

An Improved Content Based Medical Image Retrieval System Using Integrated Steerable Texture Components and User Interactive Feedback Method

B. Jyothi, Y. Madhavee Latha and P.G. Krishna Mohan

Abstract The advancement in medical technology has resulted in a huge number of medical images saved in a data-base. Content Based Medical Image Retrieval (CBMIR) mechanisms help the radiologist in retrieving the required medical images from an immense database. This paper envisages an effective content based procedure in which the region of the image is taken into account by determining the borders of the image region using gray level gradient method instead of considering the image as a whole. Later, the content within the boundary region of the image is described through the steerable filter in different orientations followed by extracting the second-order statistical components as feature vectors. Medical images correlated to the query image are retrieved by computing the Euclidean distance as a similarity measure between database images and the query image. To enhance the accuracy of the medical retrieval system, Instant Based Relevance Feedback has been used. In this procedure, the user interacts with the system and selects the most relevant image for searching again. The above search procedure is repeated for finding out more precise images by sorting out the first search and the second search similarity distances. Eventually, the corresponding top ranked images are displayed. These results reveal that the proposed algorithm outperforms by of increasing Recall Rate and reducing Rate of Error.

Keywords Content based image retrieval · Boundary recognition · Similarity measure · Relevance feedback

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1 Introduction

The amount of medical images in the database has been in creditably increased due to advancement of technology, Medical images are essential in diagnosing the various diseases in helping the curing process and in supporting the medical decision making process [1]. Precise medical images help the experts in taking effective decision so that the patients can be protected from fatal consequences.

CBIR is an active research area facilitates the process of retrieving the requisite medical images from the bulky data-base [2] with minimum human interface. It is determined as a course of action of searching similar images from the great data-base on the source of their visible features such as shape, color and texture [3].

Medical images are embellished with precise patterns of texture which have detailed information. Texture is very essential and usual surface characteristic, repetitive pixel information regarding the collection and it also provide data with the association of its exterior surroundings. The objects in a medical images distinguished only by their texture sequence. The usual texture features used in CBIR systems can be label into statistical and structural texture features. Haralick et al. [4] utilized Gabor representations which is invariant to scale and rotation. The structural techniques describe the texture patterns formed by repeated arrangement of homogenous gray levels which are described by morphological operations.

The effectiveness of the CBMIR System strongly based on the selection of the set of visible features. These features plays significant role in CBMIR System.

Medical image have a reduced boundaries. Hence there are a small amount of practical troubles at the time of scanning the medical images for the duration of scanning such as a smaller amount illumination; noise and poor contrast results difficulty in identifying the tissue patterns and arrangement of organs are reasons of decrease in the retrieval outcome. A boundary is a line that set apart it from the surroundings. It assist us in Object identification and considering the shape of an entity. Somkath in [5] has made known a technique to defeat the difficulty of boundary recognition for weakly defined, but this has got limitation that the boundary must be closed.

This paper focuses on effective feature extraction procedure. According to this first boundary of the medical image is detected by using intensity gradient and edge map techniques followed by texture feature extraction steerable filter at different orientations followed by extracting statistic texture features using seconds order statistical components at various orientations.

This frame work increases the performance of the retrieval system by using relevance feedback [6]. The Relevance Feedback is a method has been used successfully in human computer interface. This has initially been elaborated for increasing the efficiency of information system. The main objective of relevance feedback for retrieval system is to understand the user requirements. Various relevance techniques have been discussed in [7].

The medical image retrieval system profits preliminary results based on ED as a similarity metric [8]. If the user is not satisfied with retrieved output, he can interact

with the system by modifying the query image. The system accordingly analyzes the user feedback and returns superior results. The distances from the first search and second search are sorted in uphill order then the corresponding lower distance images are displayed.

The remaining paper is planned in this fashion. Section 2 focus the CBMIR system. Section 3 describes the Features Extraction. Section 4 gives the Experimental Results with Relevance Feedback. Section 5 concludes the paper.

