A Novel Medical Image Retrieval Method with Similarity Measures
## CHAPTER 4
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4.1 Introduction

Retrieving medical images from archives is a challenge in medical research. Digital images provide visual information for easy diagnosis and treatment. By using Textual Annotates images were retrieved in early days. Medical images were manually retrieved with Textual annotate and keywords for semantic queries.

For huge images retrieval keywords based method was used but it involved, manual labour and required more volume of digital Images but it was not so feasible and flexible. From above drawbacks there was a significant need of content based Image retrieval which can classify images automatically based on features by using Query images for the image to be retrieved. Earlier methods involved visual features by using text annotate for retrieving images.

Medical imaging modalities like CT, MRI, PET, X-rays provide important information to radiologists for appropriate diagnosis and proper treatment. For providing easy means to the medical professionals retrieving of images was required for easy diagnosis and appropriate therapy.

In general the Query image which is given as input is compared with the database images or archives to retrieve similar images. The classification of images carried spatial relationship in terms of features such as color, texture and shape.

The similarity features use distance measures for Image retrieval. Color, shape and texture feature mostly used for feature classification. Similarity measure use spatial relationship for MRI and
X-rays and it can also be computed using low level features of image. Recent developments automatically retrieve medical images using determining techniques such as neural networks, Bayesian network, and decision tree and support vector machines.

Feature vectors are used in medical image retrieval system to automatically extract features. This vector is stored in feature data base and is classified by preprocessing to extract features based on similarity measures. In clinical practice interpreting images required to compare the data base and retrieve the relevant images to perform accurate diagnosis in detective of suspicious lesions in various diseases.

These relevant images provide reference to the doctor to perform appropriate therapeutic treatment to the diseases. It is quite a difficult task for automated searching of relevant images with similar medical examination for large databases.

Two basic approaches are used in medical Image retrieved which are content based Image retrieval and semantic based Image retrieval. A Query image is matched with feature database to find the similarity metric such images are retrieved based on features.

Extraction feature is an Indexing mechanism which uses features such as shape, texture and color. The frequency domain techniques use Gabor transform, wavelet domain for extraction of features. Visual patterns use properties of homogeneity related to Texture and represent the properties of all surfaces to define the structural arrangement of surfaces to the environment surrounded.
For linear separable and non-separable data many machine learning tools and pattern matching techniques are used for proper clustering and classification of images. A relatively unique classification with statistical learning theory is support vector machine (SVM).

In the last decades medical images are available in multiple numbers and are stored in large online repositories and health-related sources. The images stored in archives are in commonly formed formats such as GIF (Graphics Interchange format) and JPEG (Joint pictures expert groups). This type of images provides flexibility to the user in storage than DICOM Images.

Text-based image retrieval systems are time consuming and expensive and it provides ambiguity with high domain-related knowledge for annotation. Whereas feature-based image retrieval are better because things refer to anatomical regions with various acquisition views and extracts the visual information necessary in medical images.

FBIR systems represent medical Images retrieved are COBRA, IRMA, MEDGIFT. These systems extract colour, texture and spatial location as visual features. The performance level of FBIR can be improved by working on certain aspects of image content with adequate description. The experiments share a feature-based queries relating to the Imaging content of various Images. To improve the speed of retrieval, fusion-based approaches are utilized to work with Image Queries.
For working with feature fusion models relating parameters are required from users for high accuracy among image Queries. Multiple feature Queries are known as average fusion models which work with comb max score. Comb sum rank is used for extracting the different features equally. The fusion models on average are not optimal and their performances obtained are different.

For appropriate learning genetic algorithm is used for all image Queries with applicable weights to obtain average retrieval accuracy for features in fusion model. Content based visual image retrieval is a simple and latest method which is growing every year as it is finding extensive on the requests matching database fields.

Still some answers to various Questions are not answerable by medical image retrieved systems such as speed and text descriptors. There are almost large repositories too resort with varying characteristics of growing demand of Image retrieval methods for accurate diagnosis and therapy.

Various departments of radiologist in countries store and produce 1 TB medical Images. This Image still needs a standard to answer various images relevance for a Query image given. This Images helps in giving second opinion to the doctor content based Image retrieval are the best for picture Archiving and communication systems which are created.

