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Towards Better Retrievals in Content -Based Image Retrieval System

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Abstract-This paper presents a Content-Based Image Retrieval (CBIR) System called DEICBIR-2. The system retrieves images similar to a given query image by searching in the provided image database.Standard MPEG-7 image descriptors are used to find the relevant images which are similar to thegiven query image. Direct use of the MPEG-7 descriptors for creating the image database and retrieval on the basis of nearest neighbor does not yield accurate retrievals. To further improve the retrieval results, B-splines are used for ensuring smooth and continuous edges of the images in the edge-based descriptors. Relevance feedback is also implemented with user intervention. These additional features improve the retrieval performance of DEICBIR-2 significantly. Computational performance on a set of query images is presented and the performance of the proposed system is much superior to the performance of DEICBIR[9] on the same database and on the same set of query images.
Index Terms—Content-based image retrieval, splines, All MPEG-7 Descriptors, Edge Histogram Descriptor, Color Layout Descriptor and Color Edge and Directivity Descriptor (CEDD), NMRR (Normalized Modified Retrieval Rate).

I. INTRODUCTION

THE volume of image data has grown tremendously in recent years due to increasing popularity of imaging devices such as digital cameras, the prevalence of low-cost high-capacity storage devices, and the increasing proliferation of image data over the internet and wireless networks. This is reflected in many applications including online image libraries, e-commerce, biomedicine, military and education among others. This motivates the development of efficient image indexing and retrieval systems and algorithms. Traditional image retrieval systems use textual descriptors such as keywords to annotate images. This is, however, exhausting as well as subjective. They involve significant amount of human labor in manual annotations of large-scale image databases. In view of this, Content-Based Image Retrieval (CBIR) systems have been developed to address these shortcomings. CBIR attempts to retrieve a set of desired images from the database using visual features such as color, texture, shape and spatial relationships that are present in the images. The process of feature extraction and image indexing can be fully automated, hence alleviating the difficulty of human annotation in text-based retrieval systems [1].
Many research and commercial CBIR systems have been developed, including QBIC [2], MARS [3], Virage [4], Photobook [5], VisualSEEk [6], PicToSeek [7], and PicHunter [8]. Despite these efforts, the retrieval performance of current CBIR systems remains relatively unsatisfactory. This is

mainly due to the semantic gap between the low-level visual features (color, texture, shape) and the high-level human perception. In view of this, an interactive mechanism called relevance feedback (RF) has been introduced to bridge this gap [3]. Under this framework, the users are integrated into the systems by providing their evaluations on the relevance of the retrieved images, providing improved retrievals.

The remaining of the paper is organized as follows. In section 2, preprocessing of images using Splines and the concept of Averaged Normalized Modified Retrieval Rank (ANMRR) used for performance evaluation of CBIR systems are described. Section 3 discusses the basic steps of DEICBIR 2 for image retrieval. Experimental results of the effectiveness of the present retrieval system are given in Section 4. Section 5 shows the comparison of DEICBIR 2 with DEICBIR [9]. Concluding remarks are given in Section 6.

II. PREPROCESSING AND PERFORMANCE EVALUATION

In this section, the preprocessing of images using Splines and the measurement used for performance evaluation of CBIR systems are described.

2.1 Splines

Splines are piecewise functions (often polynomials) with pieces that are smoothly connected together.Sothere are several basis (synthesis) functions instead of one. These pieces may or may not overlap. Figure 1illustrates that B-splines are a family of synthesis functions.

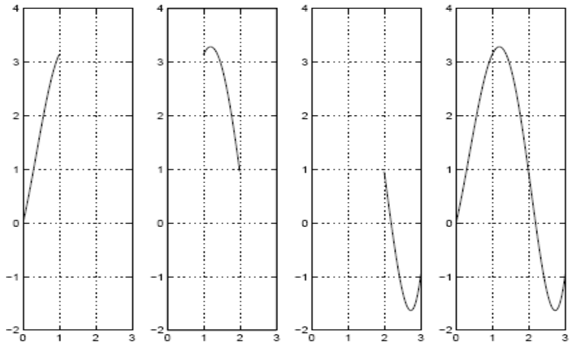

Fig.1. Illustration of smooth connection of piecewise functions (polynomials). Piecewise functions are in the three left most figures and the union of those is in the right most.

