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MRI Image Retrieval Using Wavelet with Mahalanobis Distance Measurement

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Abstract – In content based image retrieval (CBIR) system, the images are represented based upon its feature such as color, texture, shape, and spatial relationship etc. In this paper, we propose a MRI Image Retrieval using wavelet transform with mahalanobis distance measurement. Wavelet transformation can also be easily extended to 2-D (image) or 3-D (volume) data by successively applying 1-D transformation on different dimensions. The proposed algorithm has tested using wavelet transform and performance analysis have done with HH and H* elimination methods. The retrieval image is the relevance between a query image and any database image, the relevance similarity is ranked according to the closest similar measures computed by the mahalanobis distance measurement. An adaptive similarity synthesis approach based on a linear combination of individual feature level similarities are analyzed and presented in this paper. The feature weights are calculated by considering both the precision and recall rate of the top retrieved relevant images as predicted by our enhanced technique. Hence, to produce effective results the weights are dynamically updated for robust searching process. The experimental results show that the proposed algorithm is easily identifies target object and reduces the influence of background in the image and thus improves the performance of MRI image retrieval.

Keywords: CBIR, MRI, Wavelet, Mahalanobis distance

1. Introduction

With the development of multimedia network technology and the rapid increase of image application, CBIR (Content Based Image Retrieval) has become the most active one in multimedia information retrieval domain and its application fields are becoming more and more widely used. Medical application called DICOM (Digital Imaging and Communication in Medicine Standard) in which images are stored has grown rapidly during the last decades. Earlier days, meta data such as keywords (i.e.) authors name or a word from patients report was used for the retrieval process. Sometimes, the irrelevant image may be stored under the name of a keyword, this gives poor retrieval results. Most traditional image retrieval systems usually use color, texture, shape, spatial relationship. These low level image features are used to describe the image content and take them as the retrieval index and matching rule. In CBIR, texture features play a very important role in computer vision and pattern recognition, especially in describing the content of images [1]. An MRI image retrieval system using wavelet transform with mahalanobis distance measurement technique is designed in this paper.

The main contributions of this paper are as follows.

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1. Design of wavelet filters to create a candidate subset and to handle texture images efficiently.
2. Similarity measures are used to retrieve the most similar MRI images as in the query.

This above mentioned framework is particularly used to retrieve MRI images stored in the database. Section 2 introduces background knowledge about the CBIR and wavelet transform. Section 3 gives the proposed retrieval technique in details. Section 4 gives the experimental results. Conclusion and future research directions are given in section 5.

2. Content Based Image Retrieval

Content based image retrieval (CBIR) has become one of the most active areas in medical image processing. The aim of CBIR is to find the exact image which we need. Retrieving medical image from a large database is a challenging problem [2]. Content-based image retrieval systems have been dealt with the issue of automatic indexing and retrieval of images. The application of image retrieval in many areas such as fashion and design, crime prevention, medicine, law, and science makes this research field one of the important and fastest growing in information technology.

However, there are so many problems associated with retrieving of medical images based on text such as manual

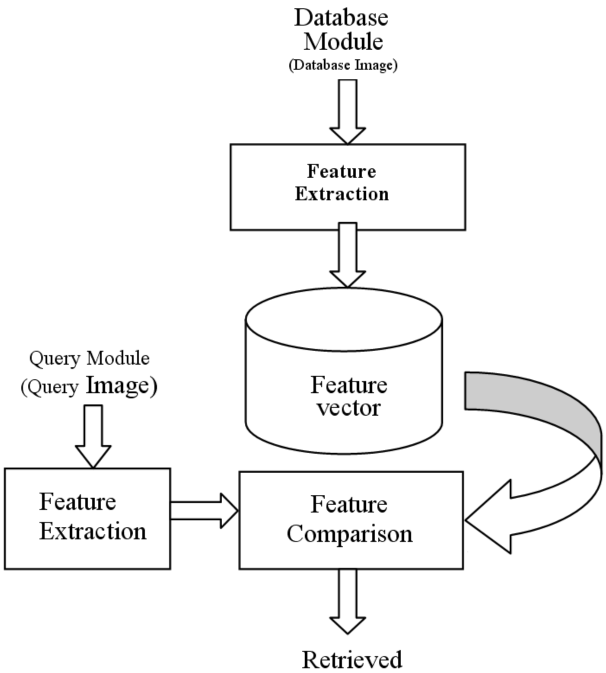

Fig. 1. Block Diagram of CBIR

representation of keywords, differences in perceptions and interpretations, and a few others. Due to this, CBIR researchers came up with retrieved images are based on automatically derived low level features or high level features. Among these low level features are the most popular due to its simplicity compared to other level of features plus automatic object recognition and classification is still among the most difficult problems in image understanding and computer vision.

