Performance of the Hybrid Method of Image Retrieval

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***Abstract* – We study the performance of the hybrid method of image retrieval (content-based followed by pixel-based retrieval) from image databases. We carry out a series of image search experiments that cover the following scenarios: a) the given image is present in the database; b) copies of the given image are present but with different names; c) similar (but not identical) images are present; and d) the given image is not present. Experiments are performed with databases of up to 1000 images, using the Oracle database and the Matlab component Database Toolbox for operations with databases.**

***Keywords* – Database, image retrieval, normalized correlation, progressive wavelet correlation.**

I. Introduction

Images, drawings, and photographs have been part of everyday life for a long a time as a means of communication among people. The easy to use World Wide Web, the reduced price of storage devices as well as the increased calculating power allow an essential and efficient management of large quantities of digital information.

However, image digitalization systems do not allow for an easy management of collections of images. The need for efficient storage and retrieval of images was recognized by managers of large collections of images long time ago and was studied at a workshop sponsored by the American National Science Foundation in 1992. Data representation, feature extractions and indexing, image query matching, and user interfacing were identified as areas with a potential for improvement. One of the issues identified was the problem of locating a picture in a large and diverse collection of images.

The earliest and the most sophisticated descriptor-based image search engine is IBM QBIC [1]. Examples for such tools are WebSEEk and ImageRover. 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.

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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 [2], 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 PWC (Progressive Wavelet Correlation) [2] is outlined in Section II. Our proposal about an application of the hybrid method for searching images stored in a database is presented in section III. Results of experiments that use the hybrid system are presented in Section IV.

II. 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 [2]. The primary idea is based on Vaidyanathan's theorem [3] 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 [2]. 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.

III. HYBRID 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 [4].

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 [4].

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. Hybrid system

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 [5] 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 algorithm intended for searching and retrieving images from a database. The modular scheme of this algorithm is given in Fig. 1.

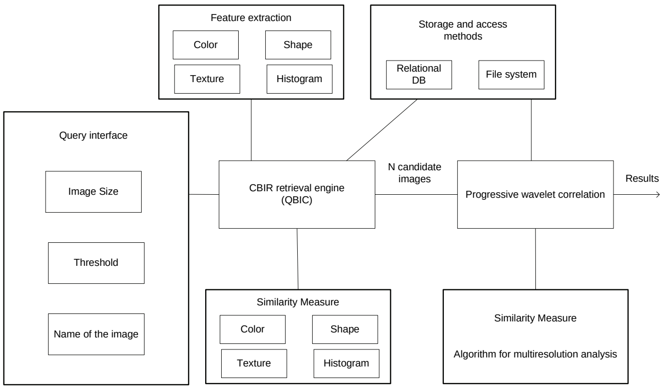

Fig. 1. A modular scheme for the proposed retrieval system

IV. 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:

$$p = \frac{|A(q) \cap R(q)|}{|A(q)|} \qquad (1)$$

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. The results obtained for precision are shown in tables.

TABLE I
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 II
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
0.9 - 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.

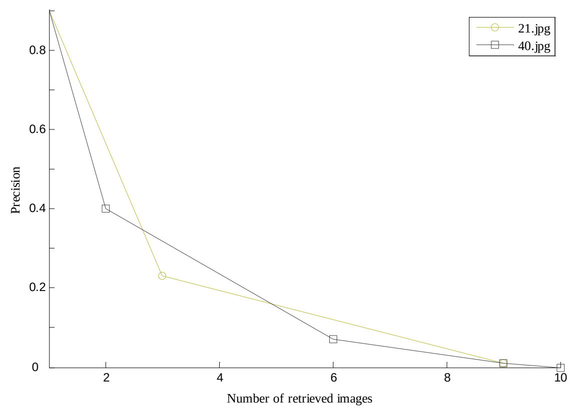

Fig. 2. Relationship between precision and the number of retrieved images for the images 21.jpg and 40.jpg

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. 3 and Fig.4.

Fig. 3. Image 181.jpg

Fig. 4. Image 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 III
IMAGE 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 III 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 IV 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 IV
IMAGE 50.JPG

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

V. CONCLUSION

Based on our experience and experimental evidence we conclude that the hybrid 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 hybrid system. In addition, the hybrid system locates and retrieves images faster than the PWC. This is achieved by using QBIC as a first step in the hybrid algorithm 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.

REFERENCES

[1] M. Flickner, H. Sawhney, W. Niblack, J. Ashley, Q. Huang, B. Dom, M. Gorkani, J. Hafner, D. Lee, D. Petkovic, D. Steele, P. Yanker, “Query by image and video content: The QBIC system,” IEEE Comp., vol. 28, pp. 23-32, Sept. 1995.

[2] H. S. Stone, “Progressive Wavelet Correlation Using Fourier Methods,” IEEE Trans Signal Processing, vol. 47, pp. 97-107, Jan. 1999.

[3] P. P. Vaidyanathan, “Orthonormal and biorthonormal filter banks as convolvers, and convolutional coding gain,” IEEE Trans. Signal Processing, vol. 41, pp. 2110-2130, June 1993.

[4] I. Stojanovic, S. Bogdanova, and M. Bogdanov, “Retrieving Images Using Content-Based Followed by Pixel-Based Search,” 15th Int. Conf. on Systems, Signals and Image Processing, pp. 271-274, Bratislava, Slovakia, June 25-28, 2008.

[5] Ritendra Datta, Dhiraj Joshi, Jia Li and James Z. Wang, ``Image Retrieval: Ideas, Influences, and Trends of the New Age,'' ACM Computing Surveys, vol. 40, no. 2, article 5, pp. 5:1-60, April 2008.