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Appliying of the Combination of Content-Based Search and Progressive Wavelet Correlation in Image Retrieving

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Abstract* – An algorithm for search and retrieval of images from massive image collections is developed. The algorithm consists of two phases. The first phase uses well-known methods of image searching by descriptors based on the content of the searched image. In the second phase the progressive wavelet correlation method is applied on the small number of image candidates selected in previous search phase. The final search result is the wanted image, if it is in the data base. Experiments are performed with data bases of 1000 and 10 000 images.

***Keywords:* content based, image retrieval, pixel-based search, progressive wavelet correlation.**

I. INTRODUCTION

A key tool that helped make the Internet universally useful is the text-search engine. The text should be alphabetically ordered for the purpose of efficient retrieval. This has been practiced for centuries either by hand in a typical library or automatically in a modern digital library. But when it comes to organization of images man is irreplaceable for most of the tasks. This is due to the fact that the text is man's creation while images are reproduction of what man has seen since his birth and their actual description is rather vague. As a rule it is difficult to characterize the interpretation of what has been seen.

Here are several examples of professional use of images: crime prevention, medicine, fashion and graphic design, publishing and marketing, architectonic and engineering design, historical researches etc.

Images digitalization system itself doesn't entail an easy management of collection of images. A particular form of cataloguing and indexing is still required. The only difference being that most of the information needed can potentially be automatically retrieved from the images themselves. The need for efficient storage and retrieval of images was recognized by managers of large collections of images long time ago and was prompted again via workshop sponsored by the American National Science Foundation in 1992 [1]. There have been recognized certain areas requiring further researches data representation, feature extractions and indexing, image query matching and user interfacing. One of the main difficulties highlighted here is the one that arises when locating the required picture from a large and diverse collection of images.

There are several techniques for image searching: descriptor-based search, pixel-based search and image understanding techniques.

The earliest and the most sophisticated descriptor-based image search engine is IBM QBIC [2]. Examples for such tools are WebSEEk and Virage. All of these techniques improve the accuracy and usefulness of image searching and may have commercial appeal in the future. The accuracy of searching has a tendency to improve by means of increasing the descriptors' resolution and pre-processing images for locating more appropriate descriptors.

The described image search engines are based on compact image representation in order to produce high processing speed. Generally there is no time for image analysis during the search phase. The main descriptor-based search techniques are limited in two ways: Firstly, they do not contain the details of the image, and secondly, they do not cover the overall features within the frames of the image descriptors. Large complex images can contain many details and as a result a suitable compact presentation will be hard to determine.

On the other side, pixel-based search represents a somewhat different direction that has promise for applications that require high resolution, such as satellite images and medical images, particularly in geosciences. Pixel-based search techniques work by locating a particular pattern in a given image library.

Popular criteria for matching are the normalized correlation coefficients [3], which measure the differences between images and patterns from the library. The particular strength of these criteria is that they are insensitive to uniform differences in brightness.

Some of the work done in the area of of content-based image retrieval and PWC (Progressive Wavelet Correlation) [3] are outlined in Section II and III. Our proposal about applying of the combination of content-based method and PWC for searching images stored in a database is presented in section IV. Results of experiments that use the proposed system are presented in Section V.

II. CONTENT BASED IMAGE RETRIEVAL

Content-based image retrieval (CBIR) aims at inventing techniques that support effective searching and browsing of large image digital libraries based on automatically derived image features. In the past decade, many general-purpose image retrieval systems have been developed, including QBIC, Photobook [4], Virage [5], VisualSEEK [6], WebSEEK [7], and others.

A typical CBIR system views the query image and images in the database (target images) as a collection of features, and ranks the relevance between the query image and any target images in proportion to feature similarities.

Many research works have been published in the field of CBIR. However, no universally accepted model has yet been developed. The research concentrates on image segmentation based on low-level features like color, shape, texture and spatial relations.

To find the semantic meanings or high-level meanings of an image, like whether it is the image of human beings or a bus or a train and so on, is still a problem. Attempts are being made to link low-level and high-level features. However, it is proving difficult for the very simple reason that there remains a vast gap between human perception and computer perception.

