Images Pseudo-hash by Using Wavelet Coefficients

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Abstract - **In this paper an algorithm for fast querying in images database is presented. It uses multiresolution technique, all the images are decomposed in few levels and the most important wavelet detail coefficients are selected to compose images pseudo-hashes. When searching for an image-query in the database, the pseudo-hashes of the images are considered instead of the images themselves.**

Keywords – **Wavelets, images database, pseudo-hash, query.**

I. Introduction

Wavelet transforms have received significant attention recently from mathematicians, signal analysts and engineers as a new tool for feature extraction, signal and image compression, edge detection and denoising. Unlike the traditional Fourier techniques, wavelets are localized both in time and frequency domain. This feature makes them suitable for the analysis of nonstationary signals.

This paper considers a practical implementation of the wavelet transform for a fast searching in an images database. Images are decomposed in a few levels. Pseudo-hash information calculated from the images themselves are stored in a database. When searching for an image-query in the database, its pseudo-hash is compared to pseudo-hashes in the database by using a simple sql statement to select images-candidates from the database that match some defined criteria.

The paper is organized as follows. The wavelet theory is summarized in Section 2. Section 3 presents the algorithm for fast querying in an images database. The experimental results are presented in Section 4. Section 5 concludes the paper.

II. Wavelet Theory

The Discrete Wavelet Transform (DWT) decomposes a signal into a set of orthogonal components describing the signal variation across the scale [1]. The orthogonal components are generated by dilations and translations of a prototype function ψ, called mother wavelet.

In analogy with other function expansions, a function f is presented for each discrete coordinate t as a sum of a wavelet expansion up to certain scale J plus a residual term, that is:

$$f(t) = \sum_{j=1}^{J} \sum_{k=1}^{2^{-j}M} d_{jk}\psi_{jk}(t) + \sum_{k=1}^{2^{-J}M} a_{Jk}\phi_{Jk}(t) \quad (1)$$

where ψ_{jk} and ϕ_{jk} denote wavelet and scaling function,

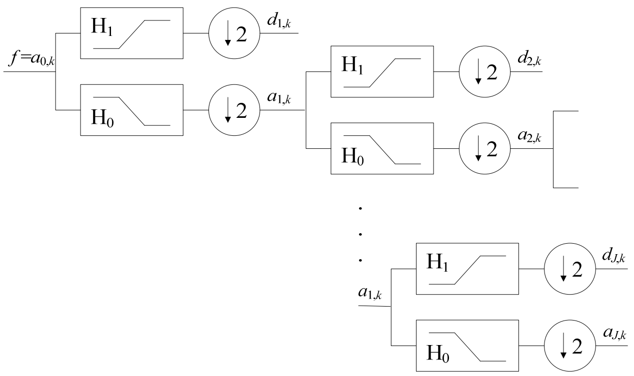

Fig. 1. Discrete wavelet transform tree.

respectively, the indexes j and k are for dilatation and translation, and a_{Jk} and d_{jk} are approximation and detail coefficients.

Wavelet decompositions and multiresolution concepts are closely related to filter bank theory. For this reason, it is helpful to view the scaling and wavelet function as a low pass and high pass filters, $\mathbf{H_0}$ and $\mathbf{H_1}$, respectively. The wavelet transform is applied to low pass results (approximations) as it is illustrated in Fig. 1.

The most popular form of conventional wavelet-based signal filtering [2], can be expressed by:

$$\{\mathbf{A}^{(k)},\mathbf{D}^{(1)},\mathbf{D}^{(2)},\cdots,\mathbf{D}^{(k)}\} = \mathrm{DWT}(\mathbf{s}),$$
$$\mathbf{s}^* = \mathrm{IDWT}\left(f\left(\mathbf{A}^{(k)},\mathbf{h}^{(1)}.\times\mathbf{D}^{(1)},\mathbf{h}^{(2)}.\times\mathbf{D}^{(2)},\cdots,\mathbf{h}^{(k)}.\times\mathbf{D}^{(k)}\right)\right) \quad (2)$$

where $\mathbf{s}$ is input signal, $\mathbf{s*}$ is filtered signal, $\mathbf{A}^{(k)}$ and $\mathbf{D}^{(k)}$ are approximation and detail coefficients at level k, respectively, f is a function of the modified detail and approximation coefficients, $.\times$ is element-by-element multiplying and

$$\mathbf{h}^{(k)} = \left[h_1^{(k)}, h_2^{(k)}, \cdots, h_j^{(k)}\right]^T \quad (3)$$

are weighting coefficients of the corresponding detail coefficients at level k.