The general CBIR block diagram is shown in Fig. 1. It consists of three main modules such as database module, query module, and retrieval module. In the database module, the feature vector is extracted from database images. It is then stored along with its database image. On the other hand, when a query image enters the query module, it extracts the feature vector of the query image. In the retrieval module, the extracted feature vector is compared to the feature vectors stored in the image database. As a result of query, the similar images are retrieved according to their closest matching scores. Finally, the target image will be obtained from the retrieved images. Similar images are identified by using mahalanobis distance measurement. This mahalanobis based distance classification provides better result than Euclidean distance measurement.

In the proposed image retrieval framework, a filtering process is first performed using wavelets to select a subset of images. Textures can be modeled as quasi- periodic patterns with spatial-frequency characteristics [3]. Wavelet transform keep both global and local information and thereby reducing the dimensionality without losing useful information. Wavelet transform can be used to decompose the image from one level to another level. Here the energy is separated into various types of scales (i.e.) analyzing the images at more than one resolution. The low frequency components (approximations) contain more information than the high frequency components (details). Wavelet transform is preferred since it uses a specific subset of all scale and translation values and less computationally complex [4]. Wavelets have been proved advantageous in terms of computational complexity and image quality of compressed images.

3. Proposed Framework

3.1 HH elimination method

During the wavelet transform, each input image goes through the row and column transform decomposing the image into four subbands (LL, LH, HL and HH). The energy efficient wavelet transformation is used to implement the HH elimination and H* elimination methods. To implement the HH elimination method after the row transform, the high pass coefficients are only fed into the low pass filter and not the high pass filter in the following column transform step as shown in Fig. 2. This avoids the generation of the diagonal subband (HH). This method saves computational energy as in accordance with the analysis of computation that denotes the two loads namely data access load and computation load that are associated with the subband generation.

The HH elimination method, which eliminates the insignificant high pass subband, can be continued to process the image by a greater depth of transformation. The multiple level of decomposition is performed in the same way neglecting the high pass subband at the first level of decomposition and be subjected to a normal two-dimensional wavelet transform from the second level with the consideration of the image loss. A number of useful information is lost when the elimination is continued after one or two levels of decomposition. To retain the image quality, the elimination level is performed only in the lower levels.

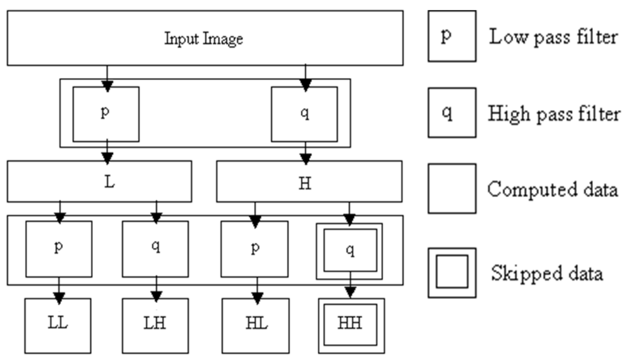

Fig. 2. HH Elimination method

3.2 H* Elimination method

The H* elimination method also employs the modified wavelet transformation and in this method it retains the most significant low pass subband and eliminates all the high pass subbands i.e., horizontal, vertical and diagonal.

The MRI image retrieval system, an image of both database and query are normalized and resized from the original, the normalized image equally resized to size of 256 x 256[5]. In the proposed frame work, MRI images are decomposed into six levels by using of wavelet transforms and the corresponding energies are extracted by calculating the mean. By using Mahalanobis distance the most similar matches are found from the database images as in the query. The retrieval is the relevance between a query image and any database image [6]. The proposed method block diagram is shown in Fig. 4. The relevance similarity is ranked according to closest similar measures computed by the Mahalanobis distance [7]. An adaptive similarity synthesis approach based on a linear combination of individual feature level similarities is analyzed. Moreover, Mahalanobis distances are based on both the mean and variance of the predictor variables, plus the covariance matrix of all the variables and therefore take advantage of the covariance among variables.

