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Integrated Multiple Features for Tumor Image Retrieval Using Classifier and Feedback Methods.

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Abstract

The content based image retrieval method greatly assists in retrieving medical images close to the query image from a large database basing on their visual features. This paper presents an effective approach in which the region of the object is extracted with the help of multiple features ignoring the background of the object by employing edge following segmentation method followed by extracting texture and shape characteristics of the images. The former is extracted with the help of Steerable filter at different orientations and radial Chebyshev moments are used for extracting the later. Initially the images similar to the query image are extracted from a large group of medical images. Then the search is by accelerating the retrieval process with the help of Support Vector Machine (SVM) classifier. The performance of the retrieval system is enhanced by adapting the subjective feedback method. The experimental results show that the proposed region based multiple features and integrated with classifier and subjective feedback method yields better results than classical retrieval systems.

Keywords:Content based image retrieval; Multiple features;SVM Classifier;Relevance feedback.

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1. Introduction

The technological advancement in medical field has recently been at faster phase. It has resulted in a huge database of medical images that help the medical experts in diagnostic process of several diseases [1]. Out of the many serious diseases tumor is more serious whose occurrence is high and fatal since it has an invasive and infiltrative nature in the narrow intracranial cavity. Tumors are cancerous lumps in the parts of the body. To study the details of various organic tumours in question, we need to analyze the medical images of similar tumor in the past and use them to study the present case. Content-based image retrieval (CBIR) approaches were invented in the last decade, to support the computer aided diagnostic (CAD) process [2]. CBIR is an extremely successful tool in facilitating the retrieval of the required medical images so that the physician can take an appropriate decision in the diagnosis of diseases. Feature extraction plays an imperative role in enhancing the performance of the retrieval system. Generally medical images are represented in gray scale rather than the color, due to their nature. Single feature may not help in describing the full content of the image, therefore we adapt multiple features [3].

Texture is an inherent surface property of an object in which it gives the relationship to the neighbouring location. In addition it also describes the structural understanding of a region. A variety of texture explanation methods are projected in the literature [4]. Among these methods, Gabor filter has gained an appreciable attention due to their capacity to illustrate features at various orientations [5].

Shape features provide useful information for recognizing the objects. Fundamentally there are two types of shape feature extraction methods defined in literature, one is boundary-based and another is region-based method. The earlier one describes the boundary information of an object and frequently used shape representation methods include Fourier descriptors, Polygonal approximation and Curvature scale space (CSS) analysis. The later one extracts the entire region content. Among the region based descriptors moments play a significant role and are very popular. They exploit both boundary and interior content of the image [6].

As the quantity of images increases in the data base the computation time increases proportionally. Integration of classifier with the CBMIR reduces the computation cost and searching space in which the classifier categorizes the database images with labels [7].

The semantic space between the low level perception and high level concept can be filled by introducing Relevance Feedback (RFB) method. RFB is a query refinement technique that captures the user needs through the given feedback learning method. Various relevance feedback techniques have been discussed in literature [8]. User interaction with the retrieval system greatly improves the retrieval results.

This paper presents a novel and more effective approach for extracting content information about region of the object. In the proposed method the region of the object is extracted based on intensity and texture gradient. We extend the framework to extract the content by means of Steerable filter at various orientations for extracting texture features and radial Chebyshev moments for shape features extraction. Finally similar medical images are retrieved by matching the region features with the database images. This frame work increases the performance of the retrieval system by incorporating the Support Vector Machine (SVM) classifier [9] and subjective feedback learning method. For a given query, the medical image retrieval system returns preliminary results based on ED as a similarity metric computed between the global features of the given query image and particular class data base images in which the entire database images are pre classified by SVM. If the user is not happy with the retrieved output, interaction can be done with the system by modifying the query image by adapting the feedback mechanism. This feedback information selects a set of better images from the portioned database in the next iteration and returns superior results.

The rest of this paper is structured as follows. **Section 2** focuses on the Proposed CBMIR system. **Section 3** focuses on features extraction algorithm. **Section 4** explains the SVM classifier **Section 5** describes the feedback technique **Section 6** gives experimental results with feedback approach. **Section 7** concludes the paper.

