An Efficient Similarity Measure for Color-Based Image Retrieval

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الخلاصة

تعد مقاييس التشابه عامل مهم في استرجاع الصور المعتمدة على المحتويات. يتناول هذا البحث ايجاد المقياس الاكثر كفاءة للتشابه من اربع مقاييس.اذ تشيرالبحوث المتعلقة بموضوع استرجاع الصور المعتمدة على المحتويات الى اهمية هذه المقاييس في تحسين كفاءة الاسترجاع. وهذه المقاييس هي مربع كاي، مسافة معدل التباين الموزونة، المسافة الاقليدية و مسافة الجيب تمام. اختيرت عينة من قاعدة الصور CALTECH مكونة من 50 صورة ملونة. تم تغيير الوان الصور الى فضاء الالوان HSV. استخرجت صفات الالوان وهذه الصفات هي عزوم الالوان. اوضحت النتائج العملية للعمل المقترح بان مقياس المسافة الاقليدية هو الاشد كفاءة لقياس استرجاع الصور المعتمدة على الالوان.

Abstract

Similarity measures are an important factor in the Content-Based Image Retrieval (CBIR). This paper finds the most efficient similarity measure from four image similarity measures. Related work on (CBIR) indicated that these measures have significantly improved the retrieval performance. These measures are the Chi-Squared, The Weighted Mean Variance distance (WMV), The Euclidean distance, and Cosine distance. A sample of 50 colored images is selected from CALTECH visual database. These images were transformed to (HSV) color space. Color features were extracted; these features are the color moments. Experimental results of the proposed work show that the Euclidean distance measure is the most efficient measure for color based image retrieval.

1- Introduction

Recently, a new application field is born via the amount of visual information. Content-Based Image Retrieval has become an active research area. The reason for this is the fact that world wide networking allows us to communicate, share, and learn information in the global manner. Digital library and multimedia databases are rapidly increasing. Therefore, efficient search algorithms need to be developed based on comparison operation and image indexing. Images would be indexed by their own visual contents, such as color, texture and shape so that,

researchers turned attention to content based on retrieval methods [1]. In this new application area, color has become the center and most extensively powerful tool in content-based image retrieval [2]. Each pixel in the color image is represented as a 3D color space, such as Red, Green and Blue (RGB) color space. This space is of three color component red, green and blue colors, also Hue, Saturation and Value (HSV). A number of color features extraction methods were exists. The color histogram is commonly used for color feature representation. Statistically it denotes the joint probability of the intensity of the three color channels. Another method is the color moment; they overcome the quantization effects as in color histogram [4].

2- Similarity Measures

Similarity measures could be termed as distance metric, which is the key component in (CBIR). It is important to explore different similarity measures to find the robust measure for color based image retrieval. The query image and the visual database are represented as feature vectors. A function of similarity distance is taken between each pair of feature vector; the smaller distance denotes the more similarity between the query image and the visual database image. A number of the commonly used similarity measurements are described and evaluated. These metric distances are [5]:

a- The Euclidean distance formula is a type of the Mminkowski-form distance as defined in equation (1) [5[[6][7]:

$$L_p(Q,T) = \left[\sum_{i=0}^{N-1} |Qi - Ti|^P\right]^{1/p} \quad \text{.....(1)}$$

Where p defines the type of distance, i stand for index coordinates. The $Q=\{Q_0, Q_1,....,Q_{N-1}\}$ and $T=\{T_0, T_1, ..., T_{N-1}\}$ are the query and target feature vectors respectively. When P = 2, equation (1) is known as the Euclidean distance.

b- Statistics $\aleph^2$ measure: The statistics Chi-Square $\aleph^2$ is defined mathematically using equation (2) [5]:

$$d_{x^2}(Q,T) = \sum_{i=0}^{N-1} \frac{(Q_i - m_i)}{m_i} \quad \text{.....(2)}$$

Where $m_i = \frac{Qi + Ti}{2}$

$\aleph^2$ Similarity measure is used to distinguish whether the distributions of the descriptor differ from one another [5]. This distance proved to be useful for image retrieval due to its better retrieval accuracy compared with the other similarity measures [8].

c- The Weighted-Mean-Variance (WMV) This distance is defined by equations (3 and 4):

$$d_{\mathrm{Wmn}}(x,y)=\sum_{m}\sum_{n}d_{mn}(x,y) \qquad \text{.....(3)}$$

$$\text{and } d_{\mathrm{mn}}(x,y)=\left|\frac{\mu^{x}{}_{mn}-\mu^{y}{}_{mn}}{\sigma(\mu_{mn})}\right|+\left|\frac{\sigma^{x}{}_{mn}-\sigma^{y}{}_{mn}}{\sigma(\mu_{mn})}\right| \qquad \text{.....(4)}$$

