An Efficient Content Based Image Retrieval Technique using Wavelet Transform

Mohini P. Sardey[1] Dr. Siddharth Ladhake[2]
[1]Savitribai Phule Pune University, Pune [2]Sant Gadgebaba Amravati University, Amravati

Abstract— The year 1990 is the witness of an explosion of wavelet-based methods in the field of Image Processing. The rapid expansion of the Internet and the wide use of digital data have increased the need for both efficient image database creation and retrieval procedure. The challenge in image retrieval is to develop methods that can capture the important characteristics of an image, which makes it unique, and allow its accurate identification. Techniques such as Color Histogram, Eigen Values and Match Point are used for image retrieval and its performance is studied wrt to retrieval time and efficiency. This paper primarily focused on Wavelet based Content based Image retrieval [24]. To check the retrieval performance, Image database containing face database, floral database, vehicle database and Animal Database is created. Retrieval efficiency and accuracy using wavelet based features is found to be superior to other existing methods such as Color Histogram, Eigen Values, Match Point method.

Key words: Wavelet Transform, Color Histogram

I. INTRODUCTION

Image processing field itself is very huge. It encompasses, at the very least, the following area of Image Processing such as Image Denoising, Image Recognition, Feature detection, Image Enhancement, Texture Classification, Image Compression, Image Retrieval etc. Reason behind that wavelet analysis provides all-encompassing too for Image Processing is that a similar type of analysis occurs in the human visual system. To be more precise, the human visual system performs hierarchical edge detection at multiple levels of resolution and wavelet transforms perform a similar analysis [1][3].

All of us know that Image speaks almost more than 1000 words. Therefore instead of manual annotated by key words, images could be indexed by their own visual content such as color, texture and shape. This is the reason Content Based Image Retrieval (CBIR) attracts many researchers. However, research on CBIR is still in its early stage [3][6].

Two main types of image retrieval systems are Text Based Image Retrieval and Content Based Image Retrieval [18], [19],[20]. Early years text based image retrieval system was popular but in recent years, CBIR has been a topic of intensive research [21]. In order to automate data analysis and indexing, many researchers are attracted towards CBIR. Important reason is CBIR acts like a filter that filters information process and used to provide a high percentage of relevant images in response to query image. CBIR system uses features to represent an image content. As these features are extracted automatically, there is no manual intervention, that eliminate the dependency of human in feature extraction stage [22][23].

We have used a simple architecture in CBIR system which perform major task of image identification at initial stage, using edge detection technique as shown in the block diagram. Search techniques are based on many features such as color, shape and texture but this paper is focused on Image retrieval technique based on Wavelets where directional features are extracted using subband coding as computation time required is very low which helps in efficient retrieval of required image.

This paper proposes a technique of image retrieval which first identifies the type of image by using edge detection technique, as shown in fig.2. This step is essential because category of images used here is Face, Animal, Vehicle and Floral database. Hence identification of type of image is essential before retrieval process begins. This process is explained in Fig. 1 below.

Rest of the paper is organized as follows. Section II illustrates the explanation of Wavelet Transform. Section III gives details of pyramidal wavelet transform. Section IV explains new technique, 'Match Point', section V, gives the comparative result in tabular and graphical form and finally section VI draws the conclusion remark and future scope is discussed.

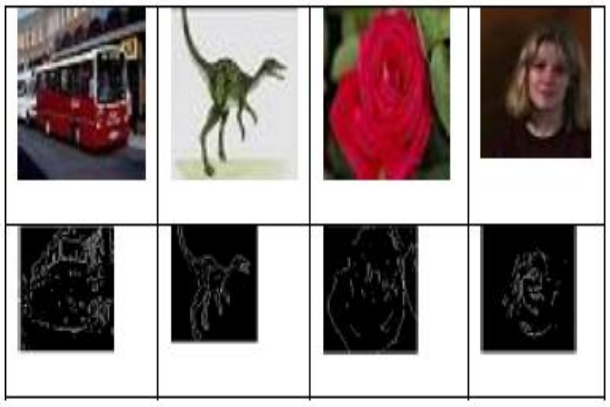


Fig. 1: Image and its edges

II. WAVELET TRANSFORM

In this section we will discuss pyramidal and tree structured wavelet transform in brief.