In case of conventional hard threshold filtering the weighting coefficients are

$$h_j^{(k)}(hard) = \begin{cases} 1, & \text{if } \left|D_j^{(k)}\right| > \tau^{(k)} \\ 0, & \text{otherwise} \end{cases}, \quad (4)$$

while for the soft threshold filtering they are

$$h_j^{(k)}(soft) = \begin{cases} 1 - \dfrac{\tau^{(k)}\,\mathrm{sgn}\left(D_j^{(k)}\right)}{D_j^{(k)}}, & \text{if } \left|D_j^{(k)}\right| > \tau^{(k)} \\ 0, & \text{otherwise} \end{cases}, \quad (5)$$

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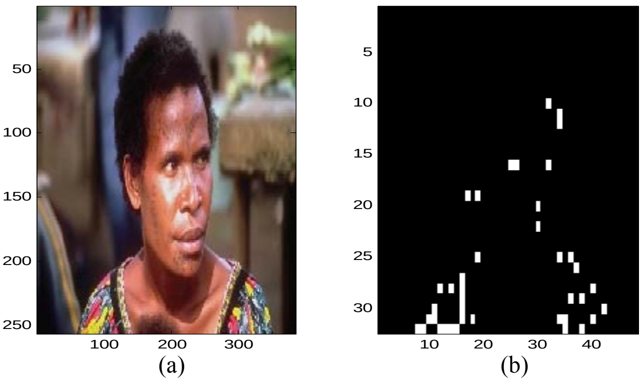

Fig. 1. (a) Image with resolution 384x256; (b) The most important wavelet approximation coefficients at level 3, resolution 48x32 (calculated with haar wavelet).

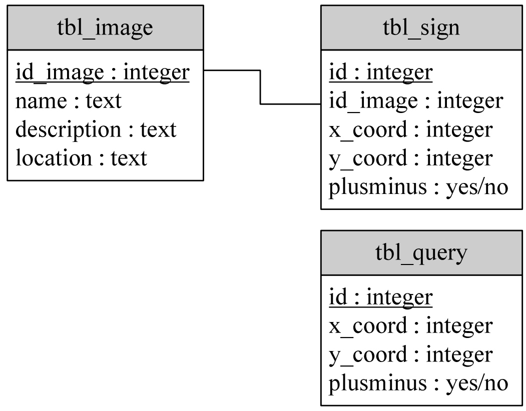

Fig. 2. Relation schemas in the images database.

where $\tau^{(k)}$ is user specified threshold for the k-th level details.

III. The Pseudo-Hash

The main idea is to search for a particular image-query in a large images database on the basis of small piece of information calculated from the images themselves [3]; in the following text it is referred as pseudo-hash information. By comparing the similarity between the images pseudo-hashes stored in the database and the image-query pseudo-hash, few images (candidates) are selected to be considered visually if some of them correspond to the image-query.

The database keeps pseudo-hash information for a large number of images. Unlike [4] the pseudo-hash is calculated from the most important wavelet coefficients from a high-resolution level. Namely, the wavelet transform tends to concentrate the energy of a signal into a small number of coefficients, while a large number of coefficients have small energy. By applying a threshold given with (4) the most important wavelet coefficients can be selected.

In order to calculate the pseudo-hash information for an RGB image, it is first converted to YCbCr colour space, where Y is the luminance (intensity) component and Cb (blue chrominance) and Cr (red chrominance) are the blue-difference and red-difference chroma components, respectively. The wavelet transform is applied over the Y component and the wavelet detail coefficients are filtered in order to keep only the most important coefficients. Both the coefficients position and sign make up the pseudo-hash information for an image: a set of triplets (x, y, s), where (x, y) denotes a coefficient position, and s is the coefficient sign (+/–).

A database that keeps images information can contain a few relations with their schemas given in Fig. 2. The relation *tbl_image* contains information like name, description and location of the images (if the images are picture files in the file system). In this relation, the primary key is the attribute *id_image*. The relation *tbl_sign* contains the pseudo-hash information for all the images. The primary key is *id*, while *id_image* is foreign key that takes its values from the primary key of the relation *tbl_image*.

The relation *tbl_query* contains the pseudo-hash calculated from the image-query by applying the same algorithm. A list of images candidates can be obtained by comparing the matching results from the tables *tbl_query* and *tbl_sign*. The image with a maximum number of matching points (positions and signs of the most important wavelet coefficients) is likely the image that is looked for.

When a database with schema shown in Fig. 2 is created and contains images pseudo-hash information, the process of querying an image can be summarized with the block-diagram shown in Fig. 3.

IV. Experimental Results

In this Section, our experimental results are explained. The experiments for fast searching are made with 1000 images which pseudo-hashes are stored in a Microsoft Access 2007 database with schema given in Fig. 2. Some of these images are shown in Fig. 4. The database contains a lot of similar images with people, animals, landscapes, objects, etc. The database does not contain the images themselves; the images are picture files in the file system.

All these images are converted in YCbCr colour space. The haar wavelet transform in three levels is applied over the Y components. The most important 5% pixels from the wavelet detail coefficients at the third level frequency region (3, 15) are kept (Fig. 1b). All the frequency regions up to the third level are illustrated in Fig. 5. Similar results can be obtained by taking into consideration coefficients from other frequency region or from all the frequency regions.