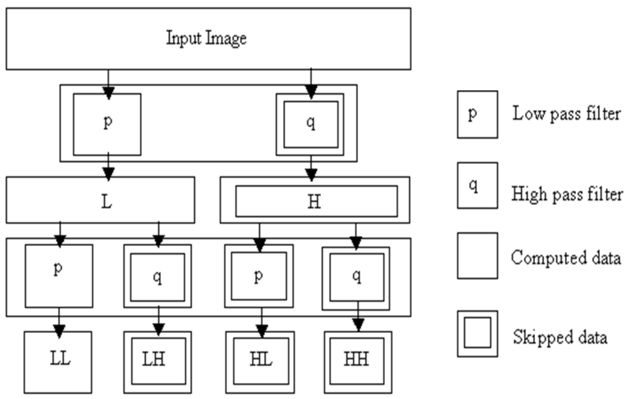

Fig. 3. H* Elimination method

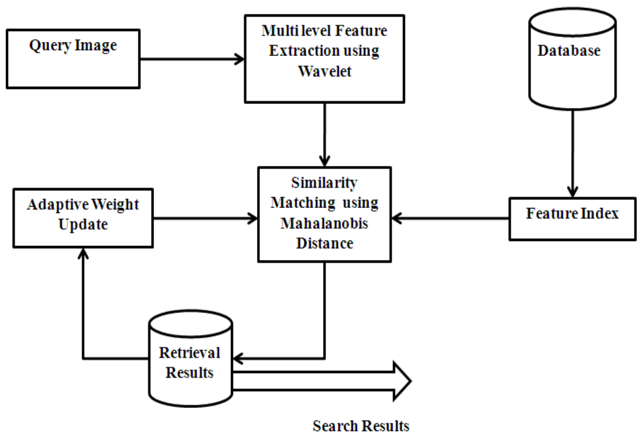

Fig. 4. Proposed Block Diagram

3.3 Algorithm for energy calculation

1. Decompose the image into 6 levels
2. Calculate the energy of all decomposed images at the same scale, using

$$\mu = 1 / N_{mn}^{2} \iint |W_{mn}(x,y)| dxdy$$

Where N is the length of a particular subband mn. The feature vector f, for a particular image is $f = |\mu_{mn}|$, $n \neq 1$ except for the coarsest level, m = 6.

$$f = |\mu_{1,2}, \mu_{1,3}, \mu_{1,4}, \mu_{2,2} \ldots \mu_{6,1}, \mu_{6,2}, \mu_{6,3}, \mu_{6,4}|$$

3. If the energy of a sub-image is significantly larger, repeat from step1

3.4. Mahalanobis distance classification

The similarity measure by a given query image involves searching the database for similar wavelet coefficients as the input query. Mahalanobis Distance is suitable and effective method over Euclidean distance measurement [8]. The retrieved images are ranked by their similarities distance with the query image. The similarity distance measure between the vectors of query image and the database image can be shown in Fig. 5. Below mentioned Eq. (2) shows the mahalanobis distance measurement expression, Where D is the mahalanobis distance. The computed distance is ranked according to closest similar, in addition, if the distance is less than a certain threshold set, the corresponding original images is close or match the query image.

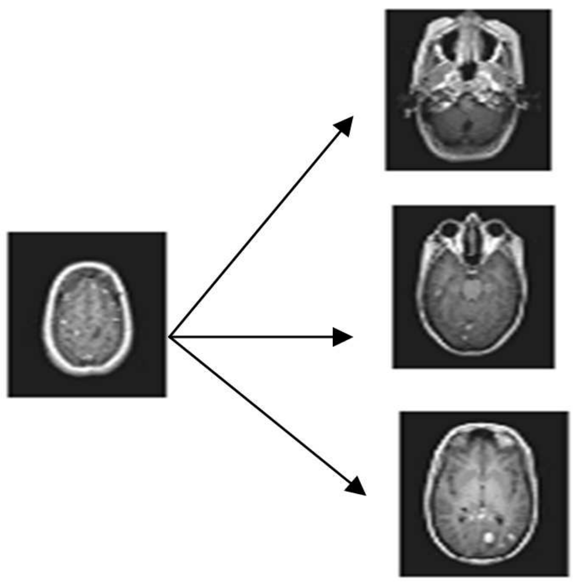

Fig. 5. Similarity measure by using mahalanobis distance

$$D^2 = (x-m)^T C^{-1} (x-m) \quad (2)$$

Where:

x - Vector of data
m - Vector of mean values of independent variables
C^{-1} - Inverse covariance matrix of independent variables
T - Indicates vector should be transposed
Here multirate vector $x = (x_1, x_2, x_3, \ldots, x_N)^T$ and
Mean $m = (m_1, m_2, m_3, \ldots, m_N)^T$