This work gives an idea of content based Image retrieval with SVM to give a second opinion to the doctor to obtain relevant cases for the suspicious disease pathology. New Avenues are in more for Image
retrieved systems not only in clinical practice but also in education of medical data cells. In simple words it is a visual search tools which assist a doctor to verify relevance of disease and provide accurate therapy. Fusion models of feature extraction provide better retrieval performance to various features considered.

In the First step training data is needed and in the second step requires learning of Image Queries to identify the similarity with logic based rule of Boolean models. Fuzzy logic based rule are represented with logic expressive for users to understand based on Query images.

A two-step SVM is proposed with classification formula to work with positive and negative samples which are randomly selected in image database upon the query image given.

Two class support vector machines are used with feature fusion model to have greater ability in generalizing the image query. Image samples provided by user have a capability of extracting from image archives with SVM.

4.2 Overall View Of Existing Image Retrieval Methods

4.2.1 Pyramidal structure wavelet transfer

Texture based image retrieval is efficient with spatial and frequency characteristics for various patterns and obtains a better result of retrieval. The difficulty is it increases redundancy with more number of orientations for non-orthogonally property in large databases. It provides major disadvantages of poor direction and shift sensitivity. These can overcome by using DWT to work with edge information in different directions.
DWT decomposes sub signals in very small channels of low frequency. The pyramid structure wavelet transfer divides the images into four types of sub bands which are low-low, high-high, low-high, and high-low and still it uses decomposition in third level.

![Wavelet Decomposition Diagram]

**Fig. 4.1: The decomposition of signal coefficients in three level**

### 4.2.2. Continuous Wavelet Transfer and the Wavelet Series

The wavelet function used are derived from basic function with $x(t)$ as analyzed signal and $\varphi(t)$ is wavelet. All this transformation are derived from $\varphi(t)$ through scaling and translation. The desired characteristics are obtained by translating the parameters to the location to be shifted with the given time information. The parameter scale is $\frac{1}{frequency}$ which gives the information of frequency.

The signal expands for low frequencies and provides the information hidden whereas signals with high frequencies use small scales to give the ultimate information on the given signal.

Wavelet signal performs the convolution operation to obtain the desired analysis. The series of wavelet is obtained by sampling accordingly with nyquist criteria. The reconstruction of very small rate of sampling is $2\omega$ where highest frequency is $\omega$. The number of computations can be reduced by decreasing the sampling rate.
4.2.3: Discrete Wavelet Transform (DWT)

Time frequency represents the transformed signal which provides short time Fourier transforms to the non-stationary signals. The resolution is normal for all frequencies with different resolutions.

![Fig. 4.2: overview of signals (a) a Wave and (b) a Wavelet.](image)

A signal wave is a function of space in a time which is oscillating periodically. They are suited with signals which have transient response. The Fourier transform is wavelets which does the same STFT analysis. The transform wavelet is not consistent because it gives good spatial resolution but low time resolution. The series of wavelet comes from the family of CWT. The resources allocation time depends on good resolution.

DWT use sub band coding which reduces the time of compacting and required resource time. Multi resolution use coding schemes known as pyramidal coding. The basic functions of signal are analyzed by scaling and translation. The signals analyzed are filtering techniques at scales of different cut of frequencies.
4.2.4 Discrete Wavelet Transform (DWT) and Filter Banks

The realization in sign processing function is with filtering functions, scaling or rotation by up sampling and down samples. DWT use both type of filters for up samples and down sampling with Mallet-tree decomposition. The time measure to discrete time filters use LPF and high pass filter as N0 and N1 where high frequency is used as 2ω which is highest frequency.

It is sampled one after another to obtain better resolution doubles the time resolution and good at low frequency. Filtering and decimation is processed to reach the desired level. The coefficients concatenating are a1 (n) and d (n) and this decomposition is approximated with up sampling by two and synthesis filtering are later added.

Fig. 4.3: shows the obtained signal from the coefficients of wavelet
4.3 Brief overview of image retrieval with SVM

4.3.1 State of art

For accurate diagnosis and treatment digital medical images are used. These medical images are obtained from X-rays CT, MRI and PET. Image retrieval is an efficient method for retrieving medical images stored in the data base for educational and research purposes.