CBIR systems includes two main sub-systems: the server subsystem and the client subsystem (Fig. 1). The server subsystem handles the processes of feature extraction, database indexing/filtering, feature matching and system learning. The client subsystem handles the process of querying.

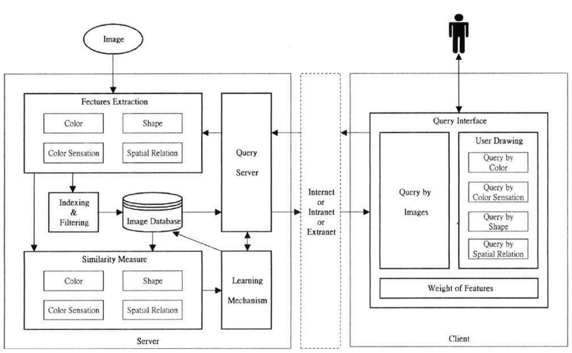

Fig. 1 System Architecture of CBIR system

III. PROGRESSIVE WAVELET CORRELATION

A. Overview

The PWC pixel-based method for retrieval of images involves correlation in the frequency domain for fast computation, discrete cosine transform (DCT) in factorizing form and wavelet representation of signals for efficient compression [3]. The primary idea is based on Vaidyanathan's theorem [8] for computing convolutions of wavelet-packet representations of signals. Progressive wavelet correlation summarizes Vaidyanathan's results replacing the operation of convolution in the wavelet domain with the equivalent operation in the Fourier-transform domain.

In this method the correlation between the two signals is formed in their original domain, without reverting from the transform domain. This method is progressive in the sense that each resolution level is calculated based only on the preceding level; lower resolution levels are irrelevant.

The algorithm can be described as follow:

Step 1: A candidate image is coarsely correlated with the pattern. Every eighth point of the correlation is generated.

Step 2: It is determined whether the pattern suitably matches the candidate image. If not, then another candidate image may be chosen or the search abandoned.

Step 3: If the match was suitable, then the candidate image is medium correlated with the pattern. We obtain the correlation at indices that are multiples of 4 mod 8 of the full correlation.

Step 4: Another similar match test is performed.

Step 5: A candidate image is finely correlated with the pattern. The fine correlation obtains the correlation at indices that are multiples of 2 mod 8 and 6 mod 8 of the full correlation.

Step 6: Another similar match test is performed.

Step 7: Full correlation: Obtain the correlation at odd indices.

Step 8: If a suitable match is found for the fully correlated image, then the image has been found.

B. Extension to two dimensions

Let the image size be N by N. In step 1, we have 64 subbands of length $N^2/64$. We perform one step of the inverse 2D JPEG transfer function, and one 2D step of the forward Fourier transform function. The next step involves adding the 64 subbands point by point to create a 2D array of size $N/8$ by $N/8$. Taking the inverse Fourier transform, we obtain the correlations at points that lie on a grid that is coarser than the original pixel grid by a factor of 8 in each dimension.

In step 2, we obtain 16 subbands of size $N^2/16$ by adding the 16 subbands point by point, and taking the Fourier inverse. We obtain the correlation values on a grid that is coarser than the original grid by a factor of 4 in each dimension.

In step 3, we obtain 4 subbands of size $N^2/4$.

Finally, in step 4, the full resolution is obtained.

Formulas for calculating normalized correlation coefficients that measure differences between images and patterns are given in [3].

Normalized correlation coefficients can be computed from the correlations described above. The normalization is very important because it allows for a threshold to be set. Such a threshold is independent of the encoding of the images.

IV. PROPOSED SYSTEM FOR IMAGE RETRIEVING

A. *Adaptation of PWC for searching in a database*

The progressive wavelet correlation provides guidelines on how to locate an image in the image library. To make this method practical, we must first decide how to store the images. The initial choice is to store them in a disk file system. This can be seen as the quickest and simplest approach. A better alternative that should be considered is to store those images in a database. Databases offer several strengths over traditional file system storage, including manageability, security, backup/recovery, extensibility, and flexibility.

