

## Enhancing the Precision of Walsh Wavelet Based Approach for Color and Texture Feature Extraction in CBIR by Including a Shape Feature

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**Abstract:** *This paper proposes a method for enhancing the performance of Content Based Image Retrieval, employing a shape feature along with color and texture of Walsh wavelet. The color and texture features of the images are extracted using Walsh Wavelet and the shape feature is extracted by edge detection using any of Roberts, Sobel, Prewitt or Canny Operator. The performance of the approach is tested based on the precision values on a database containing 44 images. The results show that the precision of retrieval is increased when a shape feature is employed in the second stage of a two-stage retrieval process. Adding the shape as a third feature in a single stage retrieval process does not provide any improvement in retrieval performance with respect to precision and recall. Performance comparison was also carried out with other existing approaches, namely Walshlet and Walsh transform. The experimental results show that Walsh Wavelet has higher precision than Walshlet and Walsh transform. Also, shape extraction with Sobel and Prewitt operators provides better performance when compared to Canny and Roberts.*

**Keywords:** *Content Based Image Retrieval (CBIR), Walsh transform, Walshlet, Walsh wavelet, shape feature, edge detection, Roberts, Sobel, Prewitt, Canny.*

### 1. Introduction

The demand for developing improved and efficient methods for searching digital image database is increasing enormously as the size of the databases is increasing

rapidly. The methods used for searching must be fast and effective. This requirement has led to the technique called Content Based Image Retrieval (CBIR). In CBIR the images are described in terms of its properties color, shape and texture, etc., and represented in the form of feature vectors. And the searching application will analyse these properties rather than the text given with the image. In text based image retrieval, the images are retrieved only if the search key is associated with the image. CBIR technology is used in art galleries, medical imaging, crime prevention, World Wide Web, military applications, weather forecast, etc. CIREs, QBIC, PicQuest are examples of some of the Content Based Image Retrieval systems.

## 2. Related work

Some of the important works in CBIR are those by Kekre et al. [1-8], Belongie et al. [9], and Jianhua et al. [10]. The contourlet is explained in [11]. The shape features are explained by B. G. Prasad [12], Ohashi and Shimodaira [13], Jain and Vailaya [14], Hiremath and Pujari [15], Kekre et al. [16] and Laaksonen et al. [17]. These are reviewed briefly as follows.

Kekre et al. presented in [1] image retrieval techniques based on features extracted from Kekre transform applied on row mean, column mean and combination of both. The experimental results show that taking the row mean, column mean and combination has better performance of image retrieval as compared to taking Kekre Transform of a full image. A performance comparison of image retrieval was done by Kekre et al. [2]. The methods based on texture feature extraction using Vector Quantization (VQ) codebook generation techniques like LBG (Linde, Buzo, Gray), KEVR (Kekres Error Vector Rotation) with assorted color space are used in this work. Their results show that KEVR based codebook generation is better than LBG based codebook generation in CBIR. Kekre et al. [3, 4] extracted the color and texture features of the images based on the vector quantization with Kekres fast codebook generation. using Walsh transform and DCT respectively. The main advantages of these methods are reduced feature vector size and better precision and recall compared to a full transform based CBIR. And these methods also avoid resizing of the images.

Kekre et al. [5] proposed an algorithm to generate discrete wavelet transform from any orthogonal transform. In this work, they implemented the image compression using wavelet transforms and their results show that image compression using wavelets performs better than normal transforms. Kekre et al. [6] proposed CBIR techniques based on feature vectors as a fractional coefficient transformed image using Discrete Cosine, Walsh, Haar and Kekre transforms. The advantage of these techniques is the reduced feature vector size per image by taking fractional coefficients of the transformed image. Kekre et al. [7] proposed Walshlet Pyramid for image retrieval techniques. Another approach of Kekre and Mishra [8] for CBIR makes use of the sectorization of Walsh Wavelet for feature extraction. In this, the Walsh Wavelet has been used to transform the images and sector it into various sector sizes to generate the feature vectors of those images.