Where $\sigma(\mu_{mn})$ and $\sigma(\sigma_{mn})$ are the standard deviations of the respective features over the entire database. They are used to normalize the individual feature components, which increase the robustness and improve retrieval performance [6][8].

d- The Cosine distance is an m-dimensional feature vectors *Q* that stands for query and *T* (Target) that stands for visual database. The Cosine similarity is defined as in Equation (5):

$$\cos(\theta)=\frac{Q.T}{|Q\|T|}=\frac{Q^{T}.T}{|Q\|T|} \qquad \text{.....(5)}$$

|*Q*| and |*T*| are the magnitudes of the feature vectors *Q* and *T*. The dot product is equal to *Q.T*. The numerator of the above equation could be further simplified as the following Equation :

$$Q.T=Q^{T}\,T=Q_1\,T_1+\ldots..+Q_m\,T_m=\sum_{i=1}^{m}Q_iT_i \qquad \text{.....(6)}$$

This gives the final Cosine similarity as in equation (7) [9]:

$$\cos(\theta)=\frac{Q^{T}.T}{|Q\|T|}=\frac{\sum_{i=1}^{m}Q_iT_i}{\sum_{i=1}^{m}Q_i\sum_{i=1}^{m}T_i} \qquad \text{.....(7)}$$

3- The Proposed Work

In this section the details of the visual image database, feature extraction operation, the similarity measurement and the image retrieval process are discussed.

3-1 Visual Image Database

A sample of fifty different size color images is used. Then these images could be resized to any common size such as 128*128, 256*256 and 512*512 pixels and used in this application. In order to gain accurate results with less distortion, we prefer the 128*128 pixels . Also, we transform their color from Red, Green and Blue (RGB) to Hue, Saturation

and Value (HSV) color space due to that this space is more related to human color perception than the (RGB) color space.

3-2 Color Feature Extraction

Color features are extracted that represent the global level. These features are the color moment which is useful in image retrieval. These moments have been proved to be effective and efficient in representing color distributions of an image. Mathematically the mean is defined as: [10][11]

$$\mu_i = \frac{1}{N}\sum_{j=1}^{N} f_{ij} \qquad \text{.....(8)}$$

Where f_{ij} is the value of the i-th color components of the image pixel j, and N is the number of pixels in the image.

The Standard Deviation (STD) shows the contrast of an image. It describes the spread of the data. Standard deviation is defined mathematically by equations (9): [10][11]

$$\sigma_i = \left(\frac{1}{N}\sum_{j=1}^{N}\left(f_{ij} - \mu i\right)^2 \right)^{1/2} \qquad \text{.....(9)}$$

As shown f_{ij} is the value of the i-th color components of the image pixel j, *N* is the number of features over all database, while μ_i is the mean of the color i [10][11].

We have computed these features of H,S and V colors for both Query image as well as to the database images. So that we gain six feature vectors three for the mean values and the other three for STD values. Then a distance metric is used to compute the similarity or match value for a given pair of images. It is known that the distance of an image from itself is zero. Then the distances are tested with a selected threshold. We select this threshold dynamically by computing the average of the maximum and minimum distance related to each query image. Images with distance values less or equal to this threshold are denoted to be retrieved. After computing the error rate that represents the retrieval measure as defined in equation (10) [12]:

$$\text{Error rate} = \frac{\text{Number of non-relevant image retrieved}}{\text{Total number of relevant images}} \qquad \text{.....(10)}$$

The error rate to each four distance is computed and recorded, and then we applied the One-Way Analysis of Variance (ANOVA) to find the robust similarity measure from these four measures.

3-3 Experimental Result

We run the experiment with the denoted four measures. The Euclidean, the WMV, the Chi-Squared and the Cosine distance measure.

These distances are tested with the same image set with 50 images. This test shows and proves to be the best measure for image retrieval. A sample from these results is shown in Table (1). This table shows the image number and the retrieval accuracy related to each measure. The retrieval accuracy is represented by the error rate. The error rate is the ratio between the relevant to the irrelevant images. A selected threshold was used to discriminate between the relevant and the irrelevant images. This threshold is based on the STD of the different between the query image and the retrieved images.

