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HAAR WAVELET TRANSFORM FOR SOLUTION OF IMAGE RETRIEVAL

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ABSTRACT:

An efficient algorithm based Haar Wavelet approach for image retrieval solution, is proposed. This method is applicable for different kinds of image extraction features. Wavelet Transformation is a powerful tool for many problems. It can be used in numerical techniques. Here we proposed a new technique of wavelet transformation trough which a feature vector of size ten, characterizing texture feature of image is constructed from only three iterations of Wavelet transform. Mask technique is used to group images based on feature vector of images by considering the minimum Euclidean distance. Experiments are performed on texture images, and successful matching results are found.

Keywords: *Image Retrieval, Haar Wavelet Method, Transformation, Extraction, Algorithm, Results*

[I]. INTRODUCTION

With the increasing growth of computer technology, rapidly declining cost of storage and ever-increasing access to the Internet, digital acquisition of information has become increasingly popular in recent years [8]. Digital information is preferable to analog formats because of convenient sharing and distribution properties. This trend has motivated research in image databases, which were nearly ignored by traditional computer systems due to the enormous amount of data necessary to represent images and the difficulty of automatically analyzing images.

Rapid advances in hardware technology and growth of computer power make facilities for spread use of World Wide Web. This causes that digital libraries manipulate huge amounts of image data. Due to the limitations of space and time, the images are represented in compressed formats. Therefore, new waves of research efforts are directed to feature extraction in compressed domain [2]. In the proposed paper, Haar Wavelet transform is used to calculate the feature vectors of textured images.

The outline of the paper is as follows. Haar Wavelet Method is reviewed in section 2. Method of feature extraction and Mask Technique is presented in section 3 and 4 respectively. Results and conclusions are presented in section 5 and 6 respectively.

[II]. HAAR WAVELET TRANSFROM

Haar Transform is the simplest and basic transformation from the space domain to a local frequency domain and can work as an example for orthonormal wavelet transforms [7]. It is the first known Wavelet and was proposed by Alfred Haar [6]. The Haar Wavelets family for $m \in (0,1)$ is defined by

$$h_i(m) = \begin{cases} 1 & 0 \le m \le 0.5 \\ -1 & 0.5 \le m \le 1 \\ 0 & otherwise \end{cases}$$ for

This is also called mother Wavelet. Haar Wavelets are orthogonal, and their forward and inverse transform require only additions and subtractions. So it can be easily implemented on computer.

A HT decomposes each signal into two components, one is called average or trend and the other is known as difference or fluctuation. A precise formula for the values of first average sub signal, $a^1 = (a_1, a_2 .... a_{N/2})$ at one level for a signal, length N i.e. $f = (f_1, f_2 .... f_N)$ is

$$a_n = \frac{f_{2n-1} + f_{2n}}{\sqrt{2}}, n = 1,2,3,....N/2$$

and the first detail sub signal, $d^1 = (d_1, d_2, ... d_n)$ at the same level is given as

$$d_n = \frac{f_{2n-1} + f_{2n}}{\sqrt{2}}, n = 1,2,3,.....N/2$$

To understand how wavelets work, let us start with a simple example. Assume we have a 1D image with a resolution of four pixels, having values

[6 12 8 6]

Haar wavelet basis can be used to represent this image by computing a wavelet transform [4]. Consider the pairs of pixels (6, 12) and (8,6), take the average of each pair, 9 and 7, and then record this in the next line. Then record the difference of the averages from the first value of the pair. This process is then applied to this new string resulting in the line, where the differences are just carried down. As follows:

[6 12 8 6]
[9 7 -3 1]

The differences recorded to the right-hand side are known as the detail coefficients. Thus, the original image is decomposed into a lower resolution (two-pixel) version and a pair of detail coefficients. The recursive process of averaging and differencing is called a filter bank. The original image can be reconstructed by recursively adding and subtracting the detail coefficients from the lower resolution versions.

2.1. Steps of Haar Wavelet Transform:

To calculate the Haar transform of an array of n samples:

1. Compute the average of each pair of samples. (n/2 averages)
2. Compute the difference between each average and the samples it was calculated from. (n/2 differences)
3. Write the first half of the array with averages
4. Write the second half of the array with differences.
5. Repeat the process on the first half of the array. While doing this the array size should be power of two.

For 2D Haar Transform [5] the procedure remains the same. For example, apply 2D HT to the following finite 2D signal.

$$I = \begin{bmatrix} 2 & 3 & 3 & 4 \\ 6 & 7 & 5 & 2 \\ 4 & 8 & 7 & 3 \\ 3 & 9 & 2 & 3 \end{bmatrix}$$

Using 1D HT along first row, the approximation coefficients are

$$\frac{1}{\sqrt{2}}(2+3) \text{ and } \frac{1}{\sqrt{2}}(3+4)$$

and the detail coefficient are

$$\frac{1}{\sqrt{2}}(2-3) \text{ and } \frac{1}{\sqrt{2}}(3-4)$$

The same transform is applied to the other rows of I.

