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An Efficient CBIR System for Medical Images Using Neural Network

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Abstract
This paper introduces an innovative Content-Based Image Retrieval (CBIR) system that has been specifically developed for medical databases. Its objective is to resolve the drawbacks of conventional keyword-based search approaches when considering the widespread digitization of medical illustrations, diagrams, and paintings. In contrast to conventional methods that rely on textual queries, CBIR systems effectively locate and retrieve relevant images by analyzing image content using computer vision and image processing techniques, as well as information retrieval and database methods.
A key challenge in CBIR lies in bridging the semantic gap between high-level user queries, often expressed through example images, and the low-level features of images such as texture, shape, and objects. This paper explores techniques to mitigate this disparity, enhancing the system's ability to accurately interpret user queries and retrieve relevant images.
The proposed CBIR system operates within a medical database containing images of various human organs, including the brain, heart, hand, chest, spine, and shoulder, categorized into six distinct classes. By leveraging low-level image features such as texture and shape, extracted using methods like mean, variance, standard deviation, area, perimeter, circularity, and aspect ratio analysis, the system performs iterative searches to retrieve relevant images.
Classification of retrieved images is accomplished using Artificial Neural Networks (ANN), which have demonstrated efficacy in medical image classification tasks based on imaging modalities and the presence of normal or abnormal conditions. Performance evaluation of the CBIR system is conducted using confusion matrices to calculate precision and recall, essential metrics for assessing retrieval accuracy.
By focusing on medical datasets and integrating advanced feature extraction and classification techniques, this CBIR system aims to significantly enhance image retrieval efficiency and accuracy, particularly in the context of medical applications where precise retrieval of relevant images is critical for diagnostic and research purposes.

Keywords: CBIR, Medical Database, ANN, Classification Accuracy, Semantic Gap

Introduction

In many areas of engineering and study, the amount of image data that needs to be kept, searched, retrieved, and stored keeps growing. Most of the time, people use search engines like Google, Yahoo, and Bingo to look for pictures. When we search for pictures, we give them text, and those engines find related pictures [17] based on the text we give. In text or keyword-oriented retrieval technology, if you give it a text of "water lilies," it will look for, match, and retrieve only images of lilies. It will also give you more information about images with the text "lilies flowers [15] in pond," which means it will find an image that fits what the user wants. So, the user has to describe the picture completely in text or using keywords to find it.
The text-oriented method has some problems, which are listed below. One thing that makes image explanation hard is that databases that are very big make it impossible to find images using text or keyword-based methods. To get an image given by the operator, the language used should also be known. The second difficult thing is operator point of view that is find a problem like subjectivity of user need and more concern need on the end user. Third one difficult thing is more clarity needs to sharp queries that cannot be possible at all into the different features of images to find.

Content Based Image Retrieval (CBIR)

CBIR searches by image query instead of text query, so pictures are retrieved based on what's in the image [21]. Since then, CBIR has been used instead of text-based picture retrieval. The user interface is very important because it's how people connect with each other. People often say that the lack of CBIR [22] use in clinical settings is due to an interface that is hard to use [1, 2]. Both and [2] suggest that more work should be put into studying how easy it is to use CBIR[16] tools. The interface should support a lot of different ways to submit a question.

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Medical Content Based Image Retrieval (MCBIR)

An image retrieval system is a computer system that lets you look through a big database of digital pictures and get pictures that you want. The term "CBIR" refers to methods that get pictures by looking at their content instead of their metadata. It's not always easy to use CBIR methods on different types of medical images because they were designed to work with particular parts of images. Endoscopy, Magnetic Resonance Imaging (MRI), X-rays, Computed Tomography (CT) scans, and Position Emission Tomography (PET) scans are some of the types of medical pictures that are made in different health and medical centers [3]. A huge number of medical pictures are made every day in medical centers by machines like CT, MR, X-ray, and others. When picture archiving and communication systems (PACS) were first used in medical settings, they were saved in image databases. People who work in medicine use CBIR to help them find images that have similar information.

Imaging tests like X-rays, MRIs, and endoscopies are very important to modern medicine [20] and produce a huge amount of different data. Traditional picture retrieval methods that rely on textual metadata can't quickly search through these huge databases because they can't capture all the rich visual content. This made Medical Content-Based Image Retrieval (MCBIR) possible, a way to find pictures that are useful for medicine by looking at their visual properties.

Literature Review

This paper goes into great depth about the background theory that was used in the rest of the paper. We don't want to go into too much information about the background theory so that the paper is short and there aren't any pointless discussions. Instead, we give a short introduction that focuses on the main ideas and meanings that will help you understand the rest of the paper. The main ideas and definitions will be used when this work is looked over again later.

Many researchers have given their significant contribution in the field of testing CBIR application. In this section we are going to discuss their work.

M. Flickner, H. Sawhney, W. Niblack [8] [9] who take an initiative by proposing query-by image content (QBIC). QBIC developed at the IBM Almaden Research Center is an open framework and development technology. Query can be images, user created sketches or a selection of color and texture patterns.

J. R. Smith, S. F. Chang [10] Use content-based & spatial image query (provides feature comparison & spatial query for unstructured color images). Visual SEEk: A Completely Computerized Content Based Image Retreival for the Query.

J. Laaksonen, M. Koskel [11] PicSOM: CBIR For Self-Organization Map (SOM). Similarity scoring method using tree structured SOM.

Megha. P. Arakeri, G. Ram Mohana Reddy [12] Medical Image Retrieval System for diagnosis of Brain Tumor Based on Classification and Similarity in Content. To tell the difference between brain tumors at each level, a set of shape and texture traits that don't change with rotation is used. The suggested method that combines texture and shape shows promise for better precision, recall, and retrieval time.