Basic idea behind wavelet transforms is to iterate invertible smoothing and differencing operations and, at each iterations, maintain the same number of pixels as the original image. Fig. 2 shows how differencing and smoothing operations ca be applied to a test image [1][6]. At Level 1, the image is smoothed (via local averages) and size is reduced to a 1=4, this is its lower resolution version of original image, and three kinds of edges are detected using local differencing operations, diagonal component images (horizontal and vertical edges suppressed), vertical component images (horizontal edges suppressed) and horizontal component images (vertical edges suppressed). At this level, total number of pixel is equal to that of the original image. Moreover, original image can be reconstructed by inverse operation

Same process of wavelet transform of averaging and differencing is repeated at level 2 on smoothed subimage of Level 1. This iterative process continues. As shown in Fig. 2, iteration is stopped at Level 3.

The Level 3 transform consists of a 1=64 size smoothed subimage, and all of the edge subimages created by local differencing at each level. The original image can be recovered from this 3-Level transform.

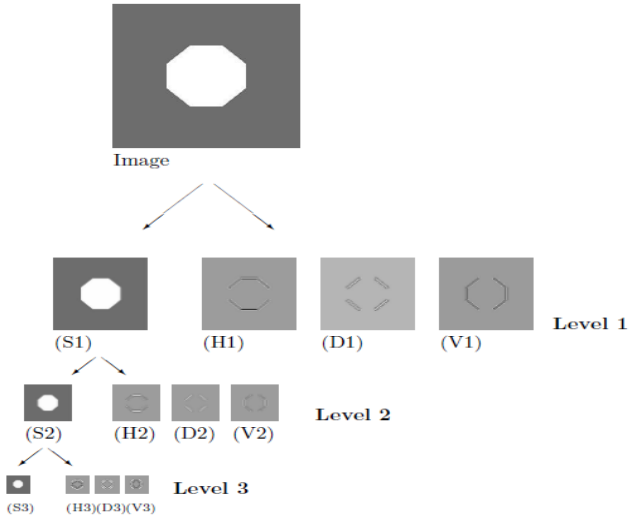


Fig. 2: Example of a wavelet transform. (S1) Smoothed subimage obtained from local averaging of image, 1/4 resolution. (H1) Horizontal component subimage (obtained from localized vertical differencing and localized horizontal averaging of image) (D1) Diagonal component subimage (obtained from localized vertical differencing and localized horizontal differencing of image) (V1) Vertical component subimage (obtained from localized horizontal differencing and localized vertical averaging of image). (S2), (H2), (D2), (V2) Iteration of localized averaging and localized differencing applied to (S1) subimage. (S3), (H3), (D3), (V3) Iteration of localized averaging and localized differencing applied to (S2) subimage [24].

Reason for why wavelet transforms have such profound effect on Image Processing. First, edge subimages that are created at multiple resolution are analogues to a process performed by mammalians vision systems (including human vision systems). See [10], [11], [12], and [13]. Second reason, the process by which a wavelet transform is constructed (differencing and local averaging operations at multiple resolutions) is akin to some important methods for analyzing images. It is akin to the Laplacian pyramid method of Burt and Adelson ([14] and [15]) and the Mumford-Shah theorem concerning edges and smooth background in images [15]. Third reason, there exist an analogy between V and wavelet transforms. See [16] for an excellent discussion. Fractal-like nature of the wavelet transform is particularly evident in Fig. 2.

