Vision-Based Automated Parking System

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Abstract — This paper describes an approach to overcome a situation of monitoring and managing a parking area using a vision based automated parking system. With the rapid increase of cars the need to find available parking space in the most efficient manner, to avoid traffic congestion in a parking area, is becoming a necessity in car park management. Current car park management is dependent on either human personnel keeping track of the available car park spaces or a sensor based system that monitors the availability of each car park space or the overall number of available car park spaces. In both situations, the information available was only the total number of car park spaces available and not the actual location available. In addition, the installation and maintenance cost of a sensor based system is dependent on the number of sensors used in a car park. This paper shows a vision based system that is able to detect and indicate the available parking spaces in a car park. The methods utilized to detect available car park spaces were based on coordinates to indicate the regions of interest and a car classifier. This paper shows that the initial work done here has an accuracy that ranges from 90% to 100% for a 4 space car park. The work done indicated that the application of a vision based car park management system would be able to detect and indicate the available car park spaces

Keywords*: object classification, coordinate method, car park, vision based, region of interest*

1. INTRODUCTION

Parking of cars in a parking area is becoming a difficult task as the number of cars increase while the number of parking spaces is finite. As a result, people would spend a certain amount of time looking for parking space and thus cause a situation where the traffic would be slowed down and cause congestion. The situation of looking for parking space and traffic congestion in parking areas is due to the fact that the information of available parking spaces is not readily available to the people looking for parking spaces. As such different approaches have been used to develop a car park management system such as wireless sensor network system [1] and a vision system [2].

2. BACKGROUND

In recent years, parking a car has become a serious problem in large cities with increasing rate of private vehicles [3]. With the emerging problem of parking cars, the ordinary parking system that does not provide any information about available parking areas would not be able to handle the problem effectively. The typical car park system would only be able to provide information of available parking locations or another system would require human resources to determine and provide information about the location of the available parking locations. These types of parking systems would only provide minimal information on the available parking locations and would not be able to handle the parking issues effectively. As such these systems would get the drivers to search the parking areas on their own and thus create a problem where there would be too many cars in the car park area.

In order to address the problem of parking effectively, sensors can be utilized to detect and provide information on the location of available parking areas. Among the implementation of sensor based parking system is a wireless sensor system [1]. This system would utilize sensors in each parking space would provide information on the status of each car park locations but the cost of installing sensors in each parking bay might prove to be prohibitive [4] as the cost of installing sensors would increase with the increase in the number of parking bays or areas.

A vision based was developed as an alternative to the ordinary system to detect available parking bay locations [2,3,4]. The availability of a vision based parking system would enable the system to be enhanced or scalable with only the utilization of a number of cameras. The method of detecting and locating available parking locations using a vision based system has proven to be robust and cost-effective where only a minimal number of cameras are needed [3,4].

The primary purpose of this paper would be to demonstrate the development of a low cost vision based parking system that can be used to determine the location of available parking locations and provide feedback on the available locations.

A. Feature Extraction

In this paper, Haar-like features were used in the detection of features detected in input videos to determine the presence of a car within a parking bay. Haar-like features use the changes in contrast values between adjacent groups of pixels rather than actual pixel values to determine common Haar features within an image [5]. The primary purpose of using Haar-like features would be for easier classification rather than raw pixel values as the Haar-like features are done in windows of 24x24 pixels [6]. The Haar-like features are typically used to determine the information of a region rather than the raw pixel values. From the utilization of a group of Haar-like features, the determination of features and computed values are used as input into a decision tree classifier for identification.

Some of the Haar-like features available for purpose of determining the information range from edge features, line features and center surround features [6]. The Haar-like features are illustrated as follows in Figure 1, Figure 2 and Figure 3.

Figure 1:Edge Features

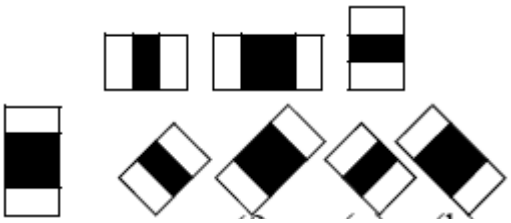

Figure 2:Line Features

Figure 3:Center Surround Features

B. Object Identification

The basis of object identification in this paper was based on the utilization of Haar-like features. The tool for object classification was developed in an open source library called Open Computer Vision Library (OpenCV) [5]. In order to train the object classification algorithm, two sets of images are required to train the classifier. One set of input images would be images that contain the object to be detected, which can be called as positive images, and another set of images that do not contain the object, that are called negative images. In the training of the classifier, the location of the object within the positive image including the height and width of the object need to be specified. In another application of the Haar-like features for training a classifier, various facial images, that included race, gender, age and lighting, were used in a classifier to train in the identification of a face [5] even if the face was tilted slightly.

3. RESULTS AND DISCUSSION

In the development of a car park management system to detect available parking space or bays, one factor needs to be taken into account which is the cost of implementation. Systems that determine the availability of car park spaces require sensors to determine the status of the parking spaces would incur cost in obtaining sensors, preparing and maintaining the infrastructure of the parking system [1,4]. The work described in this paper was a vision based car park management system that utilizes a web camera. The car park system developed was based on object classification and coordinate method to determine the status of car parking spaces.

