Content Based MRI Brain Image Retrieval - A Retrospective

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***Abstract* - With advance in technology, everyday large amount of different type of medical images such as MRI (magnetic resonance imaging), CT (computer tomography), ultrasound image, X- ray etc. are produced in different medical center. These medical images represent the symptoms of a specific disease, so collections of these images are the useful source for physicians as well as researchers. Due to the large collection of these images, a system is needed that can efficiently retrieve images that represent the specific disease for diagnostic purpose. Content Based Image Retrieval is a method for retrieving the most similar images from the large database using visual query. Content based medical image retrieval help the physician to make the clinical decision as well as manage the large database of these images. This paper tries to explain the concept of image retrieval, its type and various methods of content based image retrieval.**

***Keywords* - Image retrieval, Text based image retrieval, Content based image retrieval (CBIR)**

I. INTRODUCTION

In modern year, rapid increase in software and hardware [1] technologies various types of medical images such as MRI, Computer Tomography, X-Ray, Ultrasound etc. are produce in many medical center is growing incredibly fast. These medical images present important anatomical and functional information about different body parts for detection, diagnosis, treatment planning and monitoring as well as medical research and education [2]. Thus, the tasks of effectively storing, processing and retrieving medical image data have become important research topic [3]. So, an efficient retrieval system is needed that could efficiently organize and retrieve the medical images. Image retrieval is a computer system that can browse, search and retrieve images from large database automatically. The image retrieval system is broadly classified in two types [2]: Text Based Image Retrieval and Content Based Image Retrieval.

II. TEXT BASED IMAGE RETRIEVAL

Text Based Image retrieval is a typical and tradition method for retrieving images [4]. Here user needs to type a series of keyword and images in these databases are annotated using keywords; the match is accomplished through these keywords [2]. Best example of using this method is commercial search engines (e.g. yahoo!, google). Although this method is good there are several disadvantages like to much responsibility on end user, need a deeper abstract (queries that cannot be described by keyword but only visual content). Also, it causes errors because each word may have more than a few meanings depending on the context [4]. In medical field it is very much time consuming because for retrieving images each time medical staff must use metadata like name of patients, the part of body, date etc. and it is not possible for human beings for memorize such large metadata every time.

III. CONTENT BASED IMAGE RETRIEVAL

Content Based Image Retrieval (CBIR), is a new research for many computer science groups who attempt to discover the models for similarity of digital images. Content Based Image retrieval method uses visual content of images for retrieving the most similar images from the large database. In this method visual contents from images in the database are extracted. Now whenever user gives an image to a system as input, it extracts the visual content from that image and compares the visual content (features) with the visual content of the images in database and retrieves the most similar images [4]. Thus, CBIR uses the visual content of image such as color, shape, texture for represent and index the images [5].

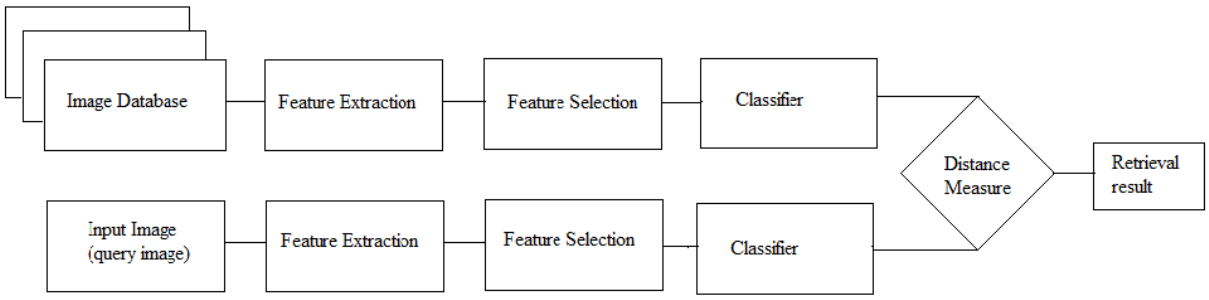

Figure 1 General diagram of CBIR.