Wan Siti Halimatul Munirah Wan Ahmad and Mohammad Faizal Ahmad Fauzi [13] Comparison of Different Feature Extraction Technique in Content-Based Image Retrieval for CT Brain Images. The best texture extraction technique is Discrete Wavelet Frame (DWF) for intensity is Gray Level Histogram (GLH) and for shape feature is Fourier Descriptor. For the combination of techniques, DWF and FD combination gives the most excellent result

V. Amsaveni, Noorul Islam, N. Albert Singh, [14] Detection of Brain Tumor using Neural Network. The extraction[23] of texture features in the detected tumor has been achieved by using Gabor filter. These features are used to train and classify the brain tumor employing Artificial Neural Network classifier

S.L.A. Lee et al [4] concentrated on lung nodule detection which is used to spot the lung abnormalities in CT lung images with the help of Random Forest algorithm. This algorithm provides hybrid random forest-based nodule classification. It is also used to detect 32 patients with 5721 images. The accuracy in proposed system is noted as 97.11 whereas in the developed system the high receiver operator characteristic is given 97.86% accuracy.

Mahnaz Etehad Tavakol et al [5] provide the high infrared cameras to diagnose the vascular changes of breasts by using the ada boost algorithm. The algorithm is used to classify the invisible images into benign, malignant and normal. In this system the accuracy of 83% is given which gives better performance than the proposed system of 66%.

Ming-Yih Lee et al [6] proposed an entropy-based feature extraction and some other protocols for the breast cancer diagnosis using decision tree algorithm. The Morphological operations used in this system to detect the unified abnormal regions. This method gives 86% accuracy which is better than the proposed system of 59%.

Ye Chen et al [7] focused on the detection of brain structural changes from the Magnetic resonance images which helps to aid the treatment of neurological diseases with the help of Support Vector Machine algorithm. In addition, the algorithm which helps to analyze the MR images from the various datasets. The accuracy range between 70% and 87% are noted.

Methodology

The first stage is CBIR with medical database that can be done with some steps: The first step is represented by the image acquisition with feature stored in database image followed by select query image then image enhancement with preprocessing techniques. Then calculate composite feature for query image and generate the feature vector. Find the Euclidian and Manhattan distance in between feature vector of database image and query image for similarity[18] calculation. Then sort distance and retrieve the best related result.

The second stage is classification of retrieval result of CBIR that can be done with some steps: The first step is apply feed forward neural network for classification of relevant and no relevant image. If relevant images are retrieved then it is further classification into normal and abnormal images. All the step for the systems are cover with in detail to the further part.

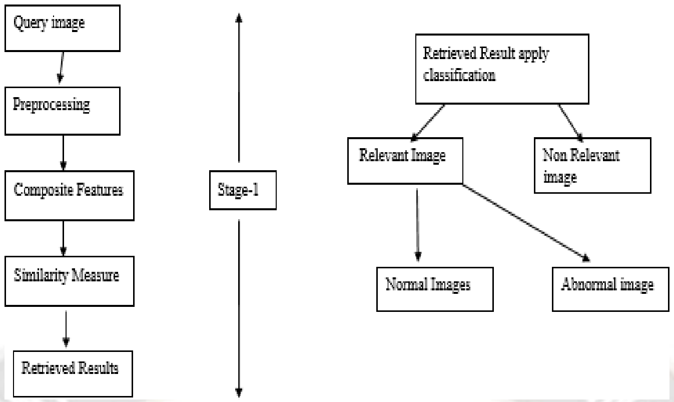

Fig.no. 1 CBIR with Classification Proposed System

Proposed System

We made progress in our study paper on testing the CBIR system with a medical database. To show that our ideas can be used, we've come up with different ways to solve the problems we listed above and built software examples to show that they work.

- Step1: Create a database of medical images with their features for Texture & Shape that can be used to search Query image.
- Step2: Select the query image.
- Step3: Extract the texture and shape feature for query image.
- Step4: Calculated the Euclidian distances for the Texture +shape feature vectors of query image and for the stored database images
- Step5: Calculated the Manhattan distance for the Texture +shape feature vectors of query image and for the stored database images.
- Step6: Apply Sorting on distance result and retrieve the best matching from database as per user want.
- Step7: The precision and recall are calculated and tabulated for performance of the system with different class of query images.
- Step8: Apply neural network for classification of image with relevant and no relevant images
- Step9: Apply neural network for classification of abnormal and normal images and identified semantics for image
- Step10: The classification Accuracy are calculated and tabulated for performance of the system with different class of query image.

Implementation & Result

The system configuration used to run system is Windows 7 Professional service pack 1, Intel(R) Core (TM) i3-3240 CPU@ 3.40GHz running at 3.40 GHz, with 4.00 GB RAM. The software used is MATLAB. MATLAB has tool for image processing and neural network. All measured times reported in this section are texture, shape and composite features with precision, recall and classification accuracy etc.

Work-1: Select Query image and calculate Texture and Shape Features

The suggested CBIR methods use a different kind of 300 images with sizes that can be changed across 7 groups and a collection of images. Fig. 5 and 6 show the different types of medical pictures and how they are grouped. The system was made in MATLAB 7 on a computer running Windows and having more RAM. The suggested MCBIR system will be built in the following ways. The first step in the suggested system is to make a database of medical images that are organized into different groups. To enter query image system, we need a way to talk to it, so we made the MCBIR Graphical User Interface (GUI) shown in Figure 2. In the second step of the suggested system, choose any query image that appears in the GUI shown in Figure 3. The chosen query picture is a heart and brain from the database. It can be seen in Figure 4. the heart and brain question images in Figures 7 and 10 were used to figure out their texture and shape.

