such as background subtraction and some improvised methods to classify the state of a parking space.**

I. Introduction

Finding empty parking spaces in a parking lot can be an aggravating experience. A system that can automatically identify empty parking spaces and guide users to it will save a lot of time, money and effort. Many solutions which employ sensors for this purpose have been suggested, but they are either too expensive to implement or have failed to be effective. This led people to look for other economical solutions. Computer vision based techniques have the potential to provide a cost effective solution to this problem because they can use existing infrastructure such as security camera's to capture images which can be processed to classify the state of the parking space.

[1] uses a multi-class support vector machine to classify the color histograms of parking spaces and thereby identify vacant parking spaces. Another possible solution is to do a background subtraction and then use some kind of statistic from the background subtracted image in every parking space region to classify its state. Yet another solution is to detect car feature points and use this to determine the existence or absence of a car in each parking region. In this project we have implemented the above methods with varying degree of success. In addition we present a method which is similar to texture matching but with a few additional tweaks which has given us better results compared to the other methods.

The images used in this project have been captured from the online webcams of Clemson university website which monitors the parking lot in between Long Hall and Sikes hall. One of the sample images captured is shown in Figure 1. The resolution of the image is 640x480.As is obvious from the figure the image quality is poor and the camera is positioned at an angle which causes vehicle occlusion and complicates the problem. Images captured from this webcam closely approximate the images captured from a security camera which makes our approach and analysis more realistic.

Figure-1

The rest of this report is organized as follows. Section-II gives a detailed description of the various methods involved, Section-III presents the various experimental results obtained and finally Section IV presents the conclusion after examining the various experimental results.

II. Method

A. Identifying Parking Subspaces and Decision Regions

The first step in any method is to uniquely identify the parking spaces from the image. This can be done automatically by taking the empty parking lot image which clearly shows the parking lines and running the hough transform on it to identify the parking regions. However we have manually accentuated these parking lines on the empty image because given that the camera position is fixed, the system would only be calibrated once and it is not necessary to do this step every time.

Next we need to determine the decision region of each parking space. One would think that the entire parking space can be used to make a decision but this is not the case. Because of the camera angle it so happens that a car parked in an adjacent parking space crosses the gridlines of that parking space and occupies a portion between the gridlines of it neighbor. This makes the task of classification all the more difficult. Fortunately in many cases we have identified a narrow strip between the parking lines which seems to be occupied by a vehicle actually parked in between those two parking lines. This region will henceforth be called the decision region.

These regions are indicated in Figure-2.

Figure-2

B. Background Subtraction

Background subtraction is a common method used in image processing. There are two ways to do background subtraction. namely absolute difference and thresholded difference. In the absolute difference method we compute the absolute difference between the two images pixel by pixel and store it in a third image. In the thresholded difference method the output image is binary. In this method we first compute the absolute difference and only set the output image pixel if the difference is above a certain threshold. By doing this we take into account subtle variations in the background such as lighting changes. In our context the background image is an image of an empty parking lot. We subtract an image with vehicles from the background image using method-2. The algorithm for the background subtraction method is as follows.

Step-1: Choose the best match background image for the given test image (between night time and daytime background images).

Step-2: For every pixel in the test image, compute the absolute difference with the chosen background image and if the difference lies within a threshold value, consider the pixel as un-occluded and mark it green.

Step-3: Look up the reference image, which has the decision region marked manually on it. The reference lines are drawn in such a way that they only get occluded when there is a car parked in that particular slot.

Step-4: The ratio of green pixels (occluded) to non-occluded one's in the decision area are computed and the one's above the threshold are considered as occupied by a car.

C. Color Histogram Analysis

In this approach we compute the color histogram for each decision region in the background image and also the test image. We then find the Euclidean distance between these two histograms. If the distance is above a certain threshold we identify the parking space corresponding to this decision region as empty, otherwise it is occupied. We have computed the histogram using RGB color space which is a 3-d histogram.

D. Texture Matching Approach

In this approach we basically take a small patch from the pavement region of the image and try to match it with each parking space region. The algorithm for this approach is as follows.