2. Proposed CBMIR System Architecture.

The fundamental framework of a typical conceptual content-based retrieval system is illustrated and discussed in figure (1).Initially the retrieval system classified the database images according to the modality using SVM classifier. The system retrieves the related images by computing the similarity matching between the feature vectors of the query image and those of the classified data base images. Finally, the system returns the results which are mainly relevant to the query image. The user checks whether the retrieved images are relevant or not otherwise he repeats the searching process in more effective way by using feedback learning algorithm

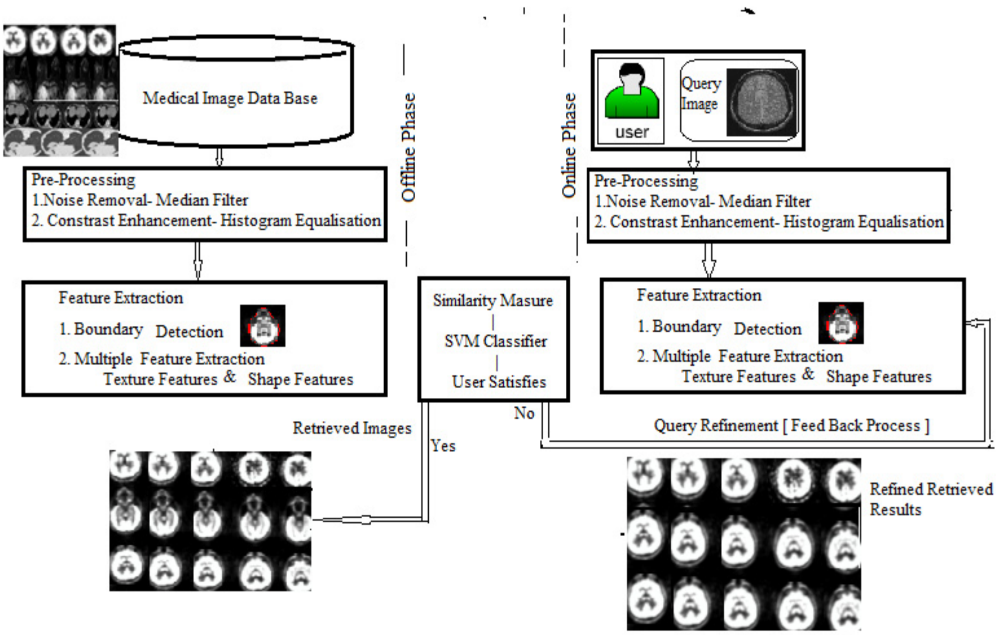

Fig. 1. Content Based Medical Image Retrieval System.

3. Content Extrication Procedure

The contents of an image are described with the help of their features. In the proposed system the local content extraction is used in spite of extracting whole image by detecting the object region. The input image F(i, j) where i, j are the pixel coordinates in the image. The image boundary is detected using edge following method [10] and corresponding region based multiple features are extracted in different orientations.

3.1 Pre-Processing

Medical images may suffer from poor contrast and noise during image acquisition with respect to scanning devices and illumination etc. Contrast enhancement can be attained by using histogram equalization technique. A 3x3 Median filter will be adapted for noise removal from the medical images.

3.2 Segmentation for Boundary Detection Approach

The region of the object is extracted by detecting the boundary of a medical image. Medical images have poor boundaries. The Intensity Gradient and Texture map are the criteria on which the boundary of the given medical image and the data base medical images are detected as follows.

$$H(i,j) = \frac{1}{H_r} \sum_{(i,j)\in N} \sqrt{H^2{}_x(i,j) + H^2{}_y(i,j)} \tag{1}$$

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

$$H_x(i,j)=-G_y x f(i,j)\approx\frac{\partial f(i,j)}{\partial y} \quad (3)$$

$$H_y(i,j)=-G_x x f(i,j)\approx\frac{\partial f(i,j)}{\partial x} \quad (4)$$

The data base images as well as query image have been convolved with texture mask T(i,j) to brighten the texture pattern .

$$T(i,j)=M.M^T \quad (5)$$

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

$$TM(i,j)=T(i,j)*F(i,j) \quad (7)$$

The edges can be tracked by at the location (i, j) in the image as fallows.

$$L_{ij}(i,j)=H_{ij}(i,j)+A_{ij}(i,j)+TM_{ij}(i,j) \quad (8)$$

H(i, j), A (i, j) and R (i, j) are the normalised magnitude, angle of gradient edge fields and edge map.

