Effect of image partitioning on content-based image retrieval using colour and texture

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Abstract. The current application of content-based image retrieval (CBIR) was urgently needed to process image retrieval in large image databases. Previous research had succeeded in combining feature extraction methods using texture and colour. Combining the two methods of Gray Level Co-Occurrence matrix with Colour moment produces a higher level of precision than that produced when method is applied individually. This research examined more deeply about the effect of image partitioning using the grid partitioning method. The results of precision and recall on the CBIR method would be compared with no partitions, two partitions and three image partitions. The results obtained indicated that the addition of image partitions did not affect the precision value. Thus, it can be concluded that increasing the image partition increases the recall value of the overall CBIR performance.

1. Introduction
The development of multimedia technology and the internet causes the number of digital images to increase rapidly. The security sector, hospital, education, tourism, and also trade use a large collection of digital images. Image retrieval techniques with text based image retrieval start are less relevant to be applied. Digital image retrieval techniques using content-based image retrieval are increasingly being developed to increasingly obtain maximum results.

Several studies have combined textural and color feature extraction methods, one of which was research [1][2][3], which used the Gray Level Co-Occurrence Matrix method and the Color Moment method. In this study, Wang Dataset was used, consisting of ten image classes and each class contained one hundred digital images. This study used pre-processing by using the Grid Partitioning method. Grid Partitioning Method divides digital images into three parts, namely the top, middle and bottom. The results showed that by combining the texture and color feature extraction method and the Grid Partitioning method, the average value of precision reached 59% and the recall value reached 11%.

Research [4] used the Block Truncation Algorithm and Grid Partitioning Method, in these study two methods were applied namely Block Truncation, an algorithm to map the color features of an image, which would then be extracted by the Color Moment method. The second one was the Grid Partitioning technique, which was used to split the image into three parts, namely the top, middle and
bottom. The dataset used in this study was Wang Dataset. The use of the grid has an advantage, namely narrowing the feature extraction area. From the results of the research, the performance of rectangular partition partitioning grid was better than the Region Segmentation method.

Based on the exposure of the two studies above, it is very important to know the effect of the number of test images and training images in the CBIR process. This study compared the effect of partitioning two images and three images, which were then measured by using precision and recall.

2. Literature Review

2.1. Content Based Image Retrieval

According to reference [5] the CBIR framework consists of five components namely the user interface, query processor, index structure, similarity measures, and image output. Each component is a separate module that is designed to achieve maximum performance in the process of retrieving.

- **User Interface**
- **Image Query**
- **Query Specification**
- **Visualization**
- **Similar Images**
- **Query Pattern**
- **Feature Vector**
- **Extraction**
- **Feature Vectors**
- **Images**
- **Image Database**
- **Ranking**
- **Similarity Computation**

**Figure 1.** CBIR Framework purpose by Su, Li and Zang.

2.2. Grid Partitioning

Grid Partitioning is a simple method for segmenting by zone in this case is to split the image into several image zones by using a grid (box) on the image [6]. In this study, the image was split into 3 (three) zones, namely the top, middle and bottom zones, as displayed in Figure 2.

**Figure 2.** Grid Partitioning Method.
2.3. Color Moments
Color Moments is a method used to distinguish images based on color features. The Color Moments method uses three main moments of the colors of an image, namely the mean (E), standard deviation, and skewness (μ), so this method produces 3 values for each part of the color that is owned [7] to get the mean value (E), standard deviation (StD), and skewness (μ) using equations 1, 2, and 3.

\[
\text{Mean} = \frac{1}{N} \sum_{j=1}^{N} P_{ij}
\]

\[
\text{Standard Deviation} = \sqrt{\left(\frac{1}{N} \sum_{j=1}^{N} (P_{ij} - E)\right)^2}
\]

\[
\text{Skewness} = \frac{\sum_{i=1}^{N}(P_{ij} - E)^3}{\sigma_i^3}
\]

N is the total number of pixels, i is the index on the color component, j is the pixel order, while P_{ij} explains the i-th value of color in the j-th pixel image.