In [9] Belongie, Carson, Greenspan and Malik presented a new image representation which provides transformation from the raw pixel data to a small set of image regions which are coherent in color and texture space. Wu, Wei, Chang [10] proposed an image retrieval method which combines color and texture features of the image. According to the image texture the information of texture can be represented by a Dual-Tree Complex Wavelet (DT-CWT) transform and Rotated Wavelet Filter (RWF). Their results demonstrate that this approach is more efficient than the traditional CBIR method based on the single visual feature and other methods combining color and texture. The use of Contourlet in CBIR is proposed in [11]. In [12] Prasad, Gupta and Biswas combined color and shape features of the image. In this the images indexed by dominant color regions and similar images form an image cluster which is stored in a hash structure. Each region within an image is further indexed by a region-based shape index.

In [13] Ohashi and Shimodaira proposed a feature extraction for content based image retrieval using graphical sketches. In it the edge based feature extraction is done by representing the relative positional relationship between the edge pixels. The advantage of this method is that it is scale, shift and rotate invariant. In [14] Jain and Vailaya used color and shape features for image retrieval. The advantage of this system is, that it is invariant with respect to large variations in the image scale, rotation and translation. In this work the shape information in the image is described in terms of significant edges. The edge information contained in the database image is generated in the preprocessing stage, using Canny edge operator.

Hiremath and Pujari [15] used all the three features, i.e. color, texture and shape for CBIR and achieved higher retrieval efficiency using image and its complement. Kekre et al. [16] discussed an image retrieval method based on the shape features extracted using the gradient operators and slope magnitude technique with Block Truncation Coding (BTC). In this work they proposed four variations of Mask Shape BTC using four gradient masks, such as Robert, Prewitt, Sobel and Canny. The performance of these methods is in the order Robert, Prewitt, Sobel and lastly Canny. In [17] Laaksonen, Brandt and Oja studied the use of the shape features in Content Based Image Retrieval. They represented the shape using edge histograms and Fourier transform based features computed for the edge image in Cartesian and polar coordinate planes. The advantage of the method is that no segmentation of the image is required. Their experimental results show that both local and global features are important for shape feature extraction.

The literature survey above done reveals that though there are many attempts to develop CBIR system, the performance of the system, in terms of precision, recall and speed needs to be further improved for its wider commercial acceptability. Hence, there is a need for further work in CBIR for achieving better precision and recall and for faster retrieval of images. The present work is an attempt to improve the precision of CBIR system.

This paper is organized as follows. Section 3 briefly presents the content based image retrieval technique. The Walshlet, Walsh and Walsh Wavelet transforms are discussed in Section 4 and the shape feature extraction – in Section 5. Section 6

presents the results and discussion of the proposed approach, and the work is finally concluded in Section 7.

### 3. Content based image retrieval

Content based image retrieval is an application of computer vision technique to image retrieval. CBIR involves the process of retrieving the desired image from a large database using the features of the image like color, texture and shape. The block diagram representation of a CBIR system is shown in Fig. 1. In a typical CBIR, the features related to visual contents are first extracted from the images in the data base and stored in the feature database. When the user gives a query image, the visual contents of the query image is extracted and the similarity between each feature vector in the feature database is computed by using some similarity measurement technique. The most similar images are retrieved. Some methods for color feature extraction are color histograms, color space, color moments and for texture extraction – Tamura features (designed in accordance with psychological studies on human perception of texture), Gabor features (extract image features using a Gabor filter), and Wold features (Based on perceptual features). The shape features of the images can be extracted by using moment invariance, turning angles, edge detection, etc. Another technique for feature extraction is based on image transforms. In it the image transform coefficients are taken and stored as a feature vector. The size of the feature vector is much smaller than the image size.