By arranging the approximation parts of each row transform in the first two columns and the corresponding detail parts in the last two columns we get the following results:

$$\frac{1}{\sqrt{2}}\begin{bmatrix} 5 & 7: & -1 & -1 \\ 13 & 7: & -1 & 3 \\ 12 & 10: & -4 & 4 \\ 12 & 5: & -6 & -1 \end{bmatrix}$$

In which approximation and detail parts are separated by dots in each row. By applying the following step of 1D HT to the columns of the resultant matrix, we find that the resultant matrix at first level is

$$\frac{1}{\sqrt{2}}\left[\begin{array}{cc|cc} 18 & 14 & -2 & 2 \\ 24 & 15 & -10 & 3 \\ \hline -8 & 0 & 0 & -4 \\ 0 & 5 & 2 & 5 \end{array}\right]$$

Thus we have

$$A=\begin{bmatrix} 18 & 14 \\ 24 & 15 \end{bmatrix}, V=\begin{bmatrix} -2 & 2 \\ -10 & 3 \end{bmatrix}, H=\begin{bmatrix} -8 & 0 \\ 0 & 5 \end{bmatrix}, D=\begin{bmatrix} 0 & -4 \\ 2 & 5 \end{bmatrix}$$

Each piece shown in example has a dimension (number of rows/2) × (number of columns/2) and is called A, H, V and D respectively. A (approximation area) includes information about the global properties of analysed image. Removal of spectral coefficients from this area leads to the biggest distortion in original image. H (horizontal area) includes information about the vertical lines hidden in image. Removal of spectral coefficients from this area excludes horizontal details from original image. V (vertical area) contains information about the horizontal lines hidden in image. Removal of spectral coefficients from this area eliminates vertical details from original image. D (diagonal area) embraces information about the diagonal details hidden in image. Removal of spectral coefficients from this area leads to minimum distortions in original image.
To get the value at next level, again HT is applied as earlier on A. Thus the HT is suitable for application when the image matrix has number of rows and columns as a multiple of 2.

2.2. The advantages of Haar Wavelet transform:

1. In terms of computation time, it produced Best performance
2. Speed of Computation is very high.
3. Haar Wavelet Transformations deals with Simplicity in working.
4. It is an efficient method for Image compression.

[III]. EXTRACTION OF FEATURE

The main purpose of this method is to show the impact of the discrete Haar wavelet transformation on an image as Feature Extraction. This is the combination of a sequence of low-pass and high-pass filters, known as a filter bank. The work of low pass filter performs an averaging/blurring operation, and is written as:

$$H = \frac{1}{\sqrt{2}}(1,1)$$

and differencing operation is performed by high-pass filter and written as:

$$G = \frac{1}{\sqrt{2}}(1,-1)$$

on any adjacent pixel pair.
After performing transformation, image composed in four new sub-images. This leads to blurred image and it removes the details, but in remaining three images it represented separately. Using this technique we can easily store and transmit images.
Here is an example of a wavelet transformed image defining the four sub-images as already explained.

Fig: 1. Before transformation

Fig: 2. After transformation

Here in this paper, we compute feature vectors using Haar wavelets [8] because they are the fastest in computing and have been found to perform well in practice. It helps us to speed up the wavelet computation phase for thousands of sliding windows of different sizes in an image. They also facilitate the development of efficient incremental algorithms for computing wavelet transforms for larger windows in terms of the ones for smaller windows. Production of large number of signatures is the disadvantage of Haar wavelets. We proposed the modified Haar wavelet transformation that reduces signatures only by calculating 10 for the image in our method. In the proposed method, we apply Haar Wavelet Transform to Texture based Images. This can also be extended to other features of the images.

In our feature vector computation process, we applied Wavelet Transformations only three times to get 10 sub images of input image in the following way.

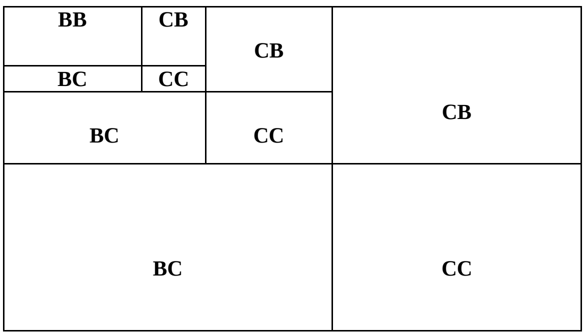

Fig:3. After applying Haar Wavelet Transformation for 3 iterations

[IV]. ALGORITHM

Algorithm for calculating the signatures of Wavelets

1. Image is for size r*r
2. Divide Image based on Haar Wavelet Transform into BB, CB, CC, BC.
3. Compute signature fr for BB, CB, CC, BC.
4. Divide image into size r/4*r/4.
5. Compute signatures fr for CB, CC, BC.
6. Divide image into r/8*r/8.
7. Obtain 10 signatures and stop.

The Wavelet signature (texture feature representation) [8] is computed from sub image as follows,

$$f_r = \sqrt{\frac{C_{ij^2}}{i \times j}}$$

fr is the computed Wavelet signature (texture feature representation) of the sub image. Cij is the representation of the intensity value of all elements of sub image. i × j is the size of the sub image.

[V]. RESULTS

The Proposed method is applied on the following images. In Fig. 2, the top left is the query image and all other are the retrieved images for the query. Fig. 3 shows the actual technique for the query image.

[VI]. CONCLUSION

By deriving ten feature vectors from wavelet transformation in three iterations, reduces overall time complexity. The Masking algorithm effectively minimizes the undesirable results and gives a good matching pattern, that will be having zero or a minimum set of no relevant images.

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