The medical images are stored in large data base where query image is given as input which compares the features in the image stored in the data base and finds relevant feedback by comparing the features such as color, texture and shape. The similarities measures used for retrieving the images describe the efficiency of the retrieval system.

In this work feature vector mechanism is implemented using discrete sine transform. The feature classification and reduction is obtained with support vector machine and information gain. The SVM classifier proposed uses two step classification with the help of perceptron neural network.

4.4. Discrete Sine Transform (DST) and Support Vector Machine (SVM)

4.4.1 Discrete sine transform

The transforms are from the class of sinusoidal where this transforms are known as sinusoidal unitary transforms. This consists of a kernel function invertible which describes a complete basis function. The generalized transform of this capability is karhunen-loeve transform (KLT). These transforms such as Discrete Cosine
Transform (DCT) and Discrete Sine Transform (DST) are the members of unitary transforms. The DCT's and DST's represents discrete trigonometric transforms identified as even and odd. A cosine transform which is of discrete nature produces a sequence of data points finite as some of cosine functions working at different frequencies.

Various applications in engineering produce numerical solution for partial differential equation. Several drawbacks of sine and cosine function in terms of efficiency and boundary conditions. The DCT is similar to DFT working on real values with variants in data of input and output samples.

For feature extraction the discrete sine transform provides an algorithm in the following steps.

1. In the first step the size of an image M x N is computed
2. The value of I in an array size will be less than M+1 or M.
3. The value of J in an array size will be less than N +1 or N
4. The DST array \( (x_i, y_i) \) is computed
5. The computed value of one dimensional array is stored
6. Perform the operation from step 1 until the all the images are computed.

The discrete Fourier transform share similar characteristics of discrete sine transform the only significant differences is real numbers the sine transforms represented in discrete nature are observed in the following equations.
The discrete sine transform is represented by

\[ S_k = P_k \sum_{n=0}^{N-1} x_n \sin \left( \frac{(n+\frac{1}{2})(k+1)}{N} \right) = 0, 1, 2, \ldots, N - 1 \quad (4.1) \]

\[ P_k = \sqrt{\frac{2-\delta_{k,0}}{N}} \quad (4.2) \]

DST works on real values with odd symmetry where \( n \times n \) is a vector of real numbers \( N \). Delta is a kronecker value with discrete sine transform in inverse form is given by equations as follows:

The inverse of discrete sine transform is given by (2)

\[ S^\dagger_k = p_k \sum_{n=0}^{N-1} x_n q_n \sin \left( \frac{(n+\frac{1}{2})(k+1)}{N} \right) = 0, 1, 2, \ldots, N - 1 \quad (4.3) \]

\[ p = \sqrt{\frac{2}{N}} \quad (4.4) \]

\[ q_n = \sqrt{\frac{1}{1+\delta_{n,0}}} \quad (4.5) \]

Discrete sine transform have Eigen values in orthonormal process which are separated by means of DST components. The solution obtained by linear filtering is optimal from karhunen loeve expansion. The real time analysis is universal basis as it represents non parametric property to the given signal. The unbiased values are like estimators which represents the volatility with a DST estimator. The values evaluated of \( M \) use linear regression in the above side equation. As the number of observations increases this approach is the best method for those values. DST have many advantages over FFT because of its time and simplicity the image coefficients are computed with very high speed and low complexity.
4.4.2 Information gain

This process is essential for feature vector classifications. The information gain is computed by means of attributes the attributes can be a class of x and y which gives a conditional entropy of y with given x.

The entropy conditional of y with given x is given by

\[ I(Y; X) = H(Y) - H(Y/X) \]  \hspace{1cm} (4.6)

The conditional entropy of Y given X is

\[ H(Y \mid X) = -\sum_{j=1}^{N} P(X = x_j) H(Y \mid X = x_j) \]  \hspace{1cm} (4.7)

4.4.3 Support Vector Machine (SVM)

This method is used for binary classifications in basic learning processes the idea behind is to find a hyper plane which perfectly divides two classes in a d dimensional data. The feature space introduced is linear separable data. The SVM’s use a system likelihood measurement for explicit learning the SVM is theoretically and practically is successful to solve regressions with trained data. Many techniques are used for clustering and classification of linear separable data and non-separable data. SVM is a statistical learning theory for classification of images, character recognition and face detection.