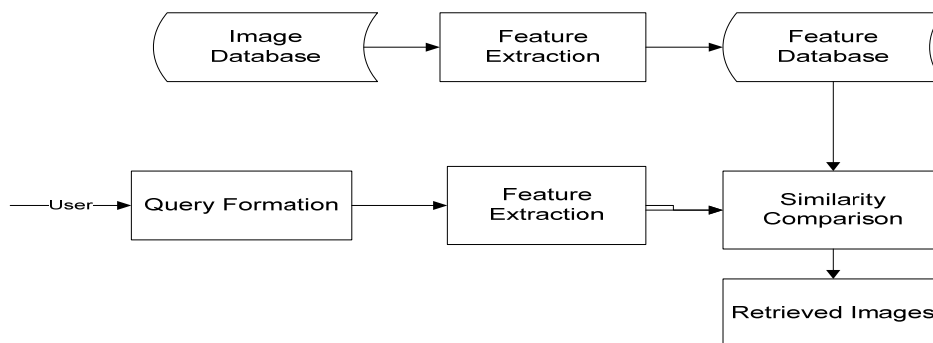


Fig 1. Block-diagram of a CBIR system

In the proposed work, a method for enhancing the precision of CBIR using Walsh Wavelet and shape features in a two-stage process is described. Reduced size feature vectors are generated using Walsh Wavelet transforms and its inverse transforms. The shape is extracted using any of the edge detection techniques, Roberts, Sobel, Prewitt or Canny. For comparative performance study, other transforms – Walsh and Walshlet based approaches are also implemented. In all three cases, the feature vector size for a color image of size  $256 \times 256 \times 3$ , is  $16 \times 16 \times 3$ . For RGB image, the image transformations are done on the three planes separately.

#### 4. Color and texture feature extraction

Colour and texture features are extracted using the transform coefficients. Thus the algorithms for computing these features using Walshlet, Walsh transform and Walsh wavelet are briefly described in the following paragraphs.

##### 4.1. Walshlet [7]

The steps for generating Walshlets are given below. Let  $I_{N \times N}$  be the image with size  $N \times N$ , of which the Walshlets are to be obtained and  $W_{N \times N}$  be a Walsh transform matrix of size  $N \times N$ .

1. Apply a Walsh transform of size  $N \times N$  on the image of size  $N \times N$  to get a Walsh transformed image,  $wI_{N \times N}$  with approximation (wIA), horizontal (wIH), vertical (wIV) and diagonal (wID) components:

$$(1) \quad wI_{N \times N} = [wIA, wIH, wIV, wID] = [W_{N \times N}] [I_{N \times N}] [W_{N \times N}]^T.$$

2. Replace horizontal (wIH), vertical (wIV) and diagonal (wID) components with zero to get modified Walsh transformed image “mwI”,

$$(2) \quad mwI_{N \times N} = [wIA, \text{Zero}, \text{Zero}, \text{Zero}].$$

3. Apply inverse Walsh transform on the modified Walsh transformed image to get  $m'wI$ ,

$$(3) \quad m'wI_{N \times N} = [W_{N \times N}]^T [mwI_{N \times N}] [W_{N \times N}].$$

4. Down-sample the result of Step3 ( $m'wI$ ) by taking alternate rows and columns to get an image with size  $N/2 \times N/2$ ,

$$dwI_{N/2 \times N/2} = \text{downsample}(m'wI_{N \times N}).$$

5. Apply Walsh transform of size  $N/2 \times N/2$  on down-sampled image ( $dwI_{N/2 \times N/2}$ ) to get the Walshlet of level 1,

$$\text{Walshlet Level 1} = [W_{N/2 \times N/2}] [dwI_{N/2 \times N/2}] [W_{N/2 \times N/2}]^T.$$

6. Repeat Steps from 2 up to 5  $P-1$  times on the level 1 Walshlet to get Walshlet of level  $P$ .

In this work Walshlet level 4 of a  $256 \times 256$  RGB image is used to create a feature vector of size  $16 \times 16 \times 3$ .

##### 4.2. Walsh transform

Let  $N \times N$  is the size of a 2D image and  $N=2^n$ . The forward kernel of the Walsh transform in 2D is defined as

$$g(x, y, u, v) = \frac{1}{N} \prod_{i=0}^{n-1} (-1)^{[b_i(x)b_{n-1-i}(u) + b_i(y)b_{n-1-i}(v)]},$$

where  $b_i(x)$  is the  $i$ -th bit in the binary representation of  $x$ . The inverse kernel of the Walsh transform is the same as the forward kernel.

The Walsh transformation kernel is a symmetric matrix with orthogonal rows and columns. The other properties of the Walsh transformation kernel  $W_j$ , for  $j = 0, 1, \dots, N-1$ , are the following: [7]

- $W_j$  takes on the values +1 and -1.
- $W_j[0] = 1$  for all  $j$ .
- $W_j$  has exactly  $j$  zero crossings, for  $j = 0, 1, \dots, N-1$ .
- Each row  $W_j$  is either even or odd with respect to its midpoint.