The object classification for the car park system used was haartraining that was available in OpenCV. The object classifier is used to detect the presence of a target object within an input image. The object classifier is trained with both positive and negative images. The positive images used in training the classifier were images with cars from all types and angles. Samples of positive input images can be seen in Figure 4. The negative images used in the classifier training were images that did not contain any cars in the image.

Figure 4: Positive Input Images

The coordinates of each car park lot is specified by the use of the "Object Maker" tool that is obtained from OpenCV. The coordinates of each car park lot is used as inputs into a function to specify the regions of interest to detect the presence of a car in the region.

The results from testing the car classifier indicated that the object or car classifier is able to detect cars accurately 271 times out of 300 attempts that gave 90.33% accuracy and false or wrong detection rate of 9.66%. Figure 5 shows the testing of the car classifier.

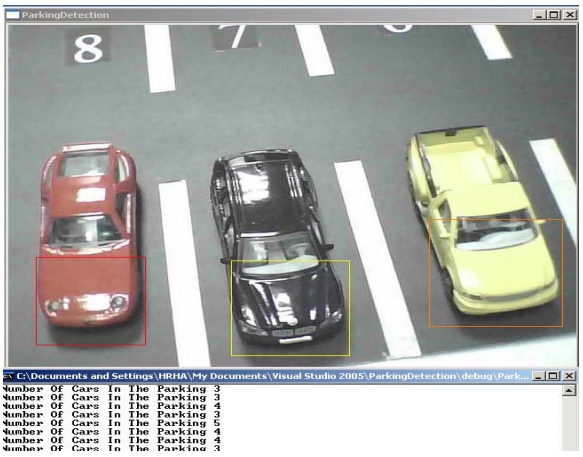

Figure 5 : Car Classifier Testing

The results from the combination of both the car classifier and coordinate methods, can be seen in Table 1. The testing was done using model cars and a sample of 4 parking spaces.

Total readings	1 car		2 cars		3 cars	
	Correct	False	Correct	False	Correct	False
30	30	0	28	2	27	3
	100 %	0	93.3 %	6.7 %	90 %	10 %

Table 1: Testing Results

From Table 1, the accuracy of the vision based parking system was found to be 100%, 93.3% and 90% when detecting 1, 2 and 3 cars respectively. The results indicate that as the number of cars being detected, the accuracy of detection reduces. The drop of accuracy was due to the type of camera used which in this project was a web camera. The web camera used in this paper had limited resolution and inaccurate lighting correction. The initial parking system output can be seen in Figure 6.

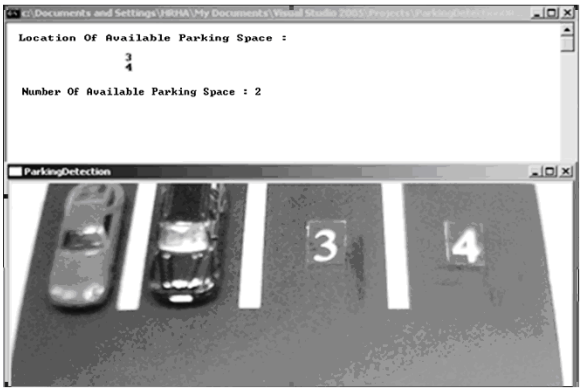

Figure 6: Initial Output

The final output of the vision based automated parking system can be seen in Figure 7.

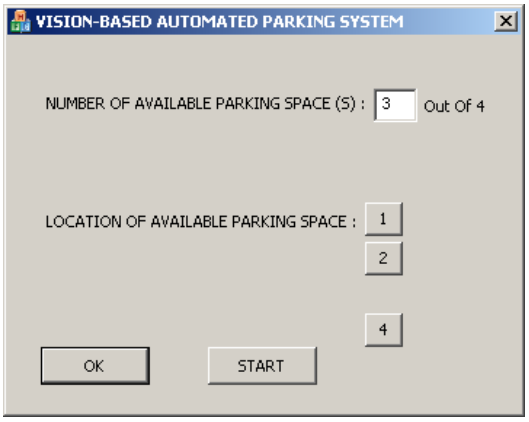

Figure 7: Final Output

4. CONCLUSION

The results obtained from the testing of the vision based car park system on model cars and car parks, it indicates that the probability of the utilization of a camera or vision based system to monitor car parks is feasible. This is seen in the results that indicate the accuracy in determining the presence of a car in a parking bay or the information that can be provided on the location of the available parking bays. The development of the vision based car park system shows the feasibility of utilizing simple cameras such as web cameras to monitor car parks. However, the utilization of such cameras has indicated some weaknesses in terms of the accuracy of the detection due to the limitations of the camera.

In order to overcome some of the weakness that was observed in the development of this vision based system, improvements can be made in the type of camera used where the web cameras can be tied in together with CCTV cameras. In addition, the coordinate method used in this paper in selecting the specific parking locations has limited the usage by making the each parking bay location fixed and thus limits the camera to be at a fixed location. As such, the usage of character recognition can be used to determine exact parking bay that is available and thus frees up the camera to be able to change its position and be able to pan and tilt to have a larger view of the car park area and thus use less cameras. In order to have greater ability in detecting the presence of a car within the region of interest, the object or car classifier would have to be trained with a larger set of positive and negative images.

5. REFERENCES

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