CHAPTER 5

Image Retrieval based on the combination of color Histogram and Color Moment

5.1 Introduction

In this chapter, a novel technique for Content based image retrieval (CBIR) system that employs color histogram and color moment as color features is presented.

Nowadays the application of World Wide Web and the internet is increasing exponentially and the collections of images accessible by the users are also growing in number. As huge amount of Image databases are added every minute, hence there is a need for effective and efficient method for searching, browsing, retrieving and interacting with these image collections.

Content-based image retrieval (CBIR) (Dutta et al., 2008) has become a prominent research topic because of the proliferation of video and image data in digital form. The increased bandwidth availability to access the internet in the near future will allow the users to search for and browse through video and image databases located at remote sites. Therefore, fast retrieval of images from large databases is an important problem that needs to be addressed. High retrieval efficiency and less computational complexity are the desired characteristics of CBIR systems. In content-based image retrieval (CBIR), images would be indexed by their visual content such as color, texture, shape etc. and the desired images are retrieved from a large collection, on the basis of features that can be automatically extracted from the images themselves (Gudivada and Raghavan, 1995). Considerable research work has been done to extract these low level image features (Manjunath and Ma, 1996; Rui et al., 1998), evaluate distance metrics, and look for efficient searching schemes (Swets and Weng, 1999; Zhang and Zhong, 1995). Basically, most CBIR systems work in the same way: A feature vector is extracted from each image in the database and the set of all feature vectors is organized as a database index. At query time, a feature vector is extracted from the query image and it is matched against the feature vectors in the index. The crucial difference between the various systems lies in the features that they extract and in the algorithms that are used to compare feature vectors.
In the whole retrieval process, feature extraction is crucial (Yu-guang, 2007), it is closely related to all aspects of the future. Thus the research of content-based image feature extraction has been the focus of people's attention. The most commonly used features in image retrieval are the color, texture, shape and space. Among all the visual features, color is perhaps the most distinguishing one in many applications. It may be represented by a color histogram, color moments, color correlograms etc. However, color histograms and color moments have their own advantages and disadvantages (Xue and Wanjun, 2009). In recent years, many scholars began to study high-level semantic features of images. In practice, a feature or a combination of several features is often used to search for images. If the feature most suitable for retrieval of a particular image is used in flexible weighted combination with other features, then a higher level of precision and recall can be achieved (Kodituwakku and Selvarajah, 2004; Choras et al., 2007; Liu et al.; 2007; Xue and Wanjun, 2009; Reddy and Prasad, 2011a, Sandhu and Kochhar, 2012).

Kodituwakku and Selvarajah, (2004) have carried out an experimental comparison of a number of different color descriptors for content based image retrieval. The authors have used color histograms, color moments (based on whole image) and color coherent vectors (CCV) for retrieval. The authors reported that the combination of color descriptors produced better retrieval rate compared to the individual color descriptors. Xue and Wanjun, (2009) has proposed a method in which the features of color histograms and color moments (based on whole image) are integrated to represent the color feature. They reported that the precision and recall had been improved and the index sorting was better.

The color histogram has the advantages of rotation and translation invariance and it has the disadvantages of lack of spatial information. Color moments have also been successfully used in content based image retrieval system. In order to improve the retrieval accuracy, Xue and Wanjun, (2009) have studied the effect of the combination of color histogram and color moment as global features and the results have shown improvement in the retrieval process. However, in this chapter, an attempt has been made to study the effect of combination of the color histogram and color moment, by dividing the image into 3 equal parts so that the local features are also taken into
consideration. To improve the retrieval efficiency, color histogram and color moment (based on local regions) feature vectors will be combined for searching images.

For the color moment, to exhibit the local features and to improve the discriminating power of color indexing techniques, an image is divided horizontally into three equal non-overlapping regions and spatial information is encoded in the color index from these regions. The three moments (mean, variance and skewness) are extracted from each region (in this case three regions), for all the color channels. For a HSV color space, 27 floating point numbers are used for indexing. The HSV (16, 4, 4) quantization scheme has been adopted for color histogram and an image is represented by a vector of 256-dimension. Thus, the advantages of global features of histogram and local features of color moment have been utilized for better efficiency. Weights are assigned to each feature respectively and calculated the similarity with combined features of color histogram and color moment using Histogram intersection distance and Euclidean distance as similarity measures. Experimental results have shown that the proposed method has higher retrieval accuracy in terms of precision than other conventional methods combining color histogram and color moments based on global features approach.

5.2 Color feature based on color histogram

5.2.1 Color space

The HSV color space is widely used in the field of computer vision. In this chapter, the HSV color space is used and the conversion from the RGB to HSV is given in section 4.2.1.