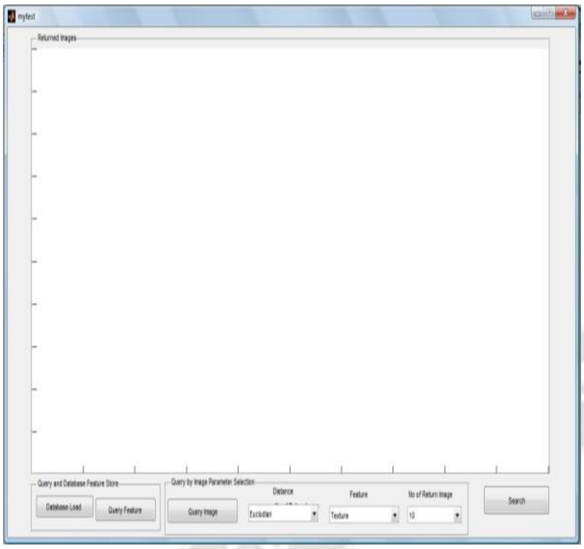

Fig. no. 2. GUI of MCBIR

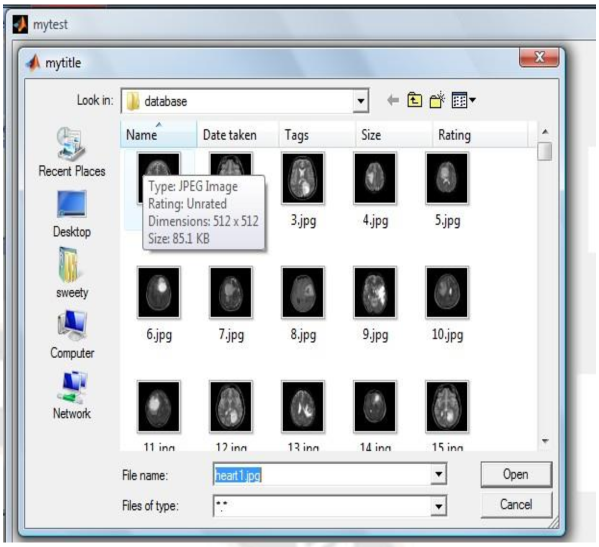

Fig. no. 3. Select heart query image MCBIR

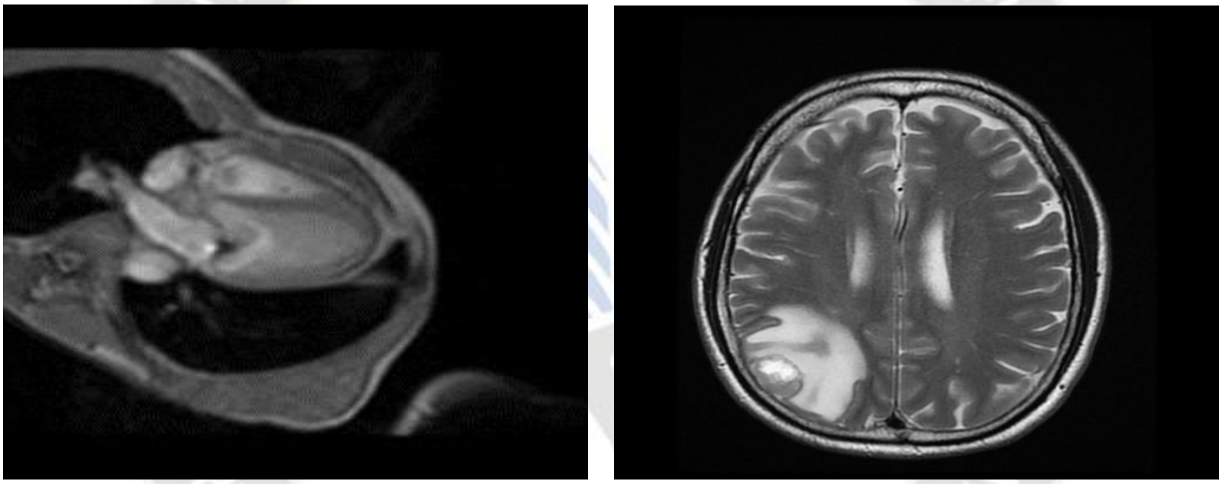

Fig. no. 4. Heart image with normal and Brain image with abnormal query image of MCBIR

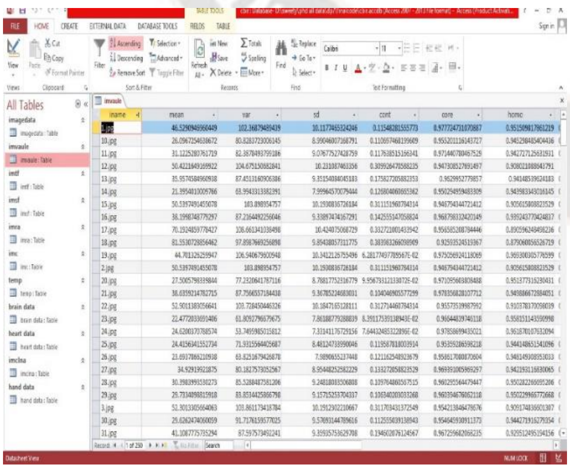

Fig. no. 5. Database with feature calculation for MCBIR

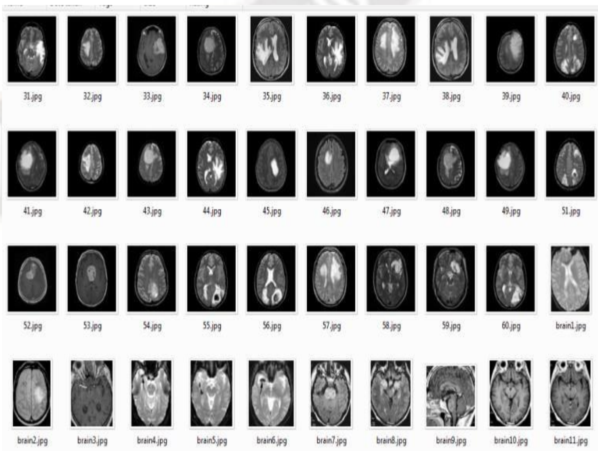

Fig. no. 6 Database image with different category

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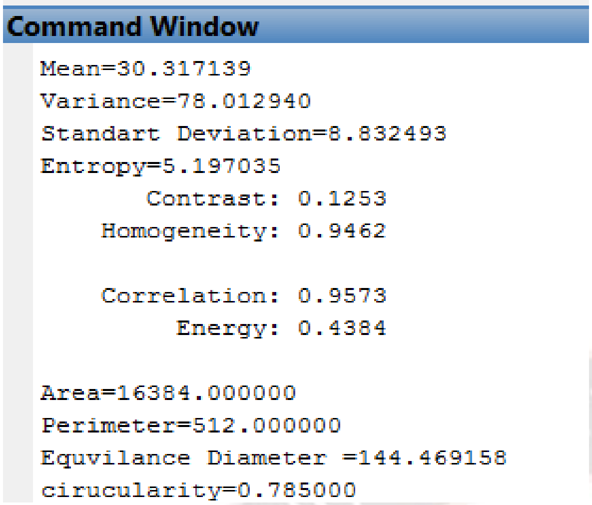