2 Proposed CBMIR System Architecture

The building block illustration of a typical theoretical content-based retrieval system is illustrated and discussed in Fig. 1. It expressed by three modes: off-line feature extraction mode, online image retrieval mode and feedback mode.

In offline mode, the images saved in the data-base are pre-processed for reducing noise by means of median filter. Later the region of the object is observed by ignoring the background of the image. Next, the visible characteristics of the image are extracted by using statistical components. These components stored in the database as a feature vector. We follow the suit for input image during online phase.

In online mode the query image is submitted for probing analogous images. In conclusion, the system profits the large amount relevant to the input image by measuring similarity among the feature vectors of the input image and individuals of the data base images.

In feedback mode user interacts with the retrieval system to refine queries representations. It is the process of selecting the most relevant image for searching again and using the information feuded back by the user.

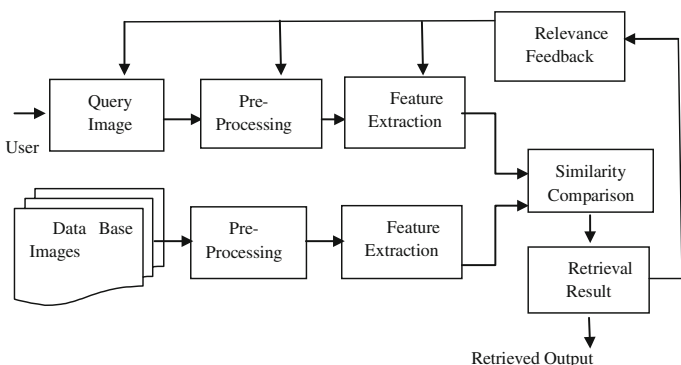


Fig. 1 CBIR system

3 Features Extraction

A feature gives the particulars about the visible property of an image in the vicinity for a little collection of gray values of the entire image. The characteristics of an image traced by means of their features. In the presented approach local feature used despite of extracting total image. The image boundary is identified by using edge following technique and consequent texture features are extricated in various orientations.

3.1 Object Boundary Detection

Medical images recognized with the help of their appropriate boundaries. The design of boundary wrenching out in blurred images is shown in Fig. 2. In this process, the boundaries of the images are recognized using intensity gradient edge subsequent algorithm which is based on magnitudes, directions and edge map [9] of given image $f(i, j)$ is calculated based on the subsequent formulas.

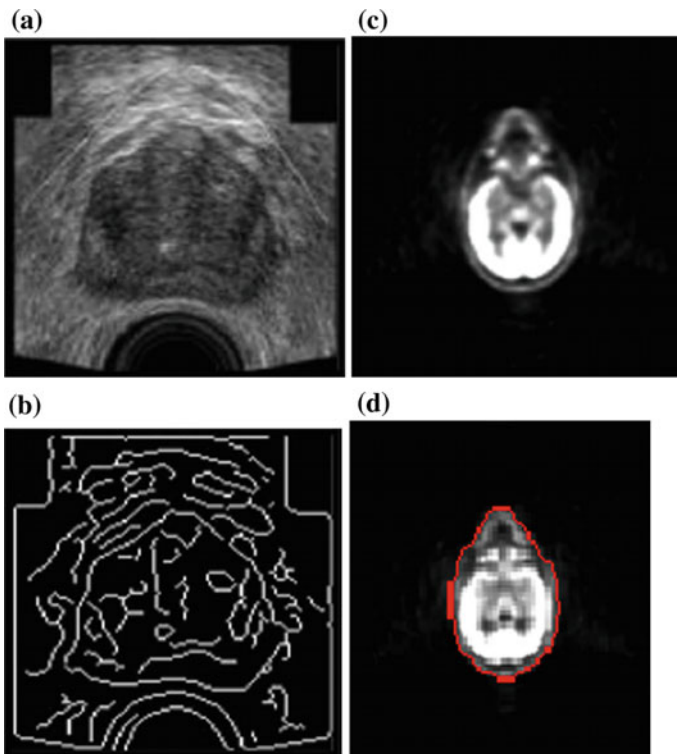


Fig. 2 a Noisy ultrasound image. b Edge mapped image. c Brain image. d Boundary detection