The fig 1 Shows the basic steps of content based image retrieval:
1. Feature Extraction.
2. Feature selection.
3. Classifier.
4. Similarity measure.

3.1 FEATURE EXTRACTION

When input image (data) to an algorithm is too large to be processed and it is assumed to be disgracefully redundant, then the input image is transformed into a reduced set of features which is known as feature vector. Thus transforming an input data into set of features is called feature extraction [3]. It is done by visual content descriptor. The descriptor could be two types either global or local. A global descriptor uses the visual feature of the whole image whereas a local descriptor use visual features of objects or regions to describe image content [5]. The descriptor extracts the low level visual feature such as color, shape, texture and makes the feature vector [6].

3.1.1 Color Extraction

Color is the most expansively used visual content for image retrieval [7]. Before choosing effective color descriptors for feature extraction first color space must be determined. Usually colors are defined in three dimensional color spaces which could be RGB (Red, Green, and Blue), HSV (Hue, Saturation and Value) and Opponent color space. RGB is widely used color space for image display and display is made using primary color (red, green, blue) or mixing of these colors. HSV color space is mostly used in computer graphics and most sensitive way of describing color. Here first component Hue is invariant to change in camera direction and illumination so it is most suitable for object retrieval [5]. The Opponent color space use opponent color axes (R-G, 2B-R-G, R+G+B) and has advantage of differentiating brightness information on third axis and first two axis is invariant to change in shadow and illumination intensity[5]. Some most widely use color descriptors are:

Color Histogram [5]

It is used for effective representation of color content of an image if color pattern is unique compared with the rest of data. It is easy to compute for both global and local distributor of color. Though it is a good method for color extraction, it does not take the spatial information of pixels into consideration so very different images can have same color distribution.

Color Moment

It has been successfully used in many retrieval systems especially when the image contains just object [8]. The first order (mean), second orders (variance), third order (skewness) color moment have been proved to be efficient and effective in representing color distribution of images. Here third order moment improves the overall retrieval performance but it is very sensitive the changes in scene and sometimes decreases the performance [5].

Color Coherence Vector [4]

Color coherence vector is same as color histogram method but here color histogram also take the spatial information of pixel. Here each histogram is divided into two types i.e. coherent, if it belongs to large uniform color region or incoherent, if it does not. It provides better result than color histogram especially for most uniform color or texture region [5].

Color Correlegram [12]

The color correlegram is projected to characterize not only the color distributions of pixels but also gives the information about the spatial correlation of pairs of colors. It gives best performance than color coherence vector and color histogram but has large computational expensive due to high dimensity.

3.1.2 Shape Extraction

Shape feature of object or region is be extracted for retrieving the images from the database. Number of features of object shape is computed for every object identified [5].Two main types of shape features most commonly extracted are global features (such as aspect ratio, circularity and moment invariants) and local features (such as sets of consecutive boundary segments)[25].The methods of feature extraction are divided in two major categories either boundary based (rectilinear shape [25], polygonal approximation [21, 25] and Fourier based shape descriptors [24, 25]) and region based (statistical moments [25].

A good shape representation feature should be invariant to translation, rotation and scaling [5]. Some of the widely used shape descriptors for shape feature extraction are as follows:

Polygonal Approximation [21, 25]

Polygonal approximation can be put to ignore the minor variations along the edge, and instead capture the overall shape information. In this method there are two ways to extract feature from shape, merging and splitting. Merging methods add successive pixels to a line segment if each new pixel that is added doesn't cause the segment to deviate too much from a straight line .Splitting methods work by first drawing a line from one point on the boundary to another then compute the perpendicular distance from each point along the boundary segment to the line. If this exceeds some threshold, break the line at the point of greatest distance. Repeat the process recursively for each of the two new lines until no longer need to break any more. It is simple method for contour representation and description.