Fig. no. 7. Various features for heart query image of MCBIR

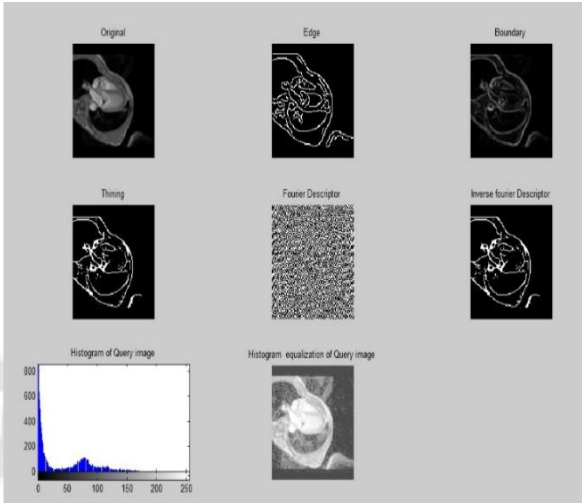

Fig. no. 8. Texture and Shape features for heart query image of MCBIR

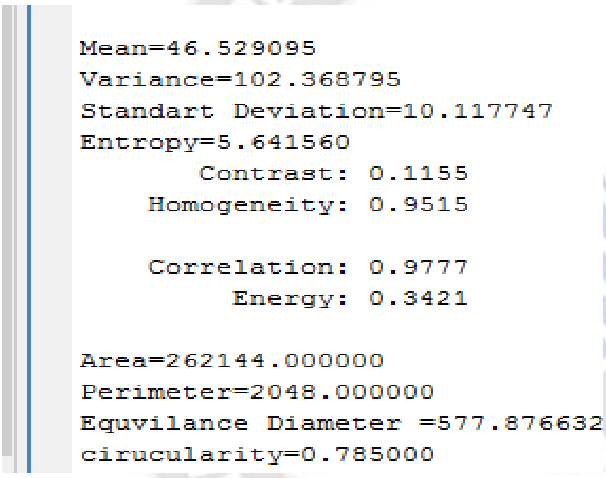

Fig. no. 9. Various features for brain query image of MCBIR

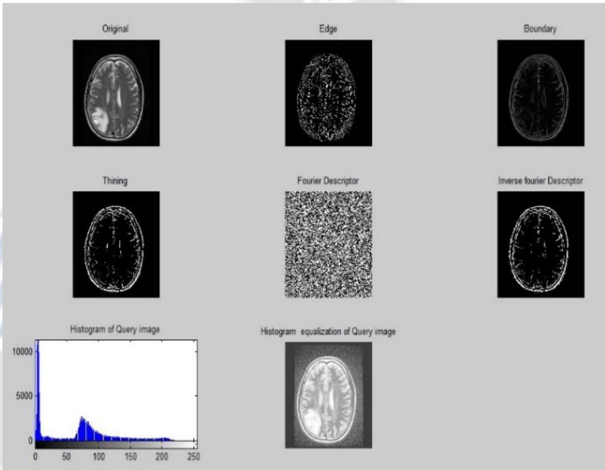

Fig. no. 10. Texture and Shape feature for brain query image of MCBIR

Work-2: Precision and Recall for Texture and Shape Features

In GUI user has to select the no of images and distance formula for retrieved related images. For selected query image the texture feature are calculated that give in figure 9 and 7. In the texture feature calculate the mean, variance, standard deviation, correlation, energy, entropy, and contrast. In the texture feature the feature vector created with 7 different value. For the shape feature area, edge, Fourier descriptor, circularity, equivalence diameter are calculated. In the shape feature the feature vector created with 5 different value. So for the different category of image texture and shape feature are calculated that calculated texture and shape features are stored in database. In the GUI user has select distance method for retrieval result.

The precision and recall are calculated for all the category of image with Euclidian and Manhattan distance. For the heart and brain category the precision and recall show in research paper. In the fig no. 11 & 15 gives heart retrieval with texture features. In the fig no 12 & 16 give heart retrieval with shape features. In the fig no 13 give brain retrieval with texture feature. In the fig no 14 & 17 give brain retrieval with shape features. As per the user selection of distance method the retrieval result can vary but it is nearer vary.

As per the selection in GUI number of images are retrieved. The system calculated the precision and recall for the texture and shape feature with different distance formula. That is given in table no 1& 2 and table no 3& 4 respectively. As per the table if the number of images is increase as per the category, then precision and recall are decrease.

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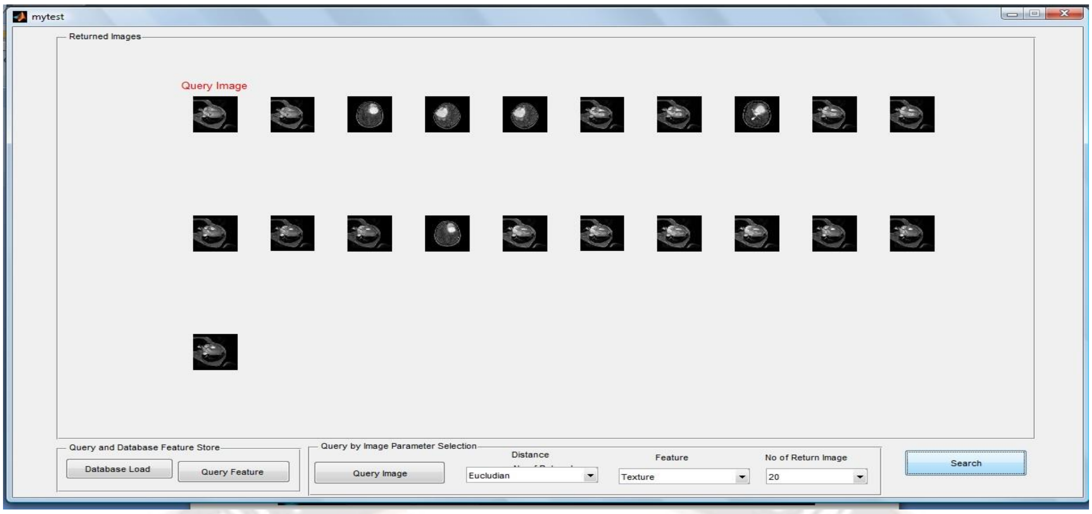