5.2.2 Feature extraction

A color histogram represents the distribution of colors in an image, where each histogram bin corresponds to a color in the quantized color space. Color histograms are a set of bins where each bin represents a particular color of the color space being used. The number of bins depends on the number of colors there in the image. A color histogram for a given image is defined as a vector:

\[ H = \{H[0], H[1], H[2], H[3], \ldots, H[i], \ldots, H[n]\} \]  \hspace{1cm} (5.1)

Where \( i \) represents the color bin in the color histogram and \( H[i] \) represents the number of pixels of color \( i \) in the image, and \( n \) is the total number of bins used in the color
histogram. Typically, each pixel in an image will be assigned to a bin of a color histogram of that image, and so for the color histogram of an image, the value of each bin is the number of pixels that has the same corresponding color. In order to compare images of different sizes, color histograms should be normalized. The normalized color histogram $H'$ is defined as:

$$H' = \{H'[0], H'[1], H'[2], H'[3], \ldots, H'[i], \ldots, H'[n]\}$$

where $H'[i] = \frac{H[i]}{p}$, $p$ is the total number of pixels of the image.

However, color histogram has its own drawbacks. If two images have exactly the same color proportion but the colors are scattered differently, then we can't retrieve correct images. There are two unrelated images in Figure 5.1, but they have the same color histogram.

![Figure 5.1: Example of two different images having same histogram](image)

### 5.2.3 Histogram similarity measure

We extract the color histogram of the image using the HSV(16,4,4) quantization scheme and we will get a 256-dimensional color feature vector as under:

$$H_Q = (h_0, h_1, h_2, \ldots, h_{255})$$

Histogram intersection method is used to measure the distance $S_1$ between the query image $Q$ and the image $P$ in the image database.

$$S_1 = 1 - \sum_{i=0}^{255} \min(H_Q[i], H_P[i])$$

### 5.3 Color feature based on color moment

#### 5.3.1 Color space

For color moment also, the HSV color space is used and the conversion from RGB to HSV is given in section 4.2.1.

#### 5.3.2 Feature extraction

If the color distribution of an image is interpreted as a probability distribution, then the
color distribution can be characterized by its moments (Stricker and Orango, 1995). If the value of the \(i^{th}\) color channel at the \(j^{th}\) image pixel is \(I_{ij}\) and the number of pixels is \(N\), then the index entries related to this color channel and the region ‘\(r\)’ are:

\[
E_{r,i} = \frac{1}{N} \sum_{j=1}^{N} I_{ij}
\]

\[
\sigma_{r,i} = \left( \frac{1}{N} \sum_{j=1}^{N} (I_{ij} - E_{r,i})^2 \right)^{\frac{1}{2}}
\]

\[
s_{r,i} = \left( \frac{1}{N} \sum_{j=1}^{N} (I_{ij} - E_{r,i})^3 \right)^{\frac{1}{3}}
\]

The entries \(E_{r,i}\) (1 <= \(i\) <= 3) are the average color of the region \(r\). The entries \(\sigma_{r,i}\) and \(s_{r,i}\) are the variance and the skewness of each color channel in this region ‘\(r\)’.

The index entry for one image consists of:

Index size = number of regions x number of color channels x 3 floating point numbers.

In this chapter, the image is divided horizontally into three equal non overlapping regions and 27 floating point numbers are stored per image.

So, the feature vector \(f\) of length 27 is given by:

\[
f = \{E_{1r}, \sigma_{1r}, s_{1r}, E_{2r}, \sigma_{2r}, s_{2r}, E_{3r}, \sigma_{3r}, s_{3r}, \ldots, E_{br}, \sigma_{br}, s_{br}\}
\]

(1 <= \(r,i\) <= 3), \(r\) represents the region and \(i\) represents the color channel.

### 5.3.3 Similarity distance

If \(f^Q = \{E_{1r}, \sigma_{1r}, s_{1r}, E_{2r}, \sigma_{2r}, s_{2r}, \ldots, E_{br}, \sigma_{br}, s_{br}\}\) denote color moment feature vector of query image Q and \(f^P = \{E_{1r}, s_{1r}, E_{2r}, \sigma_{2r}, s_{2r}, \ldots, E_{br}, \sigma_{br}, s_{br}\}\) denote color moment feature vector of database image P, then distance between Q and P using Euclidean distance is:

\[
S_2 = \sqrt{\sum_{r=1}^{27} (f^Q(i) - f^P(i))^2}
\]
5.4 Proposed algorithms

5.4.1 Image retrieval algorithm based on color histogram

The following algorithm is proposed to determine the similarity between query image and an image in the image database:

Step 1. Input query image Q

Step 2. Convert RGB color space image into HSV color space.