Moment Invariant [25, 18]

Moment invariant is also called as geometric moment. There are total seven moments which is used for shape feature extracted. The most important advantage of using this moment invariant is that they are invariant to rotation, scaling and translation. Also the moments are simple in compute. There are some disadvantages of this method like higher order moments are very sensitive to noise and this moments also suffer from information redundancy because its basis is not orthogonal.

3.1.3 Texture Extraction

Texture is that inherent property of all surfaces that describes visual patterns and contains significant information about the structural arrangement of the surface and its relationship to the surrounding environment. Various texture representations have been investigated in computer vision and pattern recognition. The texture representation method can be classified in four major groups: (i) Structural [20] (ii) Statistical [19, 20] (iii) Model based methods [20] (iv) Signal Processing based methods [17, 19, 20].

1. Structural Methods: Structural methods represent the texture by well defined primitives and spatial arrangement of these primitives [20]. So for feature extraction this primitive may be extracted. Once the primitives have been extracted, the analysis is completed by computing statistics of the primitives (e.g. intensity, area, elongation, and orientation) [20]. These methods are very effective when textures are in regular pattern but mostly natural images do not have regular patterns of texture so it is not good for those images [5]. Morphological and various clustering methods are example of these.
2. Statistical Methods [19, 20]: Statistical methods examine the spatial distribution of gray values by computing local features at each point in the image, and deriving a set of statistics from the local features. Depending on the number of pixels that defining the local feature statistical methods can be further classified into first-order (one pixel), second-order (two pixels) and higher-order (three or more pixels) statistics. The basic difference between those methods are : first-order statistics estimate properties (e.g. average and variance) of individual pixel values, ignoring the spatial interaction between image pixels, where second- and higher-order statistics estimate properties of two or more pixel values occurring at specific locations relative to each other. Grey Level Co occurances Metrix (GLCM), Local Binary Pattern are widely used statistical methods.
3. Model based Methods [20, 19]: Model based texture analysis method use the fractal and stochastic models and make effort to interpret an image texture by use of respectively, generative image model and stochastic model. The parameters of the model are estimated and then used for image analysis. The disadvantage of this method is high computational complexity that arising in the estimation of stochastic model parameters. The model based method has been useful for modeling some natural textures however it lacks orientation selectivity and is not suitable for describing local image structures. Autoregressive model, Markov Random field, Gauss-Markov random field are some model based methods those are use for texture feature extraction.
4. Signal Processing Based Methods [17, 19, 20]: Signal processing based method represent an image in a space whose coordinate system has an interpretation that is closely related to the characteristics of a texture (such as frequency or size). Both frequency and spatial domain approaches are used for filtering the image and then relevant information is captured. Various transform like Fourier, Wevelet, Gabor etc. are example of this method. Signal processing method gives better result than any type of methods for feature extraction but computational time of these methods may be large [19].

Although there are four approaches for texture extraction, transform based methods and structural based methods are widely used for their better result and they could directly applied to any type of texture [19]. The most widely used texture extraction methods are as follows:

Gray Level Coocurance Metrics (GLCM)

GLCM is old feature extraction method that was proposed by Haralick et al.back in 1973 . A GLCM contain the information about the position of pixel having similar gray level value [3]. It is a statistical method that computes the relationship between pixel pairs in the image [19]. In conventional GLCM many texture feature like energy, entropy, contract, correlation can be extracted. Other than the conventional implementation, there are a few other implementations of the GLCM, e.g. by introducing a

second-order statistical method on top of the textural features in the original implementation, one dimensional GLCM, using the raw GLCM itself instead of the first-order statistics and applied on different color space for color co occurrence matrix [19].