Fig. no. 11. Retrieval result (15) with Texture features for heart query image of MCBIR

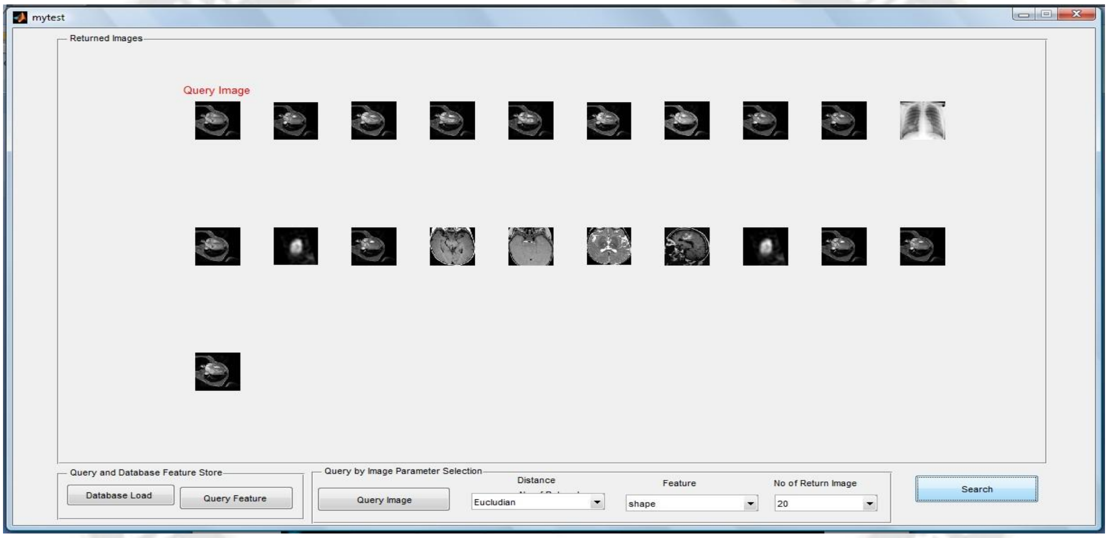
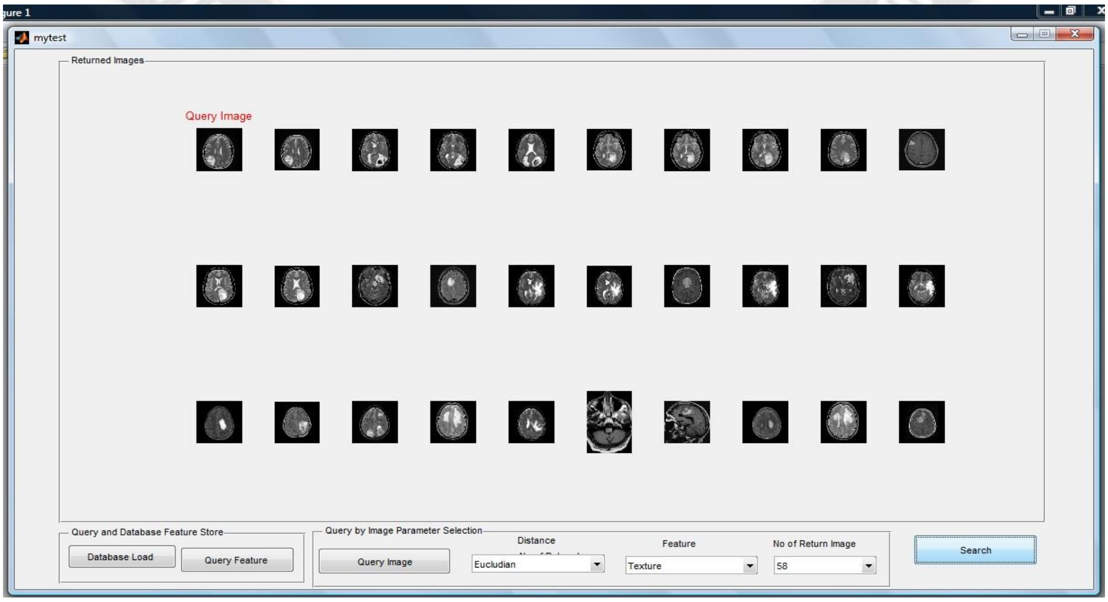


Fig. no. 12. Retrieval result (15) with shape features for heart query image of MCBIR



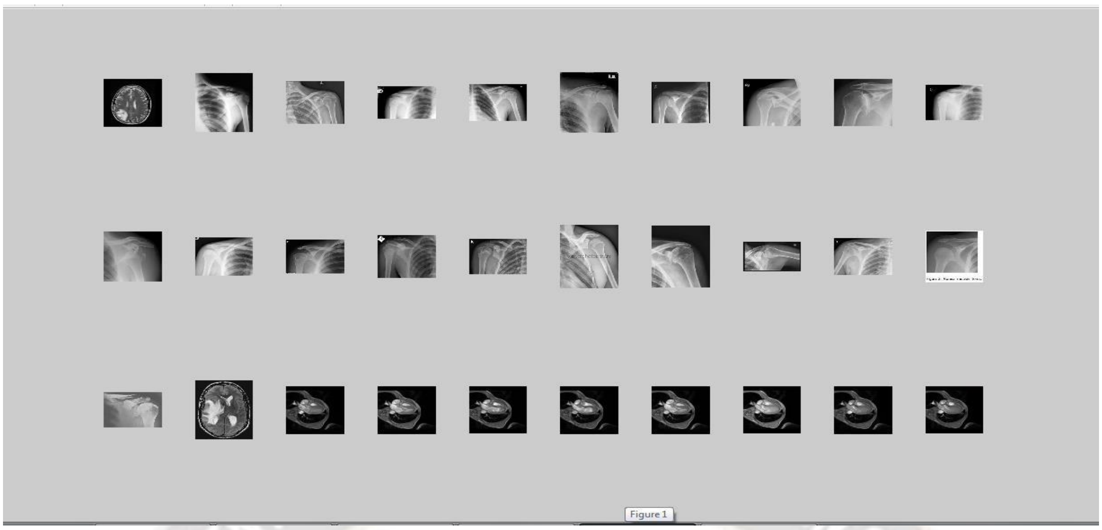


Fig. no. 13. Retrieval result (29) with Texture features for brain query image of MCBIR