The advantages of SVM over neural networks are which use less number of training data and the training error rate is minimized and it is to robust against noise and blur. The curve fitting problems in terms of dimensionality is very less in classification processes.
The binary classification for pairs of data \((x_i, y_i)\) represents an input space with \([-1, 1]\) as output class the classification function is 
\[ G(x) = W.x + b \] where \(W\) and \(b\) are slope intersection.

Fig. 4.4: The classification of support vector machines in three classes

SVM has multiclass with different groups in image data base and it separates one class of images from other set of data base. SVM generates a hyper plane decision surface based on minimization of risk, sum of training error rate while depending on vapnik and chervonenkis (VC) dimensions. SVM algorithms provide better performance when working on pattern classification and it uses a support vector as input. In the proposed work poly kernel SVM is modified and function used is \(K(X, Y)\) which is a function of kernel. Many methods are used to perform machine learning with activities and tasks. The hypothesis space is a feature space used in statistical learning for derived bias.

The accuracy is very high in SVM when compared with neural networks in various applications such as hand writing and face recognition. The wapnic method gained popularity as it is a basic foundation of SVM to obtain better empirical performance. The elements used in SVM are far superior to neural networks Because of its structural risk management.
The SVM provides very low training error and greater flexibility to solve pattern classification and regression problems. It works on structural risk minimization principle which has a classifier minimized with less dimension as Vapnik and Chervonenkis. The generalization of error rate in pattern classification is improvised by incorporating domain knowledge.

Let us consider a set of vectors trained to separate 2 classes.

![Fig. 4.5: separable data linearly](image)

The plane is a hyper which is constructed by a separating a margin of classifier with given trained data. SVM indicates weights for the relevant feedback images collected from distinguishable data. The preferences weights share a relation with numerical calculation left with vary time. The Vapnik and Chervonenkis theory has regularization properties to generate new data to model the equation.

### 4.4.4 Advantages of SVM

SVM share a similar relation between radial basis function and neural networks to find the generalization of quality. This model is able to work for text and image classification to have obtained attributes with lower limit and imposed on hardware constraints. SVM
defines decision planes and boundaries to make separation between class memberships and the set of objects. SVM gives a widest separation of various classes.

4.5 Design and Testing of Reconstructed CT Image for Content Based Image Retrieval

GUI format

Fig. 4.6: GUI model for image retrieval

Above figure shows the GUI model for image retrieval system. It consist mainly five push buttons. They are namely

1. Load database

2. Browse

3. Relevance feedback

4. Removal of artifacts

5. Histogram analysis mathematical computations
Load database

![Database Loading](image)

Fig. 4.7: After loading database, pop-up window is appeared

Browse

![Query Image Insertion](image)

Fig. 4.8: Inserting query image
4.5.1 Test & Results

Relevant feedback

Fig. 4.9: Relevant call back image

Fig. 4.10: Inserting a Query image for few retrieval images to find accuracy Interval rate
Fig. 4.11: Relevant feedback with few retrieval images to find accuracy rate

Fig. 4.12: For various relevant feedback images with mean values
4.5.2 Optimized Solution

Removal of artifacts

Fig. 4.13: Blur and noise containing query image

Fig. 4.14: Restoration of Blurred, Noisy Image Using NSR=0
4.5.3 Analysis of Results

Fig. 4.15: Histogram for the query image

Fig. 4.16: Classification accuracy measured in percentage
4.6 Concluding Remarks

From the experimental results it is shown two step Support vector machine used for classification and discrete sine transform for feature reduction proposed gives accurate results for content and feature based image retrieval system. Therefore it gives a clear picture of solving the feature based extraction problems. The accuracy measured in percentage evaluates the performance by comparing relevant methods. The retrieval rate required was only few seconds.

4.7 Summary

In this chapter the various issues related to the medical image retrieval methods observed and the design of Novel medical image retrieval method have been discussed. Based on this research line the content based image retrieval with high accuracy in classification rate related to features has been designed. In the next chapter neural network based computation for segmenting and detecting the cancerous lesion is studied. The experimental results are more promising.