Step 3. Color quantization is carried using color histogram by assigning 16 levels to hue, 4 to saturation and 4 to value to give a quantized HSV space with $16 \times 4 \times 4 = 256$ histogram bins.

Step 4. Histogram is normalized by dividing with the total number of pixels.

Step 5. Repeat step 2 to step 4 on an image $P_j$ in the database.

Step 6. Calculate the distance between $Q$ and image $P_j$ in the database using (5.3) and store it in an array $d_j$.

Step 7. Increment $j$, repeat step 5 and 6 for all the images in the database.

Step 8. The array $d_j$ is sorted in ascending order. The image corresponding to the first element of $d_j$ is the most similar image compared with the query image $Q$. The first 10 top most similar images are then displayed.

5.4.2 Image retrieval algorithm based on color moment

The following algorithm is proposed to determine the similarity between query image and an image in the image database:

Step 1. Input query image Q

Step 2. Convert RGB color space image into HSV color space.

Step 3. Partition the image into three equal non-overlapping horizontal regions.

Step 4. Calculate the moments $F_{rl,i}, \rho_{rl,i}$ and $t_{rl,i}$ for each color channel of each region to get 27 numbers from three regions of the query image $Q$.

Step 5. Apply Step 2 to Step 4 to the image $P_j$ in the database, to calculate the moments $E_{rl,i}, \sigma_{rl,i}$ and $s_{rl,i}$ from the regions of $P_j$ to get 27 numbers.

Step 6. Calculate the distance between $Q$ and $P_j$ using (5.8) and store it in an array $d_j$.

Step 7. Increment $j$, repeat step 5 and 6 for all the images in the data base.
Step 8. The array $d_j$ is sorted in ascending order. The image corresponding to the first element of $d_j$ is the most similar image compared with the query image $Q$. The first 10 top most similar images are then displayed.

The color moment is beneficial due to the fact that moments are invariant of geometric transformation and as we are taking average combined moment of each and every pixel of an image, this feature is more precise than color histogram.

Here, the problem faced in histogram is resolved but the approach of color moment is restricted to applications of images where the color is predefined like the color of sky is blue.

5.4.3 Image retrieval algorithm based on the combination of color histogram and color moment

step 1. Input Query Image $I$

Step2. Convert RGB color space to HSV color space

Step3. (i) Calculate histogram feature vector of $I$ using (5.2)
    (ii) Calculate color moment feature vector of $I$ using (5.7)

Step4. Apply steps 2 to 3 to the image $Q_j$ in the database

Step5. (i) Calculate distance ($S_1$) between query image $I$ and database image $Q_j$ using histogram intersection
    (ii) Calculate distance ($S_2$) between query image $I$ and database image $Q_j$ using Euclidean distance (for color moment)

Step6. Calculate total distance $d_j$ between $I$ and $Q_j$

$$d_j = w_1*S_1 + w_2*S_2$$

Step7. Increment $j$, repeat step 4 to 6 for all the images in the database.

Step8. The array $d_j$ is sorted in ascending order. The image corresponding to the first element of $d_j$ is the most similar image compared with the query image $I$. The first 10 topmost similar images are then displayed.

We take $w_1+w_2=1$, where $w_1=w_2=0.5$
5.5 Experimental Results and Discussions

For the evaluation of the proposed method, the algorithms presented in section 5.4 have been implemented and tested using Matlab 6.5 and the standard WANG database. To calculate the efficiency for precision, the equations 3.59, 3.61 and 3.62 of section 3.4 have been used.

The experiment was carried out with the number of retrieved images set as 10 to compute the average precision P of each query image. In order to assess the discriminating power of the techniques proposed in this paper, experiments were carried out based on global Color histogram (CH), color moment - based on whole image (CMW), color moment - image divided into 3 equal non overlapping horizontal regions (CMR), Color histogram + color moment - based on whole image (CH+CMW), and Color histogram + color moment - image divided into 3 equal non overlapping horizontal regions (CH+CMR).

A typical test result is shown in Figure 5.2. From Table 5.1, it is seen that the average precision(%) based on (CH+CMR) is 58.1 and the average precision(%) based on (CH+CMW) is 56.8. Thus the proposed method demonstrates clearly that the encoding of spatial information in the color index from different regions of the image significantly increases the discriminating power compared to the Color histogram + color moment (based on whole image) indexing techniques in which color moments are extracted from the entire image.

It is also seen that the value of the average precisions (%) based on single features i.e. only Color histogram features or only Color moments are less than the average precisions (%) of combined features of Color histogram and color moments as shown in Table 5.2 and Table 5.3. This also shows that there is increase in retrieval efficiency when both Color histogram and color moment are combined for CBIR.
Table 5.1. Precision of retrieval for top 10 images.