$$H(i, j) = \frac{1}{H_r} \sum_{(i, j) \in N} \sqrt{H_x^2(i, j) + H_y^2(i, j)} \quad (1)$$

$$A(i, j) = \frac{1}{H_r} \sum_{(i, j) \in N} \tan^{-1} \left(\frac{H_y(i, j)}{H_x(i, j)} \right) \quad (2)$$

H_r is the sum of pixels.

The edge map of an of images is determined by convolution with the query image $F(i, j)$ through the texture mask $T(x, y)$ and the ensuing image is $R(x, y)$.

$$TM(x, y) = LM.LM^T \quad (3)$$

$$L = (1, 4, 6, 4, 1)^T \quad (4)$$

$$RE(i, j) = F(i, j) * TM(x, y) \quad (5)$$

The boundary of an image obtained by using

$$L_{ij}(i, j) = H_{ij}(i, j) + A_{ij}(i, j) + RE_{ij}(i, j) \quad (6)$$

$H(i, j)$, $A(i, j)$ are the magnitude, angles of gradient and $R(i, j)$ is the map of edges.

3.2 Texture Features Extraction

Medical images are frequently exemplified in gray level; the majority medical image surfaces demonstrate texture. Kriti et al. utilized the capabilities of GLCM for breast cancer classification [10]. We have implemented invariant texture descriptor based on steerable filter rotting explained in [3]. Steerable is synthesized at different orientations and determines the output as a linear combination of basis filters. Steerable oriented filter designed is a quadrature pair to permit adaptive control over phase and orientation. The filter at any orientation θ is a linear combination of basis filters $G_1^{0^\circ}$ & $G_1^{90^\circ}$ and interpolation functions $\cos(\theta)$ and $\sin(\theta)$

$$G_1^\theta = \cos(\theta)G_1^{0^\circ} + \sin(\theta)G_1^{90^\circ} \quad (7)$$

$G_1^{0^\circ}$ & $G_1^{90^\circ}$ are set of Basis filters and are derivatives of Gaussian function $G(x, y)$ in x and y directions with scaling and standard deviation set to one.

$$G(x, y) = e^{-(x^2+y^2)} \quad (8)$$

where $G_1^{0^\circ} = -2xe^{-(x^2+y^2)}$ and $G_1^{90^\circ} = -2ye^{-(x^2+y^2)}$

The steering constraint is

$$F_{\theta}(m, n) = \sum_{k=1}^N b_k(\theta)A_k(m, n) \tag{9}$$

where $b_k(\theta)$ is the interpolation function and $A_k(m, n)$ are the basis filters.

Texture information can be described by appertain second order statistics in a variety of tilting sub-bands using steerable filter. In this paper, we extort the texture features from (b) 10 tilting sub-bands as shown in Fig. 3.

$$SR_i(i, j) = \sum_{i_1} \sum_{j_1} F(i_1, j_1)S_i(i - i_1, j - j_1) \tag{10}$$

where $SR_i(x, y)$ is symbolizing horizontal and S_i symbolize the deviation band pass filters at direction $i = 1, 2, 3, 4, 5, 6 \dots$

The subsequent steps give the depiction of the statistical computation of the statistical elements examination [11].