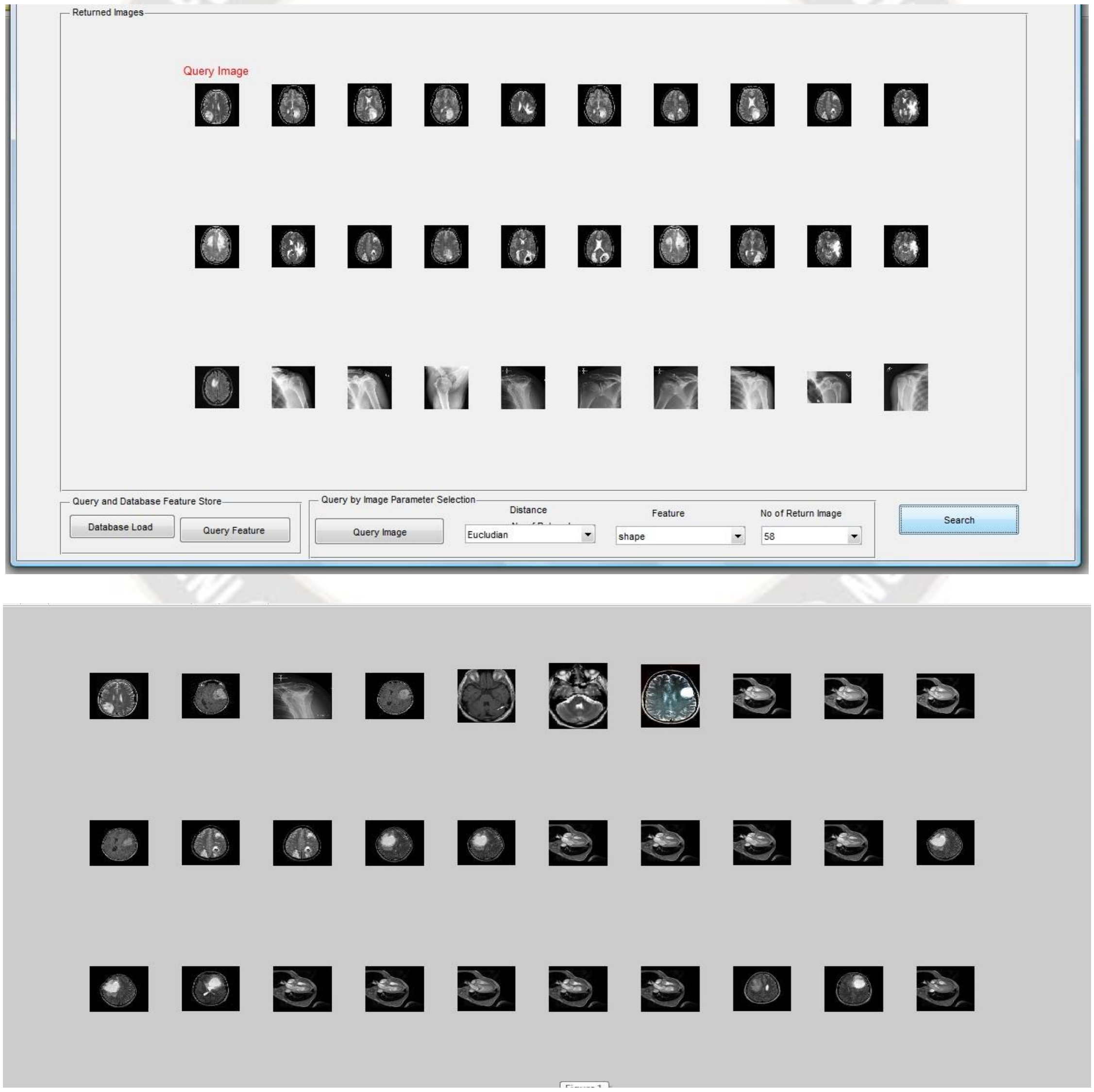


Fig. no. 14. Retrieval result(32) with Shape features for brain query image of MCBIR

Texture Feature	Precision with Euclidian Distance	Recall with Euclidian Distance	Precision with Manhattan Distance	Recall with Manhattan Distance
Hand	81%	81%	81%	81%
Heart	75%	75%	75%	75%
Shoulder	70%	70%	72%	72%
BrainMri	68%	68%	70%	70%
Spine	60%	60%	69%	69%
Chest	53%	53%	69%	69%
BrainCT	51%	51%	67%	67%