<table>
<thead>
<tr>
<th>Class</th>
<th>CH</th>
<th>CMW</th>
<th>CMR</th>
<th>CH +CMW</th>
<th>CH + CMR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa</td>
<td>0.68</td>
<td>0.48</td>
<td>0.56</td>
<td>0.58</td>
<td>0.61</td>
</tr>
<tr>
<td>Beach</td>
<td>0.29</td>
<td>0.51</td>
<td>0.45</td>
<td>0.48</td>
<td>0.45</td>
</tr>
<tr>
<td>Building</td>
<td>0.29</td>
<td>0.23</td>
<td>0.26</td>
<td>0.27</td>
<td>0.29</td>
</tr>
<tr>
<td>Buses</td>
<td>0.73</td>
<td>0.65</td>
<td>0.63</td>
<td>0.72</td>
<td>0.65</td>
</tr>
<tr>
<td>Dinosaur</td>
<td>0.99</td>
<td>0.63</td>
<td>0.77</td>
<td>0.87</td>
<td>0.89</td>
</tr>
<tr>
<td>Elephant</td>
<td>0.55</td>
<td>0.41</td>
<td>0.29</td>
<td>0.46</td>
<td>0.32</td>
</tr>
<tr>
<td>Flowers</td>
<td>0.52</td>
<td>0.37</td>
<td>0.55</td>
<td>0.41</td>
<td>0.60</td>
</tr>
<tr>
<td>Horses</td>
<td>0.49</td>
<td>0.72</td>
<td>0.86</td>
<td>0.70</td>
<td>0.84</td>
</tr>
<tr>
<td>Food</td>
<td>0.67</td>
<td>0.62</td>
<td>0.51</td>
<td>0.68</td>
<td>0.56</td>
</tr>
<tr>
<td>Mountain</td>
<td>0.28</td>
<td>0.51</td>
<td>0.54</td>
<td>0.51</td>
<td>0.60</td>
</tr>
<tr>
<td>Average</td>
<td>54.9</td>
<td>51.3</td>
<td>54.2</td>
<td>56.8</td>
<td>58.1</td>
</tr>
</tbody>
</table>

Color histogram(CH); Color moment - whole image (CMW); Color moment - image divided into 3 equal non overlapping horizontal regions (CMR); Color histogram + Color moment - whole image (CH+CMW); Color histogram + Color moment - image divided into 3 equal non overlapping horizontal regions (CH+CMR)

Table 5.2. Average retrieval using features Color histogram (CH); Color moment - whole image (CMW); Color histogram + Color moment - whole image (CH+CMW)

<table>
<thead>
<tr>
<th></th>
<th>CH</th>
<th>CMW</th>
<th>CH+CMW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Precision (%)</td>
<td>54.9</td>
<td>51.3</td>
<td>56.8</td>
</tr>
</tbody>
</table>

Table 5.3. Color histogram (CH); Color moment - image divided into 3 equal non overlapping horizontal regions (CMR); Color histogram + Color moment - image divided into 3 equal non overlapping horizontal regions (CH+CMR)

<table>
<thead>
<tr>
<th></th>
<th>CH</th>
<th>CMR</th>
<th>CH+CMR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Precision (%)</td>
<td>54.9</td>
<td>54.2</td>
<td>58.1</td>
</tr>
</tbody>
</table>
Query image 1:

(a)

(b)

(c)
Figure 5.2: Different image retrieval results for the same query image: (a) query image (b) result based on Color histogram (c) result based on Color moment (whole image) (d) result based on Color moment (image divided into 3 equal non overlapping horizontal regions) (e) result based on Color histogram + Color moment (whole image) (f) result based on Color histogram + Color moment (image divided into 3 equal non overlapping horizontal regions).

5.6 Chapter summary

In this chapter, an efficient image retrieval method is proposed in which color histogram and color moment feature vectors are combined. For color moment, to improve the discriminating power of color indexing techniques, a minimal amount of spatial information is encoded in the index by extracting features from the regions of the image divided horizontally into three equal non overlapping regions. In this approach, from each region in the image, the first three moments of the color distribution are extracted from each color channel and store the 27 floating point numbers (or 3 regions, each region being represented by a vector of 9 floating point numbers) of the image in the index. For color histogram, the HSV (16, 4, 4) quantization scheme has been adopted and an image is represented by a vector of 256-dimension. The similarity with combined features of color histogram and color moment is calculated using Histogram intersection and Euclidean distance as similarity
measure. The experimental results demonstrate that the proposed method has higher retrieval accuracy in terms of precision than other conventional methods combining color histogram and color moment features based on global features approach. The experiment shows that there is considerable increase in retrieval efficiency when both color histogram and color moment features are combined.