$$\text{Energy (E)} \quad E = \sum_{x=0}^{N-1} \sum_{y=0}^{M-1} \{F(i, j)\}^2 \tag{11}$$

$$\text{Contrast (C)} \quad C = \sum_{i=0}^{N-1} \sum_{j=0}^{M-1} |i - j|F(i, j) \tag{12}$$

$$\text{Inverse Difference Moment (IDM)} \quad IDM = \sum_{i=0}^{N-1} \sum_{j=0}^{M-1} \frac{1}{1 + (i - j)^2} F(i, j) \tag{13}$$

$$\text{Entropy (E)} \quad E = \sum_{i=0}^{N-1} \sum_{j=0}^{M-1} F(i, j)X \log(F(i, j)) \tag{14}$$

$$\text{Correlation (Cr)} \quad Cr = \sum_{i=0}^{N-1} \sum_{j=0}^{M-1} \frac{\{iXj\}X(F(i, j) - \{\mu_iX\mu_j\})}{\sigma_iX\sigma_j} \tag{15}$$

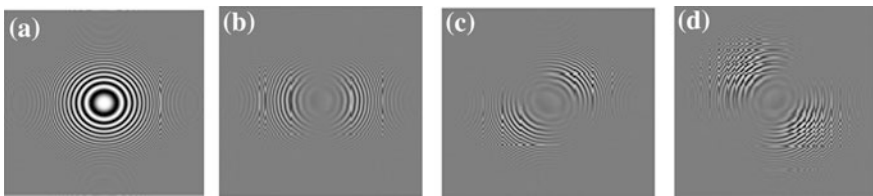


Fig. 3 a The input image. b Oriented image horizontally. c Rotated image with 45°. d -45° rotated image

$$\text{Variance (V)} \quad V = \sum_{i=0}^{N-1} \sum_{j=0}^{M-1} (i - \mu)^2 F(i, j) \tag{16}$$

$$F_v = [ASM, C, IDM, E, Cr, V] \tag{17}$$

4 Experimental Results with Instance Based Relevance Feedback

To test the performance of proposed approach we make use of the medical images from web accessible international resources called Frederick national laboratory.

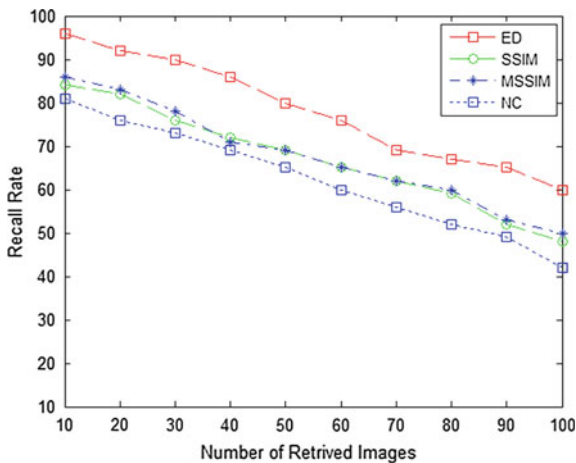
The database in our proposed algorithm contains 1000 medical images of the human organs—lungs, brain, abdomen etc. Analogous medical images retrieved by calculating the Euclidian distance [12] between the input image feature vectors and matching feature of the data-base images.

$$D(F_{v1}, F_{v2}) = \sqrt{\sum_{\forall i} (F_{v1}(i) - F_{v2}(i))^2} \tag{18}$$

The feature resemblance measure also plays an important role on the retrieval outcome. We have experimented with a variety of similarity measures to assess the performance as illustrated in Fig. 4. It is found that Euclidian provides better retrieval output when compared with SSIM, MSSIM and NC techniques respectively.

For a given query, the medical image retrieval system returns preliminary results based on ED as a similarity metric. If the user is not satisfied with retrieved output,