Table no 1: Precision and Recall with Texture Feature

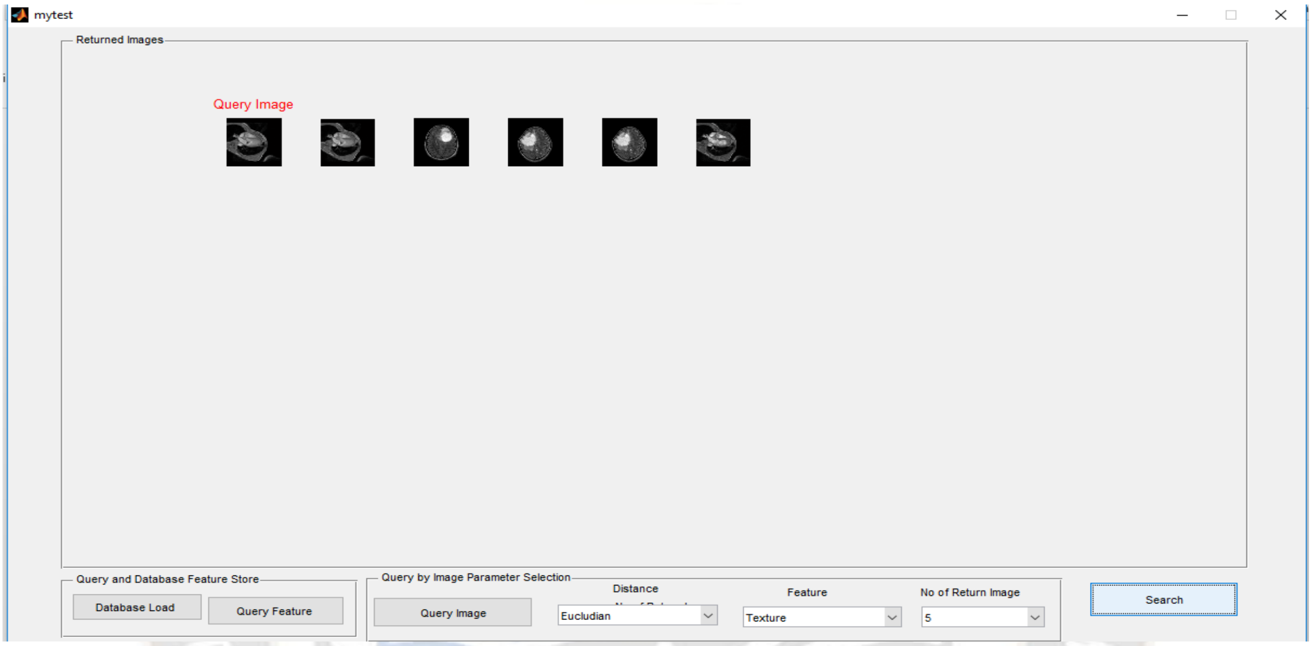


Fig. no. 15 Retrieval result (2) with Texture features for heart query image of MCBIR

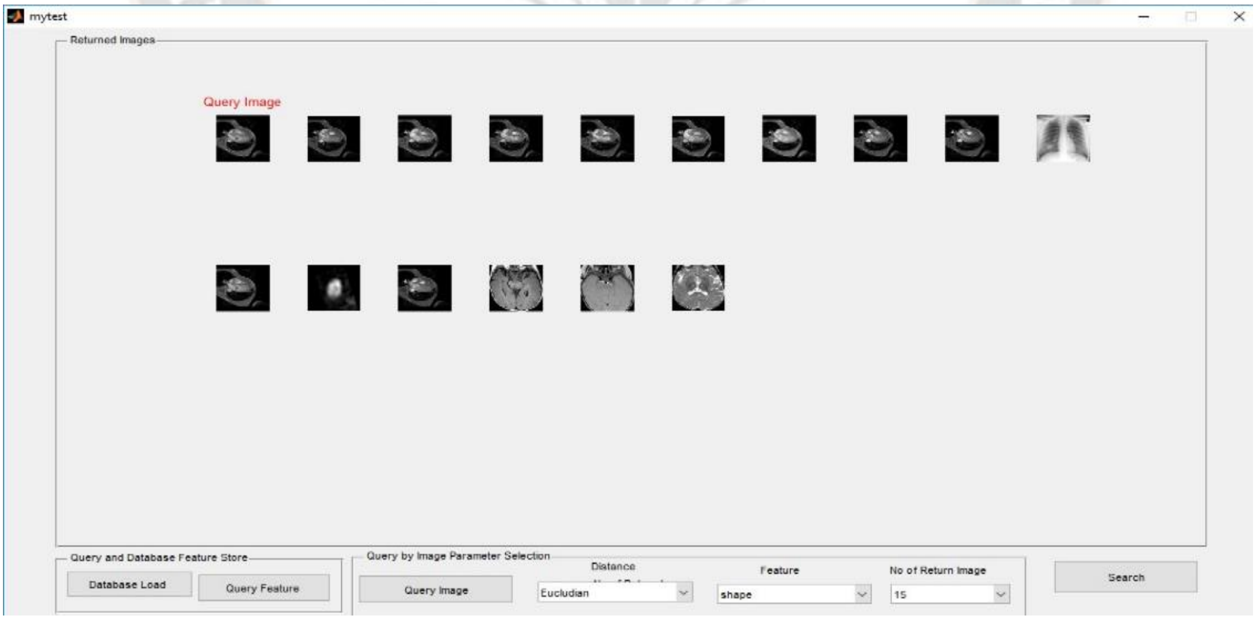


Fig. no. 16. Retrieval result (11) with Shape features for heart query image of MCBIR

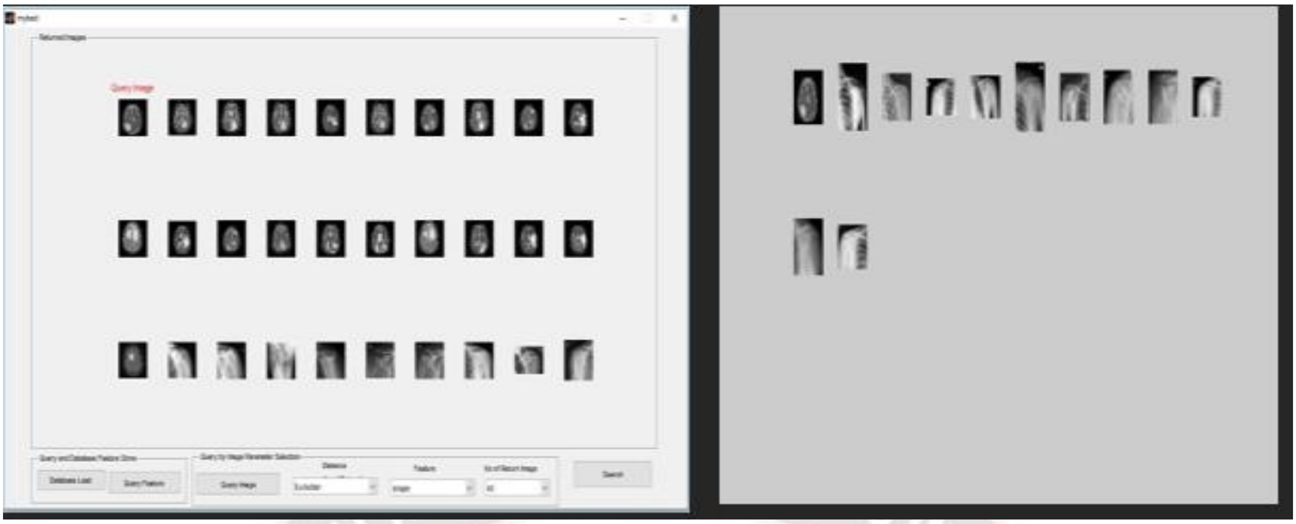


Fig. no. 17. Retrieval result (40) with Shape features for brain query image of MCBIR

