Parking Slot Detection Using GLCM and Similarity Measure

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Abstract. Increasing the number of vehicles, especially cars, raises some quite complicated problems. One of them is parking availability. Searching for empty parking slots is often be problematic related to time efficiency issues. In this paper, we proposed the detection of parking slots using GLCM and similarity measure. There are four main step that using in this paper. The first step is getROI, then feature extraction using GLCM method. For the classification step, similarity measure with Euclidean distance is used and the last step we calculate the accuracy. Detection of parking slots using gray level co-occurrence matrices and similarity measure is pretty good, marked by an average accuracy rate that is above 95% in all three datasets with different weather.

1. Introduction
Increasing the number of vehicles, especially cars, raises some quite complicated problems. One of them is parking availability. Searching for empty parking slots is often be problematic related to time efficiency issues [1]. Therefore we need a system that can detect the availability of empty parking slots. The parking lot is usually equipped with a CCTV camera so that it can be easier to find the information whether there is an empty slot or not. The results of CCTV camera images can be processed using the principle of digital image processing. There are several research that already study about this problem. Xiangwu Ding et.al. proposed vehicle and parking space detection using YOLO network model that using real time environment to detect an object [2]. Lei Li et.al. proposed slot parking detection using around view monitor system that show the good result by reduce the missing detection [3]. In this paper proposed the detection of parking slots using GLCM and similarity measure.

2. Research Method
There are five main step in this research, such as input image, getROI, feature extraction, similarity measure, and performance measure. Flow diagram of this research shown in the Figure 1.

![Flow diagram parking slot detection system](image_url)

**Figure 1.** Flow diagram parking slot detection system
2.1. Input Image
Input image used in this study is Pontifical Catholic University of Parana (PUCPR) image dataset that consists of 3 sub data, each of them taken in different weather, namely sunny, cloudy, and rainy [4]. The image size 720 x 1280 pixels in RGB colour space. Furthermore, the RGB image will be converted into a grayscale image and the position is determined for each slot with different positions and sizes.

2.2. getROI
The getROI process aims to retrieve the location of a parking slot on a parking lot. The ROI or Region of Interest is a certain part of the image that will be processed later on feature extraction using GLCM. So not the whole image will be processed but only certain part of the image. The example of ROI shown in the Figure 2.

![Figure 2. Example of ROI](image)

2.3. Feature Extraction
In digital image processing, there are several features that can be used for the analysis process including colour, shape, and texture features. The features used in this study are the texture features obtained using the co-occurrence matrix. The texture feature is chosen based on the characteristics of the object under study by assuming that the texture in an empty parking slot will be different from the texture of the filled parking slot. There are eight characteristics of GLCM that used in this paper, such as Mean, Variance, Contrast, Dissimilarity, Homogeneity, Correlation, Entropy, and Energy [5].

2.4. Similarity Measure
The combination of features obtained from the GLCM method in each slot is then compared with training data by measuring the distance between them. Distance measurement used the Euclidean distance method [6], where the smaller the distance value, the more similar the data being compared. Euclidean distance is denoted in the Equation (1).

\[ Dist(x, y) = \sqrt{\sum_{i=1}^{n}(x_i - y_i)^2} \]  

where \(x\) and \(y\) are the data that compared and \(n\) is the total of data.

Training data is divided into two, namely positive training data and negative training data. The training data will then be extracted the same features as the testing data in the form of texture features. Data testing is ROI or a parking slot in the image. Each slot will measure its Euclidean distance with positive training data and negative training data. The classification process uses the concept of similarity measure, where each slot will be classified into two classes, namely positive slots and negative slots.
Class determination is based on comparing Euclidean distance values between testing data and training data. If the slots used as testing data have a smaller Euclidean distance when compared to the positive training data, then those slots are categorized as positive slots or filled slots. Otherwise, if the Euclidean value of the slot is smaller when compared to negative training data, then the slot is assumed to be a negative slot or an empty slot.

2.5. Performance Measure
Performance evaluation of the proposed method for detecting parking slots is done by comparing the predicted class with the actual class (ground truth) of the image. Evaluation is done by calculating the accuracy value. Accuracy is defined as the ratio of the number of parking slots that are detected correctly to the number of all available parking slots. Calculation of accuracy can be done by Equations (2).

$$Accuracy = \frac{(TP + TN)}{(TP + TN + FP + FN)}$$ (2)

The calculation is done based on the confusion matrix shown in the Figure 3.

| Actual Class | True | False |
|--------------|------|-------|
| Predicted Class | True Positive (TP) | False Positive (FP) |
| False | False Negative (FN) | True Negative (TN) |

Figure 3. Confusion Matrix

3. Result and Discussion
The dataset consists of three sub datasets taken at different times, namely sunny, cloudy, and rainy. Performance evaluation of the results of parking slot detection is based on accuracy calculations. The higher the accuracy value, the more efficient the system performance is in detecting parking slots.

System analysis is divided into three parts based on sub datasets.

a. Sunny
The testing results using the dataset in sunny weather are done by taking 20 sample images from the dataset. Figure 4 is the performance result based on accuracy using sunny images. Based on those graphs it can be seen that the accuracy of detecting parking slots is quite good, where the average accuracy value is 99.19%. All of the testing images have an accuracy above 95%.

b. Cloudy
Performance testing result using a dataset in cloudy weather is quite satisfactory based on the accuracy values obtained. The following graph is the recapitulation results of the testing process using a dataset in cloudy weather, where the average value of accuracy is 99.55%. All of the testing images have an accuracy above 95%. Figure 5 is an illustration of the distribution of accuracy values in the cloudy weather dataset.
c. Rainy
Performance testing result using a dataset in rainy weather is quite satisfactory based on the accuracy values obtained. Figure 6 illustrates the distribution of accuracy values in the rain weather dataset. Based on the graph, it can be seen that the accuracy of detecting parking slots is quite good, where the average accuracy value is 99.35%. All of the testing images have an accuracy above 95%.

Figure 4. Performance result of sunny weather

Figure 5. Performance result of cloudy weather

Figure 6. Performance result of rainy weather
Parking location detection results are shown in the following figure. Slots detected as positive slots are marked with a blue square, while slots that are detected as negative slots are marked with a red square.

**Figure 7.** Result image using sample image 1

**Figure 8.** Result image using sample image 2

Even though the accuracy is pretty good, there are still some slots that have been detected incorrectly. This is influenced by the colour of the object that almost resembles the background so that the object fails to be detected and classified as a negative slot. In addition, parking slots that should be categorized as negative slots or empty slots are detected as positive slots because there are objects that are detected even if they are not cars, such as human, pole, and so on.

4. Conclusion

Detection of parking slots using gray level co-occurrence matrices and similarity measure is pretty good, marked by an average accuracy rate that is above 95% in all three datasets with different weather. The detection of parking slots can still be developed by more efficient object detection so that it can distinguish objects in the slot in the form of cars or other objects.
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