Fig. 4 Performance analysis of various distance measures



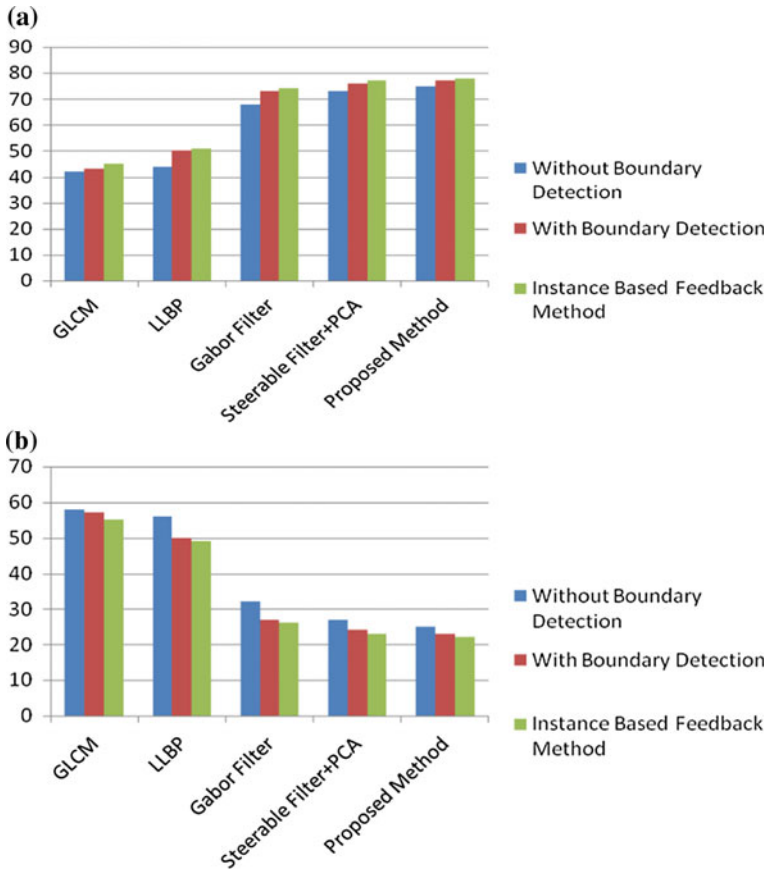


Fig. 5 **a** A comparison of the recall rate with various feature extraction methods. **b** A comparison of error rate with various feature extraction methods

he can interact with the system by modifying the query image. The system accordingly analyzes the user feedback and returns superior results.

In this approach further search will be taken up if the user requirements are not met. The best medical image from the results will be selected by the user and given as input to the medical image retrieval system. The distances from the first search and second search are sorted in ascending order then the corresponding lower distance images are displayed As a result we get superior medical images by sorting the Euclidian distances which have been obtained from first search and second search respectively. On the whole the performance of the presented CBMIR system is evaluated by measuring Recall Rate and Error Rate which have been recruit in [13]. The retrieval output of the presented CBMIR method has been analogize with the following feature extrication techniques such as PCA, LLBP [14, 15].

The existing proposed system has considered the whole image for feature extraction. The existing methods like PCA LLBP giving poor results when the images are corrupted with noise. In our approach we have proposed a more effective approach that enhances the production of the retrieval system. The present approach considers only the object region of the medical image by detecting the boundary of an image. Juxtapose principally above mentioned methods, the presented feature extraction procedure gives superior retrieval showing even in the noisy database images also (Fig. 5a, b).

$$\text{Recall Rate} = \frac{\text{Number of Relvant Images Retrieved}}{\text{Total Number of Relavant Images in Datab}} \quad (19)$$

$$\text{Error Rate} = \frac{\text{Number of Non Relvant Images Retrieved}}{\text{Total Number of Images Retrieved}} \quad (20)$$

5 Discussion and Conclusion

In this paper an effective feature extraction method for medical image retrieval has been proposed. This approach utilizes the segmentation method which enormously helped in feature extraction of the noisy medical images. In addition Instance based Relevance Feedback has been integrated with the feature extraction method to enhance the efficiency of CBMIR system. The Proposed approach is limited to time. As the quantity of medical images grows, the computing time increases and retrieval results decreases. To address these limitations, in future multiple features and an integrated with classifiers will be used to enhance accuracy of the result. Thus the CBMIR System will be an effective tool in assisting CAD System.

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