Step-1:Choose a Point on the Pavement region in the foreground image and Choose a 11x11 size pixel patch around it. Find the absolute difference of all the pixels in the parking region with the 11x11 Window and replace the center pixel of the window with the sum of absolute differences.

Step-2:Repeat Step-1 for background image.

Step-3:Find the difference between the foreground and background SAD images.

Step-4:Perform erosions followed by dilations on the image obtained in step-3 twice to remove possible noise that may lead to false classification.

Step-5:Classify the Pixels that are more than the threshold value as occluded(fall under the car occupied region).

Step-6:Look up the reference image which has the parking lot lines marked out in RED color and the rest in black. Perform connected components on the image to assign a unique label to each parking slot.

Step-7:Compute the ratio of occluded pixels to non-occluded one's and if the ratio exceeds threshold value, classify the slots as occupied.

E. Other Techniques & Approaches Attempted

While the methods listed above have given us fairly good results there were some other approaches we tried that did not give desirable results. We used PCA to detect feature points in the background and foreground image. It turned out that if the pavement area had no irregularities in texture then very few feature points were detected in the empty parking slots as opposed to when some of the cars were parked. However sufficient number of car feature points detected did not fall in the decision region so that we could make a confident classification.

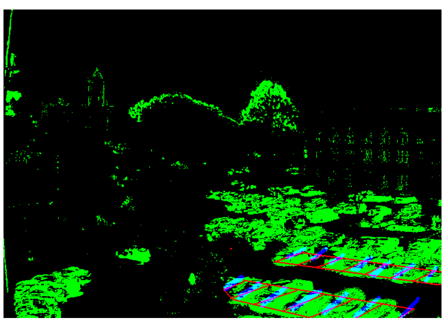
Automatic identification of parking spaces by the use of hough transform was attempted after doing a canny edge detection on the empty parking lot image. However it did not give satisfactory results. Also we tried to extract and segment the parking space stretch in the image but this needed a rotation and interpolation of the image. The interpolation step introduced some noise which was difficult to get rid off

III. Experimental Results

A. Background Subtraction

Background Image

Foreground/Test Image



After background subtraction
Parking lines- Red   Decision Regions-Blue

Final Classified Image

B. Modified Texture Matching

Test Image

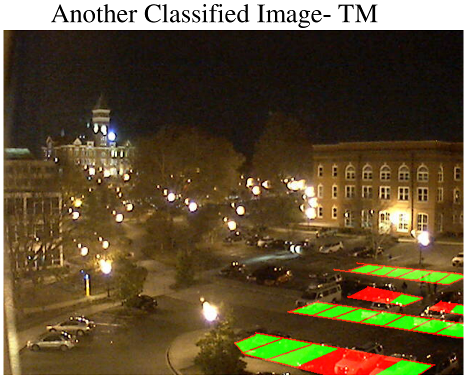
Background Image SAD with 11x11 patch from pavement

Test Image SAD with 11x11 patch

Resultant Image after subtraction Erosions & Dilations


Final Classified Image –Texture Matching(TM)


Another Classified Image- TM


Night-Classified Image-TM

C. *Color Histogram Analysis*


Background Image


Final Classified Image

The different algorithms have been run over a test set of 12 images which included 193 parking slots in all. The success rate (which is calculated as the percentage of total number of parking slots correctly classified) for each method is as shown below.

S.No	Method	Success Rate
1	Background Subtraction	63.21%
2	Color Histogram Analysis	59.06%
3	Modified Texture Matching	69.99%

IV. Conclusion

It is clear from the above findings that the color histogram analysis approach has performed poorly. One of the reasons for this is that when the color of the car closely matches that of the pavement this method fails. Many of the test set images had several cars which were close in color to the pavement. Also the modified texture matching method that we proposed has fared better than the other two presumably because of the window technique we use which kind of smoothens the effect of any noise. We also notice that the overall performance of any of the three methods does not exceed 70% which shows the difficulty of the problem. The decision region as we have shown in some of the images is very small and hence the decision statistic obtained from it is not very reliable. The camera angle plays an important role in the success of all these algorithms. Future work possible in this area is to automatically draw the decision regions given a set of training images. Also use of multiple cameras and motion can make the system more robust and reliable hence we will look to explore these options in the future.

REFERENCES

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