We use the Oracle Database for investigation purposes. There are two ways of storing an image into the Oracle Database. The first one is the use of Large Objects – LOB, and the second one is the use of Oracle *inter*Media.

To store images into the database we use the BLOB datatype. After creation of one BLOB column defined table we also create a PL/SQL package with a procedure for loading images (named load). This procedure is used to store images into the database.

The implementation of the progressive wavelet correlation in Matlab and the connection between the algorithm with the database are the next steps. The Database Toolbox is part of an extensive collection of toolboxes for use with Matlab.

Before the Database Toolbox is connected to a database, a data source must be set. A data source consists of data for the toolbox to access, and information about how to find the data, such as driver, directory, server, or network names. Instructions for setting up a data source depend on the type of database driver, ODBC or JDBC. For testing purposes JDBC drivers were usually used [9].

After setting up the data source for connecting to and importing data from a database we have used several standard functions of the Matlab Database Toolbox. We can retrieve BINARY or OTHER Java SQL data types. However, the data might require additional processing once retrieved. For example, data can be retrieved from a MAT-file or from an image file. Matlab cannot process these data types directly. One needs knowledge of the content and might need to massage the data in order to work with it in Matlab, such as stripping off leading entries added by the driver during data retrieval.

The last step in the adaptation is to create Matlab applications that use the capabilities of the World Wide Web to send data to Matlab for computation and to display the results in a Web browser. In the simplest configuration, a Web browser runs on a client workstation, while Matlab, the Matlab Web Server (matlabserver), and the Web server daemon (httpd) run on another machine. In a more complex network, the Web server daemon can run on a separate machine [9].

The practical implementation of progressive wavelet correlation includes two main subsystems: the server subsystem and the client subsystem. The server subsystem handles the processes of image storing in a database and similarity measure. The client subsystem handles the process of queries.

B. *Combination of content-based method and PWC*

Pixel-based search using progressive wavelet correlation is too expensive computationally to apply to large collections of images, especially when it is possible to discover in advance that no match is likely. It has to be combined with descriptor-based search or some other means of reducing the search space. After descriptor matches narrow the search, pixel-based search can find matches based on detailed content.

Results obtained from a number of performed experiments by retrieving images from a database via application of both CBIR [10] and progressive wavelet correlation led us to the idea of combining them in order to make the best use of their positive features. The initial idea was extended into a developed proposal for a new system intended for searching and retrieving images from a database. The modular scheme of this system is given in Fig. 2.

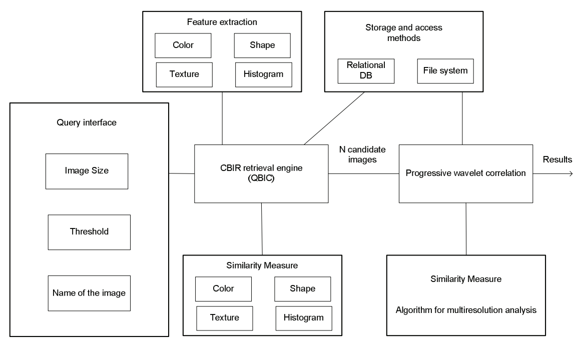

Fig. 2 A modular scheme for the proposed retrieval system

V. EXPERIMENTAL RESULTS

This section represents experimental results obtained by means of image retrieval through an algorithm of progressive wavelet correlation.

Different experiments were set up as follows:

- The required image is included several times in the database with different names;
- The image is included only once in the database;
- Aside from the required image, the database also contains an image very similar to the required one (smudged in some parts or an image generally slightly different);
- The required image is not present in the database.

The experiments are carried out with databases including between 250 and 1000 store images. Oracle 10g version 10.1.0.2.0, served as our database, while we used Matlab version is 7.0.4.365 (R14) Service Pack 2 for image search.

Using QBIC, we established a database for the following characteristics of images: color, text, color histogram, and texture feature. We query the database for those images in the library with the most similar characteristics to the input image. On this set of candidates, we apply the normalized correlation coefficients to obtain the desired image.