B-spline of degree n is denoted by $\beta^n(x)$. They are piecewise polynomials of degree n, globally symmetric and they are C^{n-1}.Expressions are

$$\beta^0(x) = \begin{cases} 1, |x| < 1/2 \\ \frac{1}{2}, |x| = 1/2 \\ 0, |x| > 1/2 \end{cases}$$

$$\beta^n(x) = \underbrace{\beta^0 * \beta^0 * \ldots\ldots * \beta^0(x)}_{(n+1)\ \text{times}}$$

or

$$\beta^n(x) = \sum_{k=0}^{n+1} \frac{(-1)^k (n+1)}{(n+1-k)!\,k!} \left(\frac{n+1}{2} + x - k\right)^n$$

with

$$(x)^n = (\max(0, x))^n, n > 0$$

A cubic B-spline is one of the most popular and is employed in this work. The advantage of employing cubic B-spline is that the edges are guaranteed to be smooth and continuous, thus providing better descriptors and hence retrievals.

$$\beta^3(x) = \beta^0 * \beta^0 * \beta^0 * \beta^0(x)$$
$$= \begin{cases} \frac{2}{3} - \frac{1}{2}|x|^2(2 - |x|), 0 \le |0| < 1 \\ \frac{1}{6}(2 - |x|)^3, 1 \le |x| < 2 \\ 0, 2 \le |x| \end{cases}$$

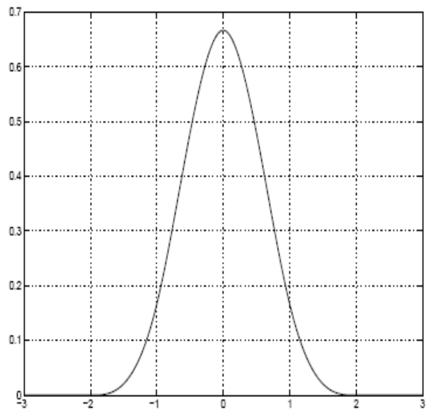

Fig. 2. A cubic B-spline

Bn(x) converges to a Gaussian of infinite variance.

2.2 Performance Evaluation

The objective Averaged Normalized Modified Retrieval Rank (ANMRR) [10] is employed to evaluate the performance of the image retrieval system that uses the proposed descriptors in the retrieval procedure.

The average rank AVR(q) for query q is:

$$AVR(q) = \sum_{k=1}^{NG(q)} \frac{Rank\ (k)}{NG\ (q)}$$

where

- NG(q) is the number of ground truth images for query q. A ground truth is defined

as a set of visually similar images.

- K= min (X_{NG} * NG(q), 2*GTM).
- GTM = max (NG).
- If NG(q) > 50 then X_{NG} = 2 else X_{NG} = 4.
- Rank(k) is the retrieval rank of the ground truth image.

Consider a query. Assume that as a result of the retrieval, the kth ground truth image for this query q is found at a position R. If this image is in the first K retrievals then Rank (k)= R else Rank(k)=(K+1).

The modified retrieval rank is:

MRR (q) =AVR (q) - 0.5* [1+ NG (q)]

Note that MRR is 0 in case of perfect retrieval. The normalized modified retrieval rank is computed as follows:

$$NMRR(q) = \frac{MRR\ (q)}{1.25 * K - 0.5 * [1 + NG(q)]}$$

Finally the average of NMRR over all queries is defined as:

$$ANMRR = \frac{1}{Q}\sum_{q=1}^{Q} NMRR\ (q)$$

where Q is the total number of queries.

The ANMRR is always in the range of 0 to 1 and the smaller the value of this measure, the better the matching quality of the query. ANMRR is the evaluation criterion used in all of the MPEG-7 color core experiments. Evidence shows that the ANMRR measure approximately coincides linearly with the results of subjective evaluation of search engine retrieval accuracy [10].