Next, as a query-image we use the image shown in Fig. 1a, which image resolution is 256x384. The database already contains pseudo-hash information for this image in the table tbl_sign and the id = 1. Its pseudo-hash is calculated from the coefficients shown in Fig. 1b. It can be noticed that resolution of the wavelet coefficients at this level is 48x32, which means that only a few coefficients were taken into consideration for the calculation of the pseudo-hash.

Next step is comparing the image-query pseudo-hash with the pseudo-hashes in the database. A simple SQL SELECT statement is used to select all the images from the database which pseudo-hash values correspond to pseudo-hash data calculated from the image-query:

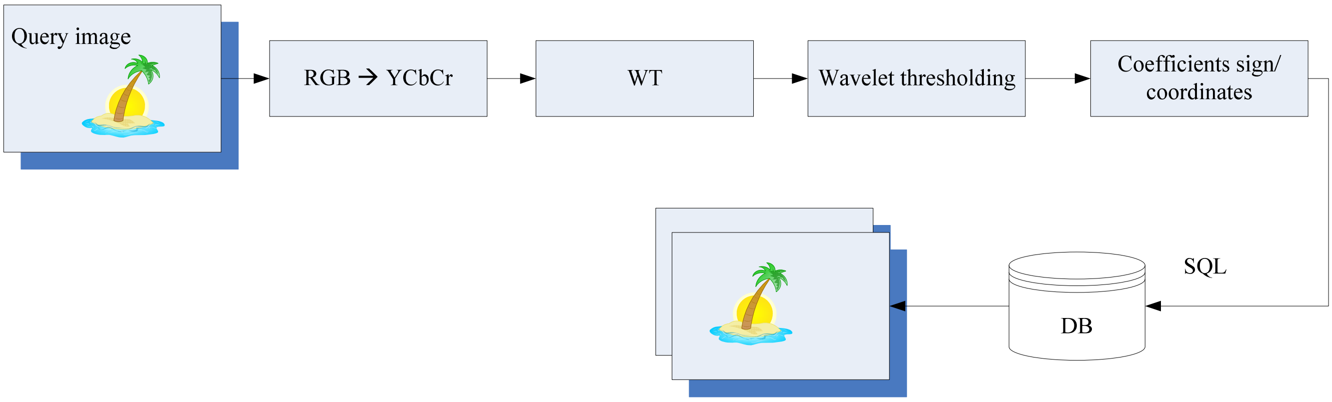

Fig. 3. Block diagram of querying with the used algorithm.

Fig. 4. Part of images database with 1000 images used for experiments.

```
SELECT TOP 10 tbl_Sign.id_image,
Count(tbl_Sign.id_image) AS [Count]
FROM tbl_Sign INNER JOIN tbl_Query ON
(tbl_Sign.x_coord = tbl_Query.x_coord) AND
(tbl_Sign.y_coord = tbl_Query.y_coord) AND
(tbl_Sign.plusminus = tbl_Query.plusminus)
GROUP BY tbl_Sign.id_image
ORDER BY Count(tbl_Sign.id_image) DESC;
```

The result of matching points between the tables *tbl_sign* and *tbl_query* is shown in the table I. It can be seen that the number of matching points (matched coefficients positions and signs) is highest for the image with *id* = 1 (77 matched points). The nearest image-candidate is the image with *id* = 216 (14 matched points).

V. CONCLUSION

In this paper an algorithm for fast searching in an images database is presented. The search is based on calculating pseudo-hash information for all the images in the database. For this reason the wavelet transform is exploited in order to select the most important wavelet coefficients, which are used to calculate the pseudo-hash.

REFERENCES

[1] G. Strang and T. Nguyen, *Wavelets and Filter Banks*. Wellesley-Cambrige Press, 1996.

[2] D. L. Donoho, "Wavelet Thresholding and W.V.D.: A 10-minute Tour", *Int. Conf. on Wavelets and Applications*, Toulouse, France, June 1992.

[3] C. E. Jacobs, A. Finkelstein, D. H. Salesin, "Fast multiresolution image querying", *SIGGRAPH '95 Proceedings of the 22nd annual conference on Computer graphics and interactive techniques*.

[4] M. Kostov, M. Petkovski, I. Jolevski “Fast Querying in Database with Images by Using Multiresolution”, *Int. Scientific Conf. on Information, Communication and Energy Systems and Technologies ICEST 2011*, Nis, Serbia, Jun. 2011.

TABLE I
RESULT OF SEARCHING AN IMAGE IN THE DATABASE

Image id	Matching points
[1]	[77]
[216]	[14]
[790]	[9]
[747]	[8]
[142]	[8]
[134]	[8]
[126]	[8]
[705]	[7]
[704]	[7]
[118]	[7]
[113]	[7]
[803]	[7]
[833]	[7]
[764]	[7]
[56]	[7]
[766]	[7]
[190]	[7]