Using QBIC, we isolated ten candidate images based on the Color Histogram Feature. After that these images are subjected to detailed pixel-based search based on the normalized correlation coefficients.

A. The required image is present several times in the database

Two images, called flower01.jpg and flower10.jpg, served as search targets. Image flower01.jpg appears eight times under different names in the database, while the image flower10.jpg appears six times. The database contains images that are more visually similar to the image flower10.jpg.

Evaluation of the quality of the system concerning its precision p is estimated using the following the definition:

$$p = \frac{|A(q) \cap R(q)|}{|A(q)|} \tag{12}$$

where q stands for query, $R(q)$ signifies a set of relevant images for the query in the database, while $A(q)$ stands for the set of images returned as a response to the set query q.

TABLE 1. flower01.jpg

Threshold	Retrieved images	Precision
0.2	9	0.89
0.3	8	1
0.4	8	1
0.5 – 1	8	1

TABLE 2. flower10.jpg

Threshold	Retrieved images	Precision
0.2	10	0.6
0.3	10	0.6
0.4	10	0.6
0.5	10	0.6
0.6	10	0.6
0.7 – 1	6	1

The Table II shows that the image flower10.jpg, when in the database is more visually similar to her, is extracted with a threshold equal to or greater than 0.7.

B. The required image is present only once in the database

The results presented in this part refer to two different images 21.jpg and 40.jpg. Each of these images is included only once in the searched database.

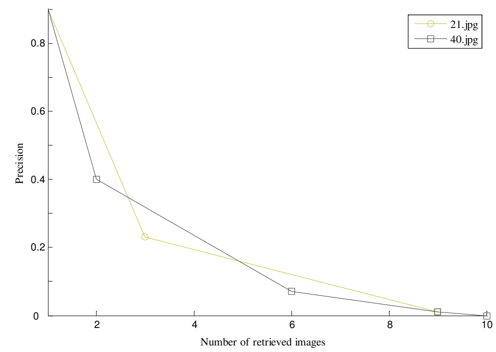

Fig. 3 Relationship between precision and the number of retrieved images for the images 21.jpg and 40.jpg

C. The database contains two very similar images

The next example refers to image 181.jpg. This example is specific because the database contains a similar image 183.jpg with its vertical sides slightly smudged. The similar images are shown in Fig. 4 and Fig.5.

Fig. 4 181.jpg

Fig. 5 183.jpg

In the previous examples, the number of candidate images that QBIC gives for further processing is 10, and in part *C* and *D* that number is 20. These images are then processed by PWC.

TABLE 3. 181.jpg

Threshold	Retrieved images	Precision
0.3	20	0.05
0.4	20	0.05
0.5	17	0.12
0.6	2	1
0.7	2	1
0.8	2	1

It is evident from Table 3 that when correlation threshold values are 0.6, 0.7 and 0.8, both the images 181.jpg and 183.jpg are retrieved. If the correlation threshold is equal to or greater than 0.9 only image 181.jpg is retrieved.

D. The required image is not present in the database

Table 4 gives the number of retrieved images for different values of the correlation threshold for image 50.jpg, which is not present in the database. For correlation threshold values greater than or equal to 0.5 there are no images retrieved from the database.

TABLE 4. 50.jpg

Threshold	Retrieved images
0.2	17
0.3	16
0.4	7
0.5 – 1	0

E. Results obtained by applying the proposed system to large databases

Considering the results obtained from a number of image retrieval examples, we become aware that the use of the proposed algorithm for search and retrieval of images from a database can be very useful.

The results demonstrated in the previous examples referred to a database of 1000 images. The following charts present results concerning the time needed to retrieve image from a database of 10 000 images. The database used in these experiments is taken from http://wang.ist.psu.edu/docs/related.shtml.

In this section the adopted value of the image size is *N*=80, while the correlation threshold value is 0.7.