III. THE PROPOSED SYSTEM (DEICBIR 2)

The basic steps of DEICBIR 2 are as follows:

- Calculate the Scalable Color, Color Layout and Edge Histogram Descriptors of all the images of the database.
- Calculate All MPEG-7 Descriptor of all the images of the database by combining the Scalable Color, Color Layout and Edge Histogram Descriptors.
- Calculate the distance of the query image supplied by the user with all the images of the database using Euclidian distance measure and give the closest 100 images as results.
- Let the user mark relevant images according to his/her perception within the results obtained.
- Calculate the average of the descriptors of all these relevant images and form a new modified descriptor.
- Supplied this new descriptor as a query descriptor. Calculate the new retrievals and provide the improved set of results.

The flow diagram of DEICBIR 2 is shown in figure 3 below.

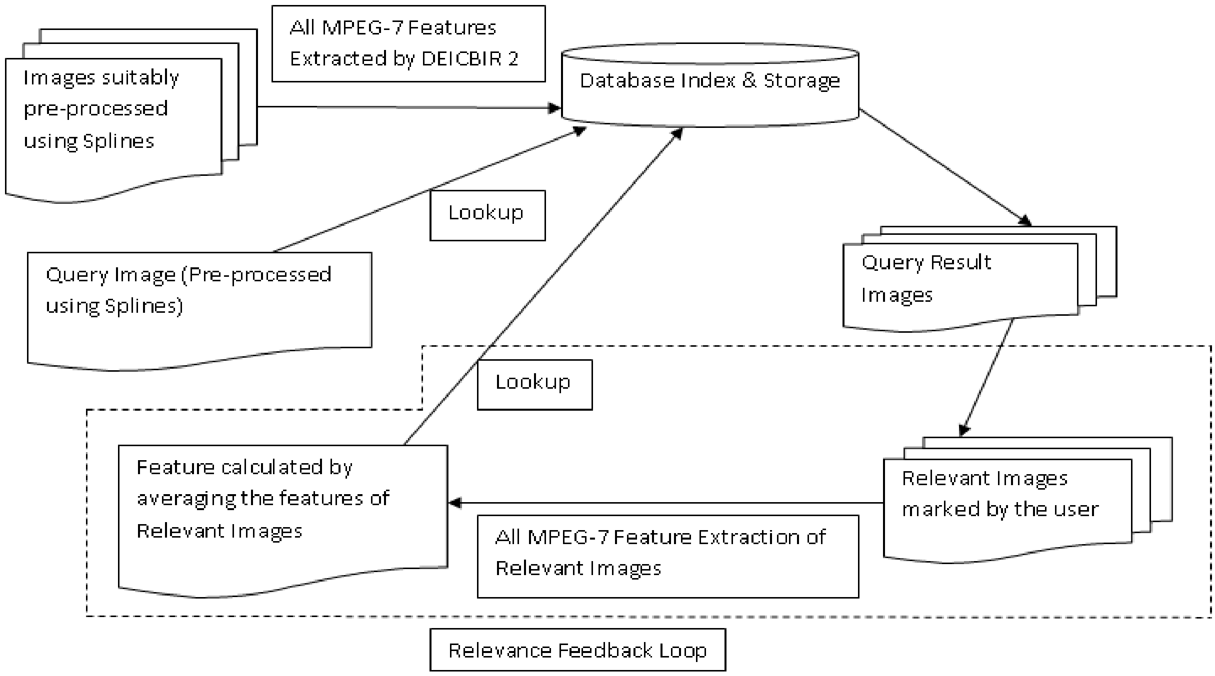

Fig. 3. Flow diagram of DEICBIR 2.

IV. EXPERIMENTAL RESULTS

In the experiment, standard MPEG-7 Descriptors are used and retrieved the images which are relevant to the given query image. A Corel Image Library consisting of 10,000 images is taken.

Initially the system is tested for the database of 1000 images for 15 query images for All MPEG-7 Descriptors, Edge Histogram Descriptor, Color Layout Descriptor and Color Edge and Directivity Descriptor (CEDD) and calculates the average NMRR (Normalized Modified Retrieval Rate), an index for the image retrieval (lies between 0 and 1, where 0 is best and 1 is worst).