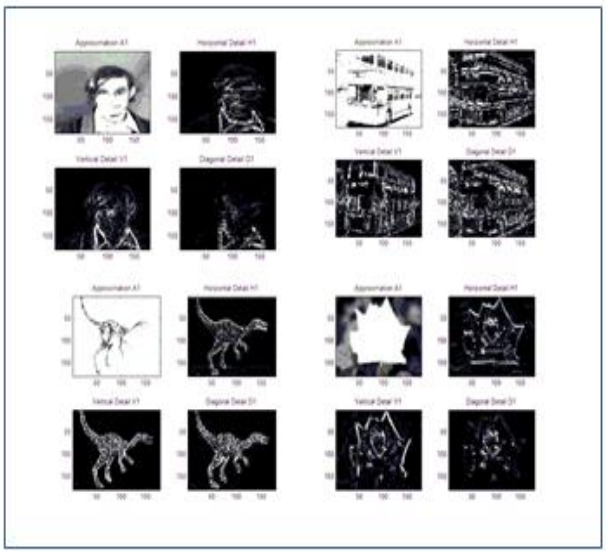


Fig. 3: Result of Pyramidal Wavelet Transform (DWT) decomposition

III. PYRAMIDAL WAVELET TRANSFORM

Discrete Wavelet Transform (DWT) has become very popular recently in image coding application. Image processing application using wavelets provide good energy compaction, multiresolution capability and adaptability to human visual characteristics [7][8].

Wavelets are obtained as a result of wavelet transform that represents a function as a superposition of a family of basis functions. These set of basis functions are obtained as translation and dilation of mother wavelet. Signal is passed through a high pass and low pass filters and output of filter is decimated by 2. This way wavelet transform extracts information from signal at different scale. To generate the original information i.e. reconstruction, the coefficients are upsampled and passed through another set of low pass and high pass filters [7][8][3].

The 2-D DWT is generally calculated using a separable approach. Three level pyramidal decomposition of an image S1 of size a X b pixels is shown in Fig 3. After 1st level decomposition, one low pass subimage S2 and three orientation selective high pass subimage (W2H, W2V, W2D) are created. At 2nd level decomposition, the low pass subimage is decomposed further into one low pass image and three high pass subimage (W4H, W4V, W4D). Similar process is repeated on low pass subimage to form higher level wavelet decomposition.

IV. MATCH POINT BASED

Here we have used Computer Vision System Toolbox to detect the objects using Viola Jones algorithm. Functions used to detect the corners in grey scale image, returns location as a matrix of [x,y] coordinated.

The object finds corner in an image using Harris corner detection, minimum Eigenvalues or local intensity comparison method. Using another function, feature vectors are extracted from intensity or binary image. These vectors are also known as descriptors and are derived from pixels surrounding an interest point by the function. These pixels match features and describe them by a single-point location specification. The function extracts feature vectors from an

input intensity or binary image. These feature vectors, also known as descriptors are returned as M-by-N matrix having M feature vectors and each descriptor having length N. Corresponding to each descriptor, M number of valid points is also returned. To match the features, match features function is used. To display corresponding feature points an overlay of pair of images in addition to a color-coded plot of corresponding points connected by a line, but the location is defined in the Surf point objects.

V. Tabular and Graphical comparison of retrieval techniques.

Tabular and Graphical comparison of retrieval time of all types of databases with three different techniques, such as match Point, Histogram and Eigen Values is as shown below in fig 4 and Fig 5. It shows that the retrieval time of mages using Wavelet is minimum as compared with all other techniques. Also retrieval efficiency is improved using wavelet. Reason behind this is iterative decomposition of images which in turn reduces the size of image at every stage.