Local Binary Pattern [22]

It is a simple and very efficient texture operator which labels the pixel of an image by thresholding the neighborhood of each pixel and considers the result as binary number. The original LBP calculates a value that reflects the relationship within a 3 × 3 neighborhood through a thresholded neighborhood that is multiplied with the respective binomial weights. The discriminative power and computational simplicity are two most advantage of this method. The disadvantage of this method is it only extracts the local texture feature.

Wevelet and Other Transform Method [23]

Wevelet transfom describe multi resolution decomposition process in terms of expansion of an image onto a set of wavelet basis functions. It decomposes image into sub images with different resolutions and different scale. Wevelet transform decomposed the image in four sub band LL, LH, HL, HH. There are two types PWT (Pyramid wavelet transform) and TWT (Tee wavelet transform). PWT recursively decompose the LL band. But for some textures the most important information often appears in the middle frequency channels so to overcome this drawback, TWT decomposes other bands such as LH, HL or HH when needed. The feature vector can be constructed using standard derivation and mean of the energy distribution of each sub band at each level.

Gabor Filter [9]

Gabor filters have the ability to perform multi-resolution decomposition due to its localization both in spatial and frequency domain. Gabor filters are a group of wavelets, with each wavelet capturing energy at a specific frequency and a specific direction. Expanding a signal using this basis provides a localized frequency description, therefore capturing local features/energy of the signal and texture features can then be extracted from this group of energy distributions. The scale (frequency) and orientation tunable property of Gabor filter makes it especially useful for texture analysis. The disadvantage of Gabor filter is that it does not form orthogonal basis set so it require the more storage space [23].

3.2 FEATURE SELECTION

In content Based Image retrieval, feature selection has been done in order to increase the retrieval speed. The main aim of feature selection is to reduce the dimensionality of feature vector that is obtained from Feature Extraction. One of the techniques commonly used for dimension reduction is Principal Component Analysis (PCA) [5]. There are two main advantage of PCA. First, it reduces the dimensions of data to computationally feasible size and second it extracts the most representative features out of the input data so that although the size is reduced, the main features remain and still be able to represent the original data [28]. Apart from PCA, Kalhunen-Loeve (KL) transform is also used for feature reduction. Although the KL transform has some useful properties like ability to locate the most important subspace but the feature properties that are important for identifying the pattern similarity may be destroyed during dimensionality reduction [5].Neural network has also been useful tool for dimension reduction of feature [5].

3.3 CLASSIFIER

In Content Based Image Retrieval various classifier are used for classify images those belong to a particular class. There are many classifier those are most popular nowadays like NN (nearest neighbor), SVM (Support Vector Machine), ANN (artificial neural network).Many other classifier are also there but they are less popular recently.

Nearest Neighbor

These classifiers compute the distance from the query image to every database images and select the best neighbor or neighbors with the shortest distance [19]. These are the simple classifier among the other two widely used classifiers. K nearest neighbor is the best example of this classifier where *k* number of best neighbors is selected and the winning class will be decided based on the best number of votes among the *k* neighbors [3, 18, 19]. Though it is simple classifier the disadvantage is, the speed of computing distance will be increase if the dataset will be very large [18, 19].

Artificial Neural Network [8, 14]

ANNs are popular classifier that was popular for the last decade and remains to be widely used until recent years [19]. The basic form of ANN is the Multilayer Perceptron (MLP). MLP works by transferring the input (features) to no of layers that have different no of nodes. There are three types of nodes: input, hidden and output node. The no of output nodes are set according to the no of output class in which we want the images. Each node has weight and activation function is assigned to it. The activation function decides which class of function it can represent. Basically ANN is the Multilayer Perceptron (MLP) which updates the weights through back-propagation algorithm during the training. Though it was very much useful in the past but nowadays, it slowly losing popularity and is showing a trend of being taken over by the SVM [19].