Then databases of 2000, 5000 and 10000 images are taken and the same experiment is performed for 15 query images for All MPEG-7 Descriptors, Edge Histogram Descriptor, Color Layout Descriptor and Color Edge and Directivity Descriptor (CEDD) and the average NMRR (Normalized Modified Retrieval Rate) is calculated.

Then the results are compared with the results of **DEICBIR** system [9].

The experimental results for all size of databases show that the proposed approach greatly improves the results of previous experiments. By analyzing the results, it can be seen that although for small size of database, the Edge Histogram Descriptor gives the best results but as the database size grows, All MPEG-7 descriptor gives best result.

Next, the minute irregularities at edges of images are removed using splines technique and the results are calculated for the database of 5000 and 10000 images for various descriptors. By this correction, it is found that the results are further improved. The best improvement is obtained for All MPEG-7 descriptors. Now, attempts are made to find the results of these corrections for DEICBIR system [9], so that comparison between its results with the results obtained can be done.

Further, from the experiment, it is found that one particular descriptor is good for one particular type of image, but it may not work so good for some different type of image. As a result, there is a need of user involvement in the image retrieval. This has led to the concept of relevance feedback.

Table 1 shows the ANMRR for the database size of 1000, 2000, 5000 and 10,000 images for All MPEG-7 Descriptors, Edge Histogram Descriptor, Color Layout Descriptor and Color Edge and Directivity Descriptor (CEDD) obtained with DEICBIR 2. These results are gross results without incorporating relevance feedback.

S.No.	**Without Splines**	**Database Size 1000**	**Database Size 2000**	**Database Size 5000**	**Database Size 10000**
1	**ANMRR for All MPEG-7 Descriptors**	0.1432	0.1753	0.1968	0.2157
2	**ANMRR for Edge Descriptor**	0.1312	0.1562	0.1936	0.2347
3	**ANMRR for Color Layout Descriptor**	0.2495	0.2657	0.2989	0.3342
4	**ANMRR for CEDD Descriptor**	0.2308	0.2823	0.3321	0.3541

Table 1. ANMRR for the database size of 1000, 2000, 5000 and 10,000 images.

This is shown graphically as follows:

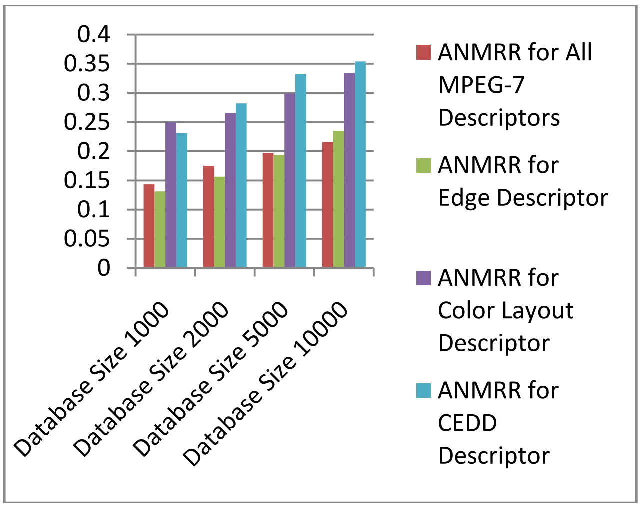

Fig.4. Graphical representation of ANMRR for the database size of 1000, 2000, 5000 and 10,000 images.

From the graph, it is clear that the initially best result is obtained by Edge Descriptors for small size of database but as the database size increases, the best result is obtained by All MPEG-7 Descriptors.So, in the subsequent experiment, All MPEG-7 Descriptor is used by DEICBIR 2.

V. COMPARISON WITH DEICBIR

Table 2 below represents the feature-wise comparison of DEICBIR [9] and the proposed system.

Item	**DEICBIR**	**DEICBIR 2**
Descriptor	Quantized Gradient Descriptors	All MPEG-7 Descriptor
Distance Measure	Euclidian	Euclidian
Relevance Feedback	Averaging the calculated feature values of QGD features	Averaging the calculated feature values of the MPEG-7 features

Table 2. Feature-wise comparison of DEICBIR and DEICBIR 2.

Table 3 below represents the statistical comparison of DEICBIR [9] and the proposed system for splines images without and with relevance feedback.