Techniques Image Database	Match Points	Histogram	Eigen Values	Wavelet
Face	5.357360	11.689926	3.745824	2.743924
Flower	15.029603	12.321363	5.893213	4.988143
Vehicle	6.987936	13.361342	4.189032	3.311586
Animal	6.152623	12.084985	4.918243	3.162717

Table 1: Comparison of Retrieval Time required in seconds

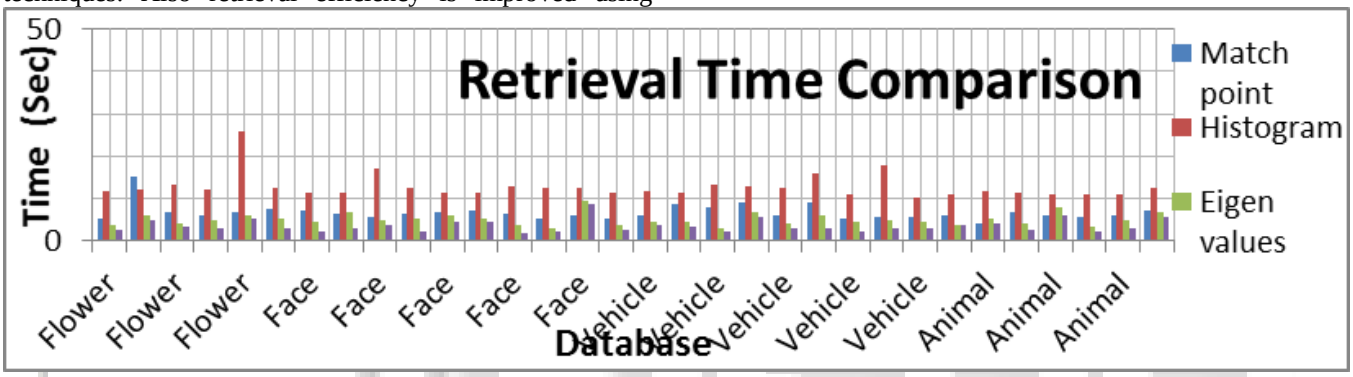
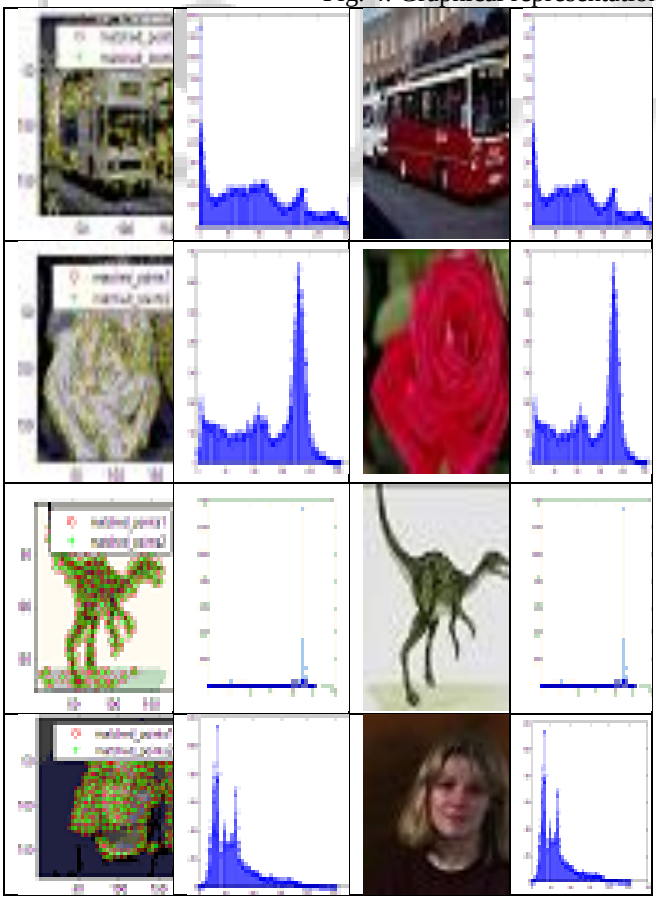


Fig. 4: Graphical representation of Comparison of Retrieval Time.



Results of Match Point	Histogram of image from database	Query image	Histogram of Query image

Fig. 5: Results of Match points and Histogram for all four image datatypes [25].