Support Vector Machine

In recent year, SVM are the latest trends in machine learning algorithm which is popular in many pattern recognition problems [19]. SVM is designed to maximize the marginal distance between classes with decision boundaries drawn using different kernels [3, 18]. SVM is designed to work with only two classes by determining the hyperplane that divide two classes. This is done by

maximizing the margin from the hyperplane to the two classes. The samples closest to the margin that are selected to determine the hyperplane is known as support vectors [18]. Multiclass classification is also applicable. The multiclass SVM is basically built up by various two class SVMs to solve the problem, either by using one-versus-all or one-versus-one and winning class is then determined by the highest output function or the maximum votes respectively [3]. Due to this multiclass SVM perform slower than the Multi layer perceptrons. Although this disadvantage of SVM, it is still considered to be powerful classifier which is replacing the ANN and has slowly evolved into one of the most important classifier [19].

There are some other classifiers which are also used in recent year like the Bayes classifier, Learning Vector Quantization (LVQ), and Hidden Markov Model (HMM), Self Organizing Map (SOM).

3.4 DISTANCE (SIMILARITY) MEASURES

CBIR compute the visual similarity instead of accurate matching between images in database and query image, so retrieval image can be single or multiple images. Many similarity measures have been developed that calculate distance between two feature vectors for image retrieval [5].

MINKOWSKI-FORM DISTANCE: If each dimension of image feature vector is independent of each other and is of equal importance this distance [5] is used and it is denoted as Lp,

$$L_p = D_p(x,y) = \left(\left(\sum_{i=1}^{N} | xi - yi |^{p}\right)^{1/p}\right) \quad \text{(i)}$$

Here $x_i = \{x_1, x_2, \ldots\ldots\ldots, x_N\}$ and $y_i = \{y_1, y_2, \ldots\ldots\ldots\ldots, y_N\}$ are feature vector of query and targeted image. if p=2 then L_p is called as Euclidean Distance. Euclidean Distance is most commonly used distance and measures the dissimilarity between feature vectors but it is not always best method because each dimension are squared before added so it gives great emphasis on those feature for which dissimilarity is large[23].

HISTOGRAM INTERSECTION: It can be taken as a special case of L1 distance, which is used by Swan and Ballard [14, 5] to compute the similarity between color images. The intersection of two histograms of X and Y is defined as,

$$D_{hist}(x,y) = 1 - \frac{\sum_{i=1}^{N} \min(x,y)}{\min(|x|,|y|)} \quad \text{(ii)}$$

The disadvantage is, it is quite insensitive to changes in image resolution, histogram size, depth and view point [5].

CHESSBOARD DISTANCE: It is a maximum distance between the components of two points [16]. It is defined as,

$$D_{che}(x,y) = \max_i (|x_i - y_i|) \quad \text{(iii)}$$

BHATTACHARYA DISTANCE: A statistical measure known as Bhattacharya distance measure is often used to comparing two probability density functions which are most commonly used to measure color similarity between two regions [16, 15].

$$D_{bha}(x,y) = \sum_{i=1}^{N} \sqrt{x_i}\,\sqrt{y_i} \quad \text{(iv)}$$

MAHALANOBIS DISTANCE: This distance metric is appropriate when each dimension of image feature vector that is depended of each other is of difference importance [5, 16].

$$D_{mah}(x,y) = [(x-y)\, c^{-1}\, (x-y)]^{1/2} \quad \text{(v)}$$

C is covariance matrix of feature vector.

There are also some other distance measure like kullback-Leibler (KL) divergence and Jeffrey-Divergence (JD), Quadratic Form (QF), cosine distance etc. and they are used according to the application [16].

IV. CONCLUSION

Due to rapid growth in producing the images in different medical centers managing the large database of images and retrieval the images for decision making for various doctors from large database is necessary. Content Based Image Retrieval is the best method for retrieving images than text based method and retrieve the most similar images in real time. In this paper, I have reviewed the basic concept of CBIR and related work done in Content based Medical image retrieval .In future I have introduce a new technique for MRI brain image retrieval and classify the abnormality of the images.

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