TABLE 5. flower01.jpg

Number of images	2000	4000	7000	10000
Time (sec) (proposed system)	11.07	11.09	11.42	11.88

TABLE 6. flower10.jpg

Number of images	2000	4000	7000	10000
Time (sec) (proposed system)	9.07	9.15	9.23	9.26

TABLE 7. 21.jpg

Number of images	2000	4000	7000	10000
Time (sec) (proposed system)	4.5	4.67	4.72	4.91

Fig. 6 1795.jpg

TABLE 8. 1795.jpg

Number of images	2000	4000	7000	10000
Time (sec) (proposed system)	7.18	7.26	7.36	7.64

Fig. 7 1890.jpg

TABLE 9. 1890.jpg

Number of images	2000	4000	7000	10000
Time (sec) (proposed system)	4.58	4.84	5.09	5.27

Fig. 8 1993.jpg

TABLE 10. 1993.jpg

Number of images	2000	4000	7000	10000
Time (sec) (proposed system)	4.53	4.69	5.96	5.17

The time required for retrieving of image flower01.jpg with proposed system for image retrieval from the database is takes approximately 11 seconds because the image appears eight times in the database. Image flower10.jpg appears six times in the database and the time needed for search and retrieve is 9 seconds. For image 1795.jpg time for search and retrieve is 7 seconds, the image appears four times in the database.

The time require to locate the images 21.jpg, 1890.jpg, and 1993.jpg, is approximately the same as the usage of the proposed system for image retrieval because the three images too, appear once in the database.

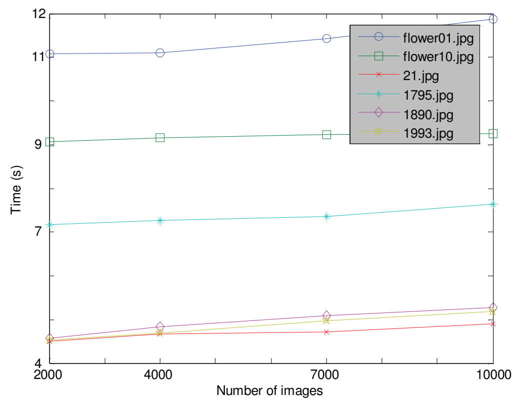

Fig. 9 Retrieval performance for different number of images

From Fig. 9 we can conclude that with using of proposed system for searching and retrieving of images the time required to locate an image doesn't depend on the number of images stored in the database.

VI. CONCLUSIONS

Based on our experience and experimental evidence we conclude that the proposed system is a useful tool for image search from databases. The main feature of PWC is its high accuracy. With the choice of an adequate correlation threshold it is possible to detect if the given image is present in the database, whether there are images similar to the required one with different names, whether there are images slightly different from the required one, and whether the required image is present in the database.

We conclude that by changing the threshold value of correlation it is possible to identify all four cases examined by the proposed system. In addition, the proposed system locates and retrieves images faster than the PWC. This is achieved by using QBIC as a first step in the proposed system for obtaining a small number of candidate images.

The efficiency of joint content and pixel-based retrieval of images from a database can be improved in some applications such as satellite and medical imaging by appropriate selection of the threshold value. Content-based image retrieval is fast, but it normally gives more than one image due to the vast differences in perception capacity between humans and computers. On the other hand, pixel-based retrieval using progressive wavelet correlation is impractical, due to the numerous operations per image it entails. However, a positive outcome should be expected if we combine the good features of content-based and pixel-based searches: speed and accuracy.

In the following years commercial systems are expected to be capable of performing extensive analysis for about one thousand images per second. Such procession speed will facilitate the construction of a real system that will operate as a combination of both content-based and pixel-based retrieval.

For some applications visual similarity can be more critical than semantic similarity. However, for other applications however, visual similarity can be of minor importance. What's the source of client's urge for image search and retrieval? What is to be achieved with the system? How is the system expected to help out in the process? These are only some of the issues that have to be dealt with in order to produce an efficient image search and retrieval system. In addition, successful implementation of this system involves various profiles, for instance: computer vision, information retrieval, man-computer interaction, database, theory of information, statistics, psychology etc.

According to the future researches, focused on the construction of image search and retrieval system, regardless of the technique that the system uses, only the issue concerning system quality assessment from the aspect of efficiency and applicability is to be tackled. Retrieval systems should be comparable for the purpose of identifying the good techniques.

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