In this work the feature vector is created by taking the upper leftmost  $16 \times 16$  elements in the Walsh transform of the image and finding its inverse Walsh transform.

#### 4.3. Walsh wavelet

The algorithm for generating a Walsh wavelet transformation matrix of size  $N^2 \times N^2$  from a Walsh transform of size  $N \times N$  is given below [5].

Let  $W_{N \times N}$  is the walsh transformation kernel of size  $N \times N$ .

**Step 1.** For  $j=1, \dots, N$

Repeat the column  $j$  of  $W_{N \times N}$ ,  $N$  times.

**Step 2.** For  $j=2, \dots, N$

Repeat the row  $j$  of  $W_{N \times N}$ ,  $N$  times each with a shift of  $N$ .

For a 2D image  $f_{N \times N}$ , the Walsh Wavelet transform is given by

$$F_{N \times N} = [\text{WLT}_{N \times N}] [f_{N \times N}] [\text{WLT}_{N \times N}]^T$$

where  $[\text{WLT}_{N \times N}]$  is the Walsh wavelet of size  $N \times N$ .

The inverse transform of the image is given by

$$f_{N \times N} = [\text{WLT}_{N \times N}]^T [F_{ij} / D_{ij}] [\text{WLT}_{N \times N}]$$

where  $[D_{N \times N}] = [\text{WLT}_{N \times N}] [\text{WLT}_{N \times N}]^T$  is the diagonal matrix and

$$D_{ij} = D_i D_j ; 1 \leq i \leq N \text{ and } 1 \leq j \leq N.$$

In the algorithm proposed, the feature vector of an image is obtained by taking the upper-leftmost  $16 \times 16$  elements in the Walsh wavelet transform of the image and taking its inverse. And this is done on each plane of the RGB image to create a feature vector of size  $16 \times 16 \times 3$ .

## 5. Shape feature extraction

The shape is an important feature in an image. In this work an edge detection method is used for extracting the shape feature. The edge detection is an important method in image analysis. Edge detection is a method which identifies the points in the digital image at which there are discontinuities in the brightness of the image. The output of an edge detector is a set of connected curves that indicate the boundaries of objects, the figures on the surface and other discontinuities in the image. Thus, applying edge detection on an image will reduce the amount of irrelevant data while preserving important structural information in the image and will simplify the subsequent data processing required for image analysis. There are many ways, such as Laplacian, gradient, etc. for performing edge detection. In the gradient method gradient operators, Roberts, Sobel, Prewitt and Canny are used for

edge detection. Roberts, Prewitt and Sobel return the edges at those points where the gradient is maximum and Canny method finds the edges by looking for local maxima of the gradient.

## 6. Experimental results and discussion

Our experimental database contains 44 RGB images of size 256×256. In this work the color and texture features of the image are extracted using Walshlet, Walsh transform and Walsh Wavelet. 10 images are retrieved using each of these methods. The database size is small since Walshlet will take long time to execute. The shape feature extraction using Edge Detection is applied on each of these 10 images and the final 5 images are retrieved. Edge detection is done using operators like Roberts, Sobel, Prewitt and Canny.

To retrieve images, the similarity between the query image and images in the database are computed using Euclidian Distance (ED). The Euclidian distance between the image  $P$  and the query image  $Q$  is given by

$$ED = \sqrt{\sum_{i=1}^n (V_{pi} - V_{qi})^2},$$

where  $V_{pi}$  and  $V_{qi}$  are the feature vectors of the image in the database and the query image.

To evaluate the performance of these techniques we have used a measure called precision and recall. The standard definitions of precision and recall are given by the following equations:

$$\text{Precision} = \frac{\text{Number of relevant images retrieved}}{\text{Total number of images retrieved}},$$

$$\text{Recall} = \frac{\text{Number of relevant images retrieved}}{\text{Total number of relevant images in the database}}.$$

The proposed image retrieval approach and the approaches based on Walshlet and Walsh transforms are implemented on Matlab R2010a on Intel i3 core processor. The experimental results show that the average precision value for CBIR by applying shape feature extraction on the output of the images retrieved in Walsh Wavelet is greater than the precision value obtained by using Walsh Wavelet alone and this precision value is greater than the value obtained by applying shape feature extraction on the output of the images retrieved in Walshlet and Walsh transform.