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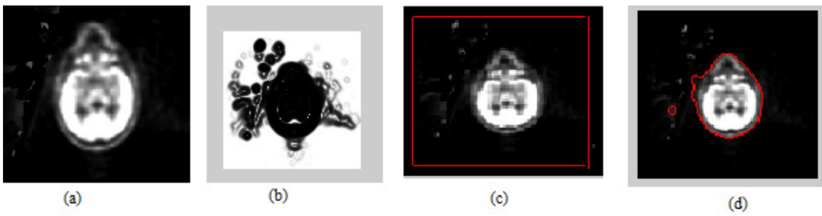


(a) Noisy brain image. (b) Corresponding gradient operated image (c) Contour initialization (d) Boundary detection image

Fig. 2. Boundary detection in noisy medical images.

3.3 Texture Features Extraction

Medical images are mostly represented in gray level, and exhibits surfaces texture. This paper focuses, on an invariant to rotation and scale texture representation method implemented with the help of steerable decomposition [11]. Steerable filter is a special class of filter which is synthesized at different orientations as a linear combination of basis filters. The filter synthesizes the image at different angles to determine the individual output of the orientation. Steerable oriented filter is a quadrature pair to permit adaptive control over phase and orientation. The second order statistical component analysis defined in [12] is used for feature representation .The filter at an orientation θ can be synthesized by linear combination of $G_1^{0^0}$ & $G_1^{90^0}$ and interpolation functions given as follows.

$$G_1^{\theta}=\cos(\theta)G_1^{0^0}+\sin(\theta)G_1^{90^0} \quad (9)$$

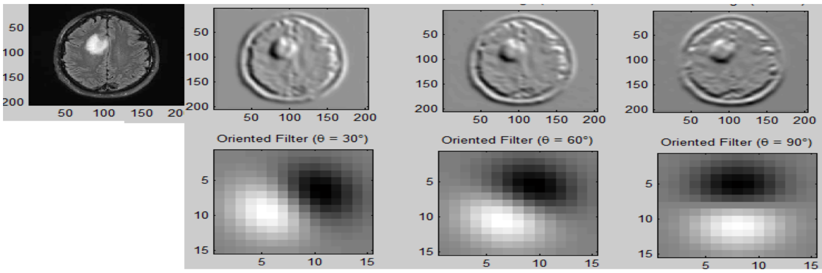
$G_1^{0^0}$ & $G_1^{90^0}$ are set of basis filters

Cos (θ) & Sin (θ) are the Corresponding interpolation functions

$$G(x,y)=\exp^{-(x^2+y^2)} \quad (10)$$

$G_1^{0^0}=-2x(\exp^{-(x^2+y^2)})$ and $G_1^{90^0}=-2y(\exp^{-(x^2+y^2)})$

Texture information can be extracted by applying second order from 10 oriented sub-bands illustrated figure (2)



(a) The input image (b) Image at 30° orientation (c) Image at 60° orientation (d) Image at 90° orientation

Fig. 3. The Steerable filter image at different orientations

$$B_i\left(i, j\right) = \sum_{i_1}\sum_{j_1} F\left(i_1, j_1\right) P_i\left(i - i_1, j - j_1\right) \tag{11}$$

Texture Feature Vector = [Energy, Contrast, Inverse Difference, Entropy, Correlation, Variance] (18)

3.4 Shape Features Extraction

In the proposed approach we extracted the shape features using moments which reduces the drawbacks allied by the continuous orthogonal moments. The radial chebyshev moments have better image reconstruction capabilities discussed by R Mukundan [13]. Hence we have adapted the same. For a digital image f(x, y) with size N×N, and $(n+m)^{th}$ order, are described as follows.

$$f(i, j) = \sum_{m=0}^{M-1}\sum_{n=0}^{N-1} T_{mn} t_m(x) t_n(x) \tag{19}$$

The radial Chebyshev moment of order *p* and repetition *q* for an image is defined as:

$$S_{pq} = \frac{1}{2\pi\rho(P, m)} \sum_{r=0}^{m-1}\sum_{\theta=0}^{2\pi} t_p(r) e^{-j2\theta} f(r, \theta) \text{, where m denotes (N/2) +1} \tag{20}$$

$$t_p(x) = \frac{(2p-1)t_1(x)t_{p-1}(x) - (p-1)\{1 - \frac{(p-1)^2}{N^2}\}t_{p-2}(x)}{p}\text{;} \quad P > 1 \tag{21}$$