S.No.	Database Size	ANMRR of DEICBIR	ANMRR of DEICBIR 2	ANMRR of DEICBIR for Splines Images	ANMRR of DEICBIR 2 for Splines Images	ANMRR of DEICBIR for Splines Images with Feedback	ANMRR of DEICBIR 2 for Splines Images with Feedback
1	Database Size 1000	0.2136	0.1312	0.1641	0.0847	0.1219	0.0100
2	Database Size 2000	0.253	0.1562	0.1811	0.1087	0.1412	0.0104
3	Database Size 5000	0.3178	0.1936	0.2514	0.1454	0.1612	0.0307
4	Database Size 10000	-------	0.2157	----------	0.1728	--------------	0.0843

Table 3. Comparison with DEICBIR [9] for database size of 1000, 2000, 5000 images.

Thus, from the table above, it is seen that the DEICBIR 2, which uses All MPEG-7 Descriptor provides improved results. From the table above, considerable improvement in the results can also be seen by applying splines corrections in images for the proposed system and DEICBIR [9] both. Also, it can be seen that the results are further improved with the introduction of relevance feedback.
This is shown graphically as follows:

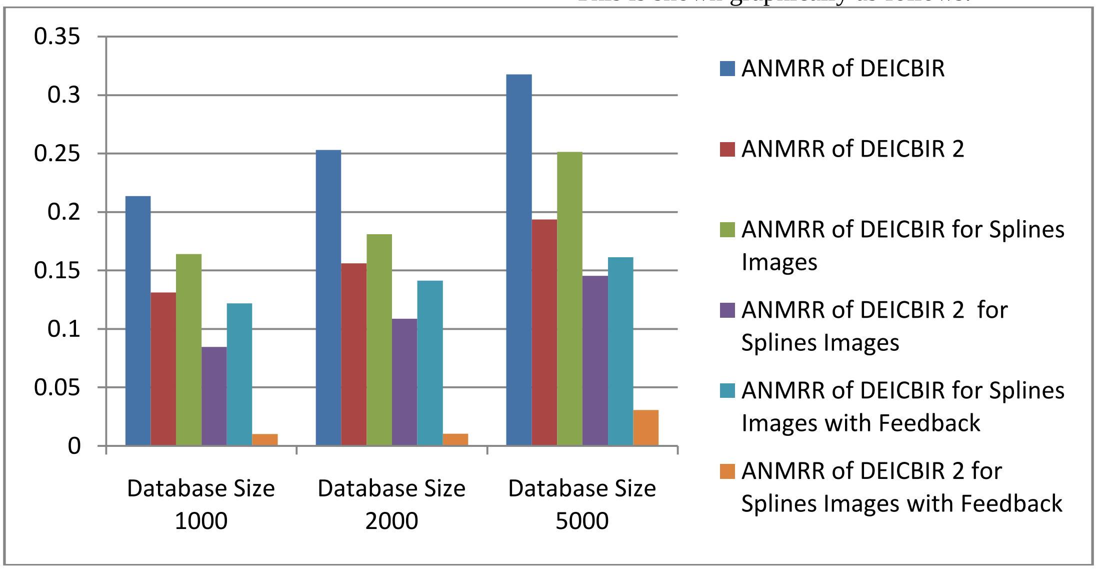

Fig. 5. Graphical representation of comparison with DEICBIR [9].

The graph depicts the considerable improvement is the retrieval performance of images using the present system as compared to DEICBIR. The results are obtained for the same 15 query images as taken by DEICBIR [9].

Figure 6 shows screen-shot of retrieval results.

Fig. 6. Screen-shop of DEICBIR 2 for top 100 retrieval results.

VI. CONCLUSIONS

The paper presents a new content based image retrieval system, which is using a new image descriptor *i.e.* All MPEG-7 Descriptor which is a combination of ScalableColor, ColorLayout and EdgeHistogram. It shows the improvement in the retrieval performance of the previous systems, as the descriptor used by the present system is using global colors, spatial information of colors as well as border and line information of images more efficiently. Further by applying splines correction to images, the results are further improved. Also it is realized that no image retrieval system can be perfect without the user intervention, which has led to the concept of relevance feedback.

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