2.4. Grey Level Co-Occurrence Matrix
For extraction of texture features using the Co-Occurrence Matrix method using gray level in the image. Co-Occurrence Matrix is a way to extract features from textures with second-order statistics [8]. There are 14 features in texture [9], in this study we used 5 features, namely Homogeneity, Energy, Contrast, Entropy, and Correlation, seen in equations 4, 5, 6, 7, and 8.

\[
\text{Homogeneity} = \sum_{i,j} \frac{P(i,j)}{1 + |i - j|}
\]

\[
\text{Energy} = \sum_{i,j} (P(i,j))^2
\]

\[
\text{Contrast} = \sum_{i,j} |i - j|^2 P(i,j)
\]

\[
\text{Entropy} = \sum_{i,j} P_{i,j}(-\ln P_{i,j})
\]
Those equations show that \( i \) is the vertical gray level, \( j \) is the horizontal gray level, \( \sigma \) is the correlation. The function of calculating Homogeneity is to measure the uniformity of local gray level variations in the image. The function of calculating Energy is to measure the concentration of a couple's gray level on the co-occurrence matrix. The function of calculating the contrast is to measure the difference in local strength in the image. The function of calculating Entropy is to measure the randomness of the distribution of local differences in images. The function of calculating Correlation is to measure the gray degree of linear dependence around the pixel [10].

2.5. Performance Measures

Confusion Matrix performance evaluation has four terms to represent the results of the classification consisting of TP (True Positive), FP (False Positive), TN (True Negative), FN (False Negative). This study used Wang Dataset which consisted of 10 classes as test data, the image sample is shown in Figure 3.1. TP is the number of true images found that correspond to the class. FP is the image found but not included in the class sought. TN is the amount of data which is not found and detected incorrectly, and not in accordance with the class sought. Meanwhile FN is the amount of correct data not found but according to the class sought [11]. The Confusion Matrix table for binary classification is represented in Table 1 below.

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

Based on the classification results, precision, recall, and accuracy are calculated. Precision is a value that represents the number of positive categorized data that is correctly classified and divided by the total data classified positively using equation 9.

\[
Precision = \frac{TP}{(TP + FP)}
\]  

(9)

Recall is a value that describes what percentage of positive category data is correctly classified by the system using equation 10.

\[
Recall = \frac{TP}{(TP + FN)}
\]  

(10)
3. Purpose Method
Data set is from the Wang data set that can be searched from the web site [12]. It consists of ten categories, such as Africa, buildings, flowers, etc. Database samples can be seen in Figure 4. The study was carried out by storing data in stages based on 10 image classes with 80 images each class, so that the total number of training images was 800 images in the database, as for the image query or test used 20 images in each image class.

The training phase began by dividing the image into several partitions, and then the feature extraction process was carried out by combining the Colour Moment method and the Gray Level Co-Occurrence Matrix. The process of combining these features beforehand was by normalizing the features. Then the distance similarity process was calculated using Manhattan Distance.

4. Result
The results of testing with no partitions, two partitions and three partitions are shown in table 1. The recall value or the completeness of the successfully retrieved image showed a better value as the number of image partitions increased. Meanwhile, the precision value was not influenced by the
number of image partitions. This can be seen in the table, the partition value increased when there were two image partitions, while it decreased when there were three image partitions.

Table 2. Research Result.

| Class     | No Partition | Two Partition | Three Partition |
|-----------|--------------|---------------|-----------------|
|           | Precision    | Recall        | Precision       | Recall        | Precision       | Recall        |
| Africa    | 45%          | 1%            | 53%            | 6%            | 41%            | 6%            |
| Beach     | 15%          | 0%            | 39%            | 1%            | 33%            | 3%            |
| Building  | 8%           | 0%            | 40%            | 2%            | 43%            | 5%            |
| Bus       | 33%          | 1%            | 81%            | 4%            | 79%            | 12%           |
| Dinosaurs | 94%          | 7%            | 99%            | 16%           | 95%            | 38%           |
| Elephant  | 38%          | 1%            | 61%            | 4%            | 51%            | 11%           |
| Flowers   | 69%          | 1%            | 78%            | 7%            | 74%            | 11%           |
| Horse     | 78%          | 3%            | 91%            | 8%            | 84%            | 16%           |
| Mountain  | 10%          | 0%            | 20%            | 0%            | 32%            | 2%            |
| Food      | 15%          | 0%            | 54%            | 3%            | 58%            | 7%            |
| Average   | 41%          | 1%            | 61%            | 5%            | 59%            | 11%           |

5. Conclusion

This research has an impact on future research regarding the effect of selecting the number of image partitions. The higher the number of image partitions, the higher the recall values are. However, the number of image partitions does not affect the level of precision of the CBIR system. Suggestions for further research is to use artificial intelligence-based methods to find out the feature extraction method that matches the class of image data sets.

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