For the query image shown in Fig. 2, the first five images retrieved for this query using Walshlet, Walsh transform and Walsh wavelet with Sobel edge detector are shown in Figs 3 and 4 respectively.



Fig. 2. Query image



Fig. 3. Images retrieved using Walshlet and Walsh transforms with Sobel operator



Fig. 4. Images retrieved using Walsh wavelet with Sobel operator

Shown below in Fig. 5 are the bar graphs of the precision values obtained for six query images Img1, Img2, Img3, Img4, Img5 and Img6, using Walshlet, Walsh and Wash Wavelet transforms with Sobel operator.

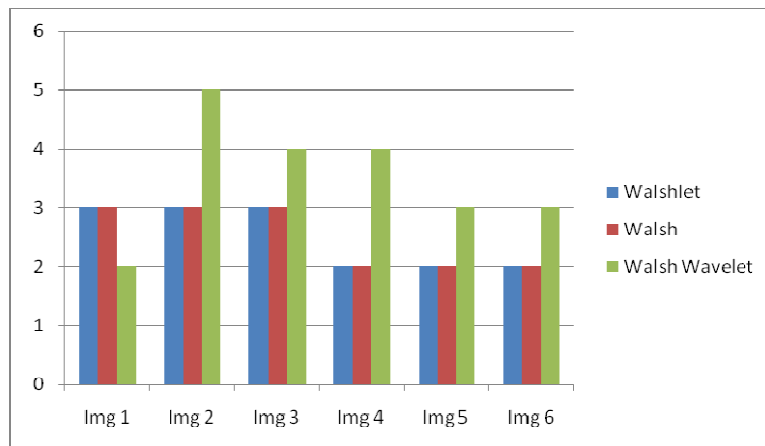


Fig. 5. Precision values for different approaches of image retrieval

The average precision values for Walshlet, Walsh and Walsh Wavelet using Sobel operator are shown in the Table 1 given below and the average precisions without a shape feature for the these three methods are shown in Table 2.

Table 1. Average precision values with Sobel operator

Transform	Walshlet	Walsh	Walsh Wavelet
Precision	0.6	0.6	0.7

Table 2. Average precision values without a shape feature

Transform	Walshlet	Walsh	Walsh Wavelet
Precision	0.5	0.5	0.57



The average precision and recall values for CBIR by taking different features in account are given in Table 3. The shape features are extracted using Sobel Edge operator. Color and Texture features are extracted using Walsh Wavelet. In the single stage retrieval process using color, texture and shape features, equal weights are given to the three features. In color, texture and shape features in two level (two stage) retrieval, the shape feature extraction is applied on the output images obtained using color and texture features. The recall value is less in this case since the number of the images retrieved is 5 and in other cases it is 10. But the average precision is higher for this method.

Table 3. The average precision and recall values for different features

Feature	Average precision	Average recall
Shape only	0.32	0.55
Color and Texture	0.48	0.75
Color, Texture and Shape using weightage	0.48	0.75
Color , Texture and Shape in two levels	0.7	0.58

In the last method for performance comparison, Roberts, Prewitt and Canny edge operators are used for shape feature extraction in addition to Sobel edge operator. The average precisions using Sobel, Prewitt, Roberts and Canny operators are given in the Table 4.

Table 4. Average precisions using different operators

Operator	Average precision
Sobel	0.7
Prewitt	0.7
Canny	0.67
Roberts	0.63

From the table it is observed that Sobel and Prewitt operators give the highest value for average precision when applied on the output of Walsh wavelet.

## 7. Conclusion

The size of image databases is increasing rapidly day by day. Efficient and effective image retrieval techniques are needed to search such huge databases. In this work a method for improving the precision of CBIR using Walsh Wavelet by taking a shape feature of the image into consideration is proposed. The performance of the proposed approach is compared with Walshlet and Walsh transform based approaches. The experimental results show that the precision value is higher in the two stage retrieval process with a shape feature in the second stage when compared to the precision using shape and Walsh Wavelet in a single stage approach. The experimental results

also show that Walsh Wavelet has higher precision than Walshlet and Walsh transform and the shape features extracted with Sobel and Prewitt give higher average precision than Canny and Roberts.

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