Mahalanobis distance for dissimilarity measure between two random vectors $\vec{x}$ and $\vec{y}$ shown in Eq. (3)

$$D(\vec{x}-\vec{y}) = \sqrt{(\vec{x}-\vec{y})^T S^{-1} (\vec{x}-\vec{y})} \quad (3)$$

Wavelet transform is used to reduce the computation time by saving the energy calculation with minimal degradation in image quality. The aim for energy calculation algorithm is to minimize computation energy. Two techniques (HH elimination and H* elimination) can be used for saving the energy. Among the four subbands, the diagonal subband (HH) is least significant, making it the best candidate for elimination during the wavelet transform step whereas in H* elimination. The most significant subband (LL) is kept and all high pass subbands (LH, HL and HH) are removed.

4. Experimental Results

The proposed method has been implemented in Matlab 2007a, on the database of 200 MRI images were collected [9]. The recall and precision rates are widely used to evaluate the retrieval efficiency of the proposed method. The recall rate is the ratio of the number of the relevant images retrieved to the total number of the relevant images in the database. While, the Precision rate is the ratio of the number of the relevant images retrieved to the total number of the irrelevant and relevant images retrieved as defined below.

We use the standard measures, precision and recall in different forms to evaluate the results.

$$\text{RECALL} = \frac{\text{Number of images retrieved and relevant}}{\text{Total no of retreived images in database}} \times 100 \quad (4)$$

$$\text{Pr ecison} = \frac{\text{Number of images retrieved and relevant}}{\text{Total no of retreived images}} \times 100 \quad (5)$$

The Average Recall Rate (AVRR) is given by Eq. (6)

$$\text{AVRR} = \frac{1}{Q} \left\{ \sum_{j=1}^{Q} \frac{\sum_{i=1}^{10} Rank_i}{N_r} \right\} \quad (6)$$

Where the rank of any of the retrieved images is defined to be its position in the list of retrieved image is one of the relevant images in the database. The rank is defined to be zero otherwise. Nr is the number of relevant images in the database and Q is the number of queries performed. Therefore AVRR is defined in Eq. (6).In our case, the number of images retrieved was 10, and Nr was less than 10.

$$\text{AVRR} = (N_r + 1) / 2 \quad (7)$$

The proposed experiment method shows promising results based on the above equations. The retrieval results

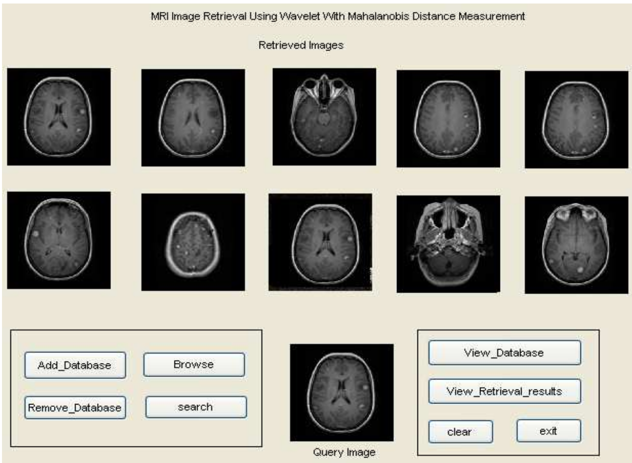

Fig. 6. Retrieval using No elimination

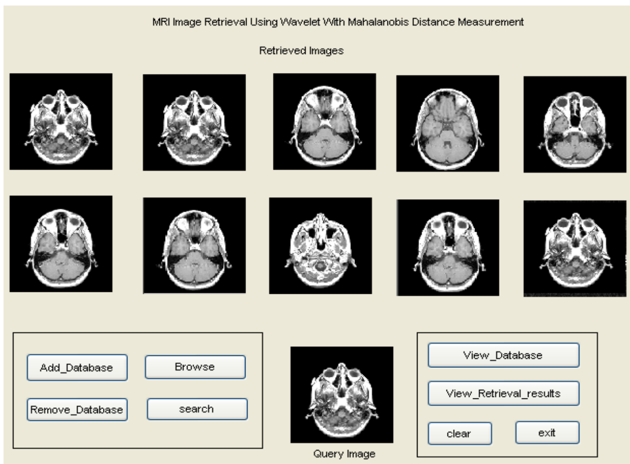

Fig. 7. Retrieval using HH elimination

based on the proposed method as shown in Figs. 6, 7 and 8.