VI. Conclusion

Content-based image retrieval using wavelet based feature is proposed. Tree structured wavelet decomposition and pyramidal wavelet decomposition is used. Large image database of 1000 images is used to check the retrieval performance. This paper proposes image retrieval technique based on Wavelet for the various type of database such as human face, vehicle, animal and flower. Since various category of database images are used, retrieval begins with searching of type of image using edge detection technique. Once the datatype is recognized, then retrieval of image is done on wavelet transformation.

It is found that retrieval time reduces significantly and with greater efficiency. Match point is a new technique which is used and found to be comparatively better than that histogram

VII. Future scope

Nowadays, discrete wavelet transform has become the most useful tool for signal processing and it still has many potentialities. For this reason, we should continue on developing more powerful tool or efficient algorithm in this area. Two main requirements of content-based image

retrieval are that it should have high retrieval accuracy and less computational complexity

REFERENCES

[1] Manesh Kokare, B .N.Chatterji and P.K.Biswas, "A Survey on current content based Image Retrieval Methods," IETE Journal of Research, vol. 48, no. 3 &4, pp. 261-271, 2002.
[2] S. Satini, R. Jain, " Similarity Measures," IEEE Transactions on pattern analysis and machine Intelligence, Vol.21, No.9, pp.871-883, Sept. 1999.
[3] Gonzalez. R.C, Woods. R.E, Eddins.S.L, Digital Image Processing using MATLAB, Pearson Education,2005, p. 482.
[4] A. W. M. Smeulders, M. Worring, S. Santini, A. Gupta, and R. jain. "CBIR at the end of early years. IEEE Transaction on Pattern Analysis and Machine Intelligence (PAMI), 22(12): 1349-1380, 2000.
[5] Y. Liu, D. Zhang, G. Lu, W. Y. Ma, 2007. "A survey of Content Based Image Retrieval with high level semantics", the journal of recognition society, pp. 262 – DOI:10.1016/j.patcog.2006.04.045
[6] Manesh Kokare, P.K. Biswas, and B.N. Chatterji, "Cosine-modulated wavelet packet based texture features for content based image retrieval," IETE Journal of Research, Vol. 51, No.6, pp. 477-483, Nov-Dec 2005.
[7] Manesh Kokare, B.N. Chatterji, and P.K. Biswas, "A survey on current content-based image retrieval methods," IETE Journal of Research, Vol.48, no.3&4, pp.261-271, May-Aug 2002.
[8] Pushpa Patil, and Manesh Kokare, "Relevance feedback in Content-based image retrieval" Proceeding of 4th International Conference Computer Application in Electrical Engineering-Recent Advances. Feb. 19 to 20, 2010, pp. 40, IIT Roorke.
[9] T. Chang and C.C. Kuo, "Texture Analysis and Classification with Tree-Structured Wavelet Transform," IEEE Trans.Image Processing, Vol.2 No.4, pp.429-441, 1993.
[10] Watson, A. B. (1987). \E_ciency of a model human image code." J. Optical Soc. Am., 4, 2401{17.
[11] Field, D. J. (1999). Wavelets, vision and the statistics of natural scenes." Phil. Trans. of the Royal Soc., 357, 2527{2542.
[12] Field, D. J., and N. Brady. (1997). \Wavelets, blur and the sources of variability in the amplitude spectra of natural scenes." Vision Research, 37, 3367{83.
[13] Marr D. (1982). Vision. San Francisco, CA: W.H. Freeman
[14] Burt P.A., and E.H. Adelson. (1983). \The Laplacian pyramid as a compact image code." IEEE Trans. COMM., 31, 532{540.
[15] Jahne, B. (2002). Digital Image Processing. 5th Ed. Berlin: Springer.
[16] Li J., and S. Lei. (1999). An embedded still image coder with rate distortion optimization." IEEE Trans. on Image Processing, 8, 913-24.
[17] An Introduction to Wavelet Transform by Pao-Yen Lin)
[18] Rajashekhara," Novel Image Retrieval Techniques: domain specific approaches," Ph.D. Thesis Department of Electrical Engineering Indian Institute of Technology – Bombay, 2006.