4. Support Vector Machine Classifier

The computation cost reduced by employing the well known SVM classifier for indexing the medical images based on their modality. During the retrieval phase and feedback phase only a particular class of the database images are accessed. At the beginning of the retrieval process the unlabeled medical database images are categorized by using SVM classifier based on the hyper plane based on the decision function which can be a linear and non linear hyper plane which maps the non linear non linear feature space into linear space by using kernel.

5. Subjective Feedback Approach

RFB process the information provided by the user to the retrieval system .It is not only the feature space but also the relevant information related to the query image is provided by the user. In our approach we are specifically dealing with the tumor images, so it is associated with the segment of the specific region of interest in the image. In medical radiology, the clinical valuable tumor information is incorporated in the extremely localized region of the image. Hence, the elements characterizing the local regions has been segmented from the medical image to extract tumor during the feedback learning approach by applying the Subjective Fussy C-Means Clustering (SFCM)

Method [14]. During the user feedback phase the tumor is identified by applying edge following method followed by Mathematical Transform operation to remove the skull. Basically there are four morphological operations [15]. Modified fussy c-means is adapted to obtain the tumor region. This segmented region is used as feedback information for retrieving abnormal images from the database.

$$\text{Dilation} = F \oplus S \tag{22}$$

$$\text{Erosion} = F \Theta S \tag{23}$$

$$\text{Opening} = X \circ S = (F \Theta S) \oplus S \tag{24}$$

$$\text{Closing} = X \bullet S = (F \oplus S) \Theta S \tag{25}$$

F is the input medical image and S is the structuring element

Fussy C-Means clustering of a skull removed image is given by the following equations

$$\text{Objective} - \text{function} = \sum_{i=1}^{N}\sum_{j=1}^{N} m_{ij} \left\| x_i - c_j \right\|^2 \tag{26}$$

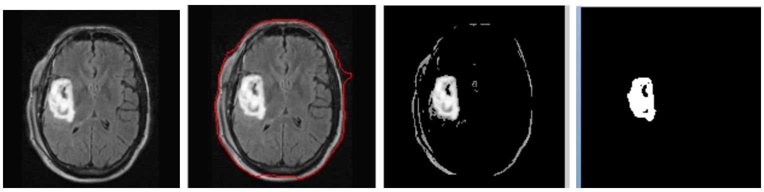
$$TS\_fuzzy = \sum_{j=1}^{n} \sum_{i=1}^{c} \frac{m_{ij} \mid X_j - k_i \mid^2}{\mid X_i + k_j \mid^2} \tag{27}$$

X_j is the j[th] data point, K_i= i[th] centre of cluster c

C=centre of the cluster, n=number of data point

$$\text{Memebership\_function}(mij) = \frac{\left(\frac{1}{\sum_{i=1}^{n}\sum_{j=1}^{n}\sqrt{x_i^2 - x_j^2}}\right)^{1/m-1}}{\left(\frac{1}{\sum_{p=1}^{n}\sum_{j=1}^{n}\sqrt{x_i^2 - x_p^2}}\right)^{1/m-1}} \tag{28}$$

m_{ij} is the membership of x_i in the j[th] cluster, m : is the fuzzification parameter



(a)) Input image (b)) object region extracted (c)) Skull removed image (d) tumor detection

Fig.4. Subjective Fussy C-Means Method

6. Experimental Results

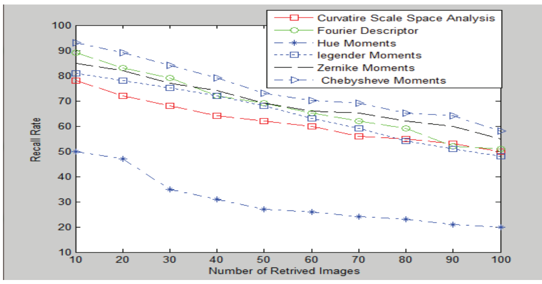
To assess the efficiency of the performance of proposed approach we make use of the medical images from web accessible international resources called Frederick national laboratory for cancer research. The database in our proposed algorithm contains 5000 medical images. Initially the medical images have been pre-processed and segmented the images from the background by employing intensity gradient and edge map techniques. Finally the content of the segmented region has been described with the help of second-order statistical components and chebyshev moments. The above process has been adapted for the query image and database images. Similar medical images have been retrieved by computing the Euclidian distance [16] between the query image feature vector and corresponding feature of the data base images. The formula for Euclidian distance as fallows