Table 1 shows the comparison of precision and recall for HH, H^* and No elimination methods and finally Fig. 9 shows the precision v_s recall graph for HH, H^* and No elimination methods.

From Fig. 9 it is observed that H* elimination performs better than other two techniques.

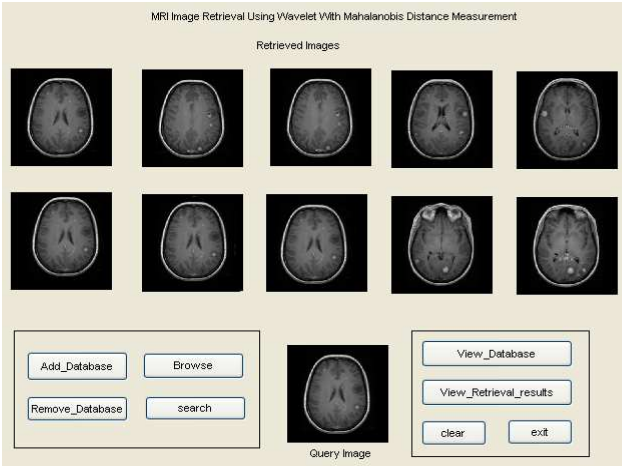

Fig. 8. Retrieval using H* elimination

Table 1. Comparison of Precision, Recall for No, HH and H* elimination

S.I. NO	No Elimination		HH Elimination		H* Elimination	
	Precision	Recall	Precision	Recall	Precision	Recall
1	1	0	1	0	1	0
2	0.6	0.1	0.65	0.1	0.68	0.1
3	0.56	0.15	0.6	0.15	0.64	0.15
4	0.5	0.2	0.56	0.2	0.58	0.2
5	0.47	0.3	0.5	0.3	0.52	0.3
6	0.45	0.4	0.48	0.4	0.5	0.4
7	0.4	0.5	0.45	0.5	0.48	0.5
8	0.35	0.6	0.4	0.6	0.45	0.6
9	0.3	0.7	0.35	0.7	0.4	0.7
10	0.25	0.8	0.3	0.8	0.35	0.8
11	0.1	1	0.25	1	0.3	1

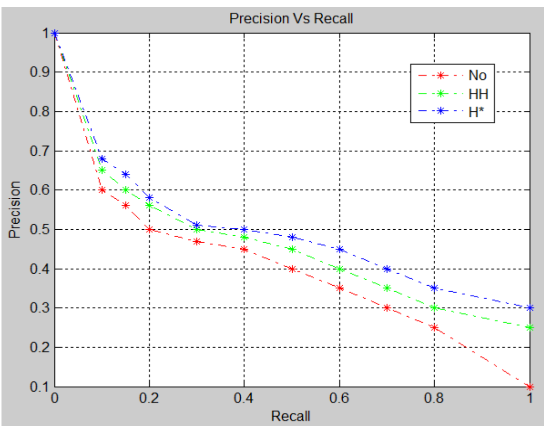

Fig. 9. Comparison of No, HH and H* Elimination

5. Conclusion and Future work

In the proposed techniques, the MRI images are classified based on the energy coefficients of the wavelet transforms. Here, the HH elimination and H* elimination techniques are used. Both techniques are very efficient in classification of the medical images. If the energy coefficients of the image are more, then the performance of the proposed algorithm will be better for medical images [10]. The features such as shape and size are not playing a role in this proposed MRI image retrieval techniques. We introduced a MRI image retrieval based on wavelet using mahalanobis distance classification. Also an adaptive weig-ht update based similarity synthesis approach is further improved the classification rate and good matching criteria. There are still many open research issues that need to be solved before the current image retrieval can be of practical use. At the current stage, we use only low level features. The performance is still far from human performance in understanding image classification. The querying interface is not powerful enough to allow users to formulate their queries freely. For different user domains, the query interfaces should ideally provide different sets of functions. Advances in CBIR are possible in the following areas.

Statistical soft classification architecture can be developed to allow an image to be classified based on its probability of belonging to a certain semantic class. We need to design more high level classifiers. Fully automated system is to find a single best feature.Accuracy with very large database. Web Oriented. High Dimensional Indexing. Human Perception of Image Content.

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