3-4 Result Analysis

It is clear from Table (1) that there is a little change in the retrieval accuracy related to each image. The Chi-square measures between 9.0909-36.3636, WMV ranges between 0-31.8181, Euclidean measures between 0-27.9070 and the Cosine metric measures between 0-28.5714. These result shows that the Chi-Square produced the maximum error rate than other distances. The WMV improves the accuracy because it normalizes the results to the mean and variance of the visual database. Despite the fact that the Euclidean distance is squared before summation which gives a chance to the different images to emphasis their dissimilarity. It finds the smallest error rate and the best measure for color image retrieval among all distances. In order to emphasize these results and due to the small change of any row in Table (1), we use the (ANOVA) to find the best distance metric. Figure (1 and 2) show the retrieval images related to the Euclidean distance. The proposed work has been implemented in Matlab7.0 environment on pantium4 computer with 1596 MHz speed.

Table (1): A comparison between the distance measurements

Image number	Chi-Square	WMV	Euclidean	Cosine
1	27.2727	0	6.9767	10.2041
2	9.0909	14.8936	11.6279	12.2449
3	27.2727	26.0870	16.2791	22.4490
4	0	4.6512	4.6512	4.0816
5	18.1818	27.9070	20.9302	26.5306
6	27.2727	13.9535	11.6279	12.2449
7	9.0909	12	4.6512	6.1224
8	18.1818	15.2174	9.3023	12.2449
9	18.1818	15.2174	13.9535	14.2857
10	18.1818	16.2791	13.9535	14.2857
11	9.0909	6.9767	6.9767	8.1623
12	27.2727	26.0870	20.9302	22.4490
13	36.3636	0	0	0
14	27.2727	31.8182	27.9070	28.5714
15	27.2727	0	11.6279	12.2449
16	9.0909	17.0732	11.6279	14.2857
17	0	0	0	8.234
18	0	2.1277	0	3

Image number	Chi-Square	WMV	Euclidean	Cosine
19	26.9231	23.4043	18.6047	20.4082
20	33.3333	23.5294	20.9302	24.4898
21	12.5	17.0213	13.9535	14.2857
22	36	29.7872	25.5814	26.5306
23	30.7692	25.5319	18.6047	22.4490
24	8	15.2174	11.6279	12.2449
25	3.8962	12.7660	2.3256	4.0816
26	33.3333	26.8293	23.2558	26.5306
27	23.0769	27.6596	16.2791	20.4082
28	22.2222	21.7391	13.9535	16.3265
29	46.1538	27.7090	18.9355	32.6531
30	11.5385	17.7778	6.9767	10.2041

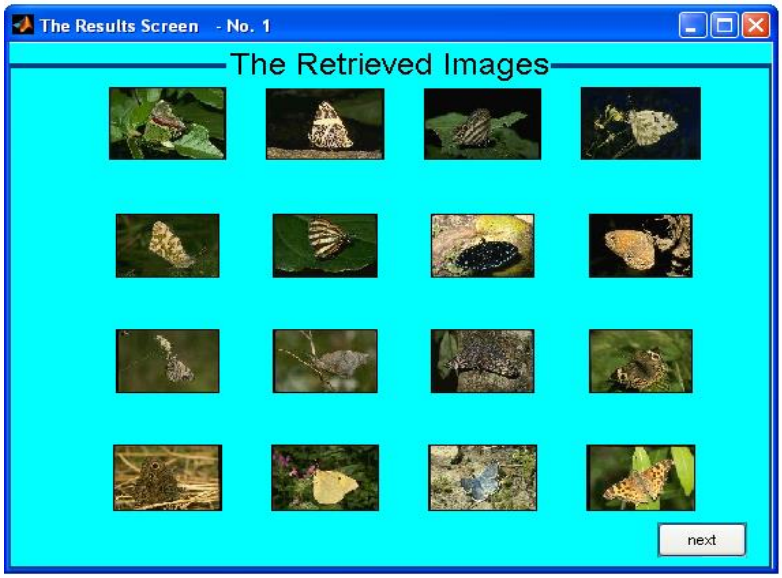

Figure (1) The retrieval images related to the Euclidean distance

Figure (2) The continuation retrieval images related to the Euclidean distance

4- Conclusion

1- The proposed work introduced the robust similarity measure for color images retrieval by a detailed comparison between the most efficient four measures commonly used in image retrieval.

2- A sample of 50 color images is used to check the best retrieval measure. Features of all images were extracted using color moment.

3- The Chi-square measures the maximum error rate while WMV improved up the results by decreasing the error rate to 31.8181.

4- The cosine metric shows better results than the previous two distances.

5- The Euclidean distance shows a minimum error results from the other distances.

6- The analysis of the final results with (ANOVA) proves that the Euclidean distance is the best color image retrieval measure.

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