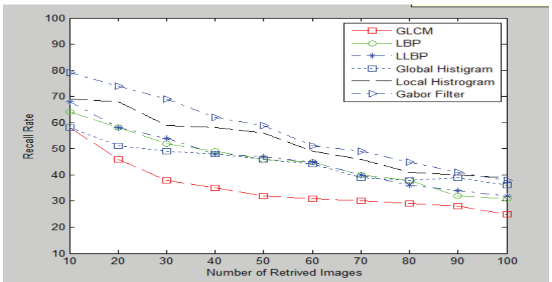
$$D(Fv_1, Fv_2) = \sqrt{\sum_{\forall i} (Fv_1(i) - Fv_2(i))^2} \tag{29}$$

Initially the users retrieve a few relevant images and further search will be taken up if the user requirements are not met, then the users can modify the original input query automatically by using feedback process which can be done by expanding query with the information fed by feedback approach. The overall performance of the proposed CBMIR system is evaluated by measuring Recall Rate and Error Rate. The retrieval performance of the proposed CBMIR method has been compared with feature extraction methods defined in [17-18]. Compared to all the above mentioned techniques, the proposed feature extraction method gives better retrieval performance for various image databases. This high performance is due to the combination extracting multiple features integration with SVM classifier and relevance feedback mechanism.

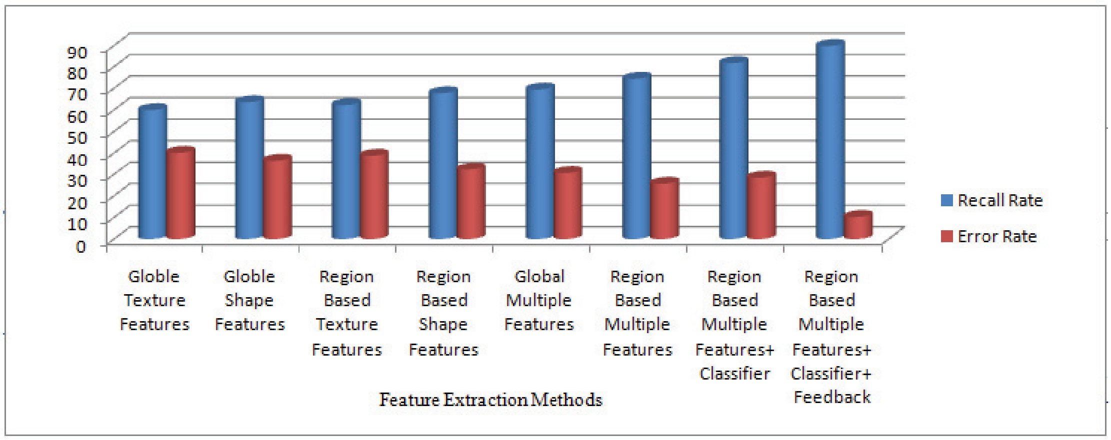
$$\text{Recall Rate} = \frac{\text{Number of Relavant Images Retrieved}}{\text{Total Number of Relavant Images in Datab}} \tag{30}$$

$$\text{Error Rate} = \frac{\text{Number of Non Relavant Images Retrieved}}{\text{Total Number of Images Retrieved}} \tag{31}$$





(a) Comparison of Recall Rate for various feature extraction methods (b) Comparison of Error Rate for various feature extraction methods



(c) Comparison analysis of various methods.

Fig. 6. Retrieval Performance analysis of various methods.

7 Discussion and Conclusion

In this paper an effective feature extraction method for medical image retrieval has been presented. This approach utilizes the segmentation method which enormously helps in feature extraction of the noisy medical images. In addition SVM classifier and subjective Feedback has been integrated with the feature extraction method to enhance the efficiency of content based medical image retrieval system. Thus CBMIR System will be an effective tool in assisting CAD System.

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