No of Retrieval for heart and Brain(Texture)	Precision	Recall per category image in database	Recall with full database image
Heart(5)-2	40%	10%	0%
Heart(10)-6	60%	50%	2%
Heart(15)-10	66%	50%	3.3%
Heart(20)-15	75%	75%	5%
Brain(20)-7	35%	11%	0%
Brain(30)-13	43%	21%	4%
Brain(40)-18	45%	30%	6%
Brain(58)-29	50%	48%	9.6%

Table 2: Precision and Recall for heart and brain with Texture Feature

No of Retrieval for heart and Brain (shape)	Precision	Recall per category image in database	Recall with full database image
Heart(5)-3	60%	15%	1%
Heart(10)-7	60%	30%	2.3%
Heart(15)-10	66%	50%	3.3%
Heart(20)-15	75%	75%	5%
Brain(20)-8	40%	13%	2.6%
Brain(30)-13	43%	21%	4.3%
Brain(40)-20	50%	33%	6.6%
Brain(58)-32	55%	53%	10.66%

Table 3: Precision and Recall for heart and brain with Shape Feature

Shape Feature	Precision with Euclidian Distance	Recall with Euclidian Distance	Precision with Manhattan Distance	Recall with Manhattan Distance
Hand	80%	80%	80%	80%
Heart	75%	75%	75%	75%
Shoulder	73%	73%	73%	73%
BrainMri	69%	69%	76%	76%
Spine	65%	65%	70%	70%
Chest	60%	60%	65%	65%
BrainCT	55%	55%	50%	50%

Table no 4: Precision and Recall with Shape Feature

Comparison with Relevance Feedback and Proposed System

In the general to get the maximum retrieval relevance feedback approach is used but it is nothing but iterative search. The main reason of CBIR created for relevance feedback is on retrieval process, permitting users to evaluate and mark the retrieval outcomes of CBIR, find out which are not relevant results and which are related to the query image, then feedback the related info that the users mark to the system as training samples for instruct next image retrieval and learning, So made the results more as per the requirements of users. A wider application of relevance feedback method changes the query vector on the one hand, using feedback information to change the weight of each feature vector in the formula, highlighting the more important vector of the query. The Relevance Feedback also implemented with heart and brain result with texture, shape feature. The heart query image tested with texture feature and relevance feedback, that is shown in fig no 19 respectively. The brain query image tested with shape feature and relevance feedback that is shown in fig no 20 and 21.

In the proposed system work with texture and shape composite feature with Euclidian and Manhattan distance for the retrieval accuracy it is nothing but more feature give nearer good result. So there is no human interaction in between the system. The heart and brain query image tested with composite feature, which is shown in fig no. 20 and 22. The precision and recall is more in composite feature which is given in table no.5 As per the table you can see the proposed system precision and recall are more compare to relevance feedback.

To compare the existing system with proposed system, in the literature review already discussed the IRMA, MIRAGE, 3D PET, ASSERT and lot many systems. This existing system IRMA, MIRAGE are compared with proposed system with precision and recall, which is given in table no.6. As per the table you can see the proposed system precision and recall are more than the existing system.

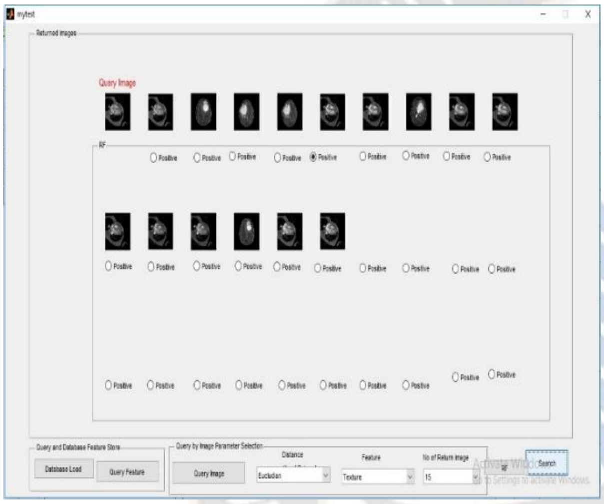


Fig. no 18. RR with Texture features for heart query image of MCBIR

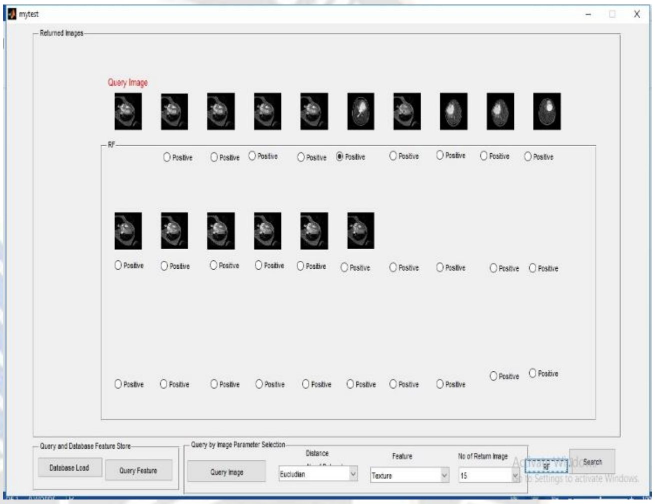


Fig. no.19. Retrieval result (11) with Texture features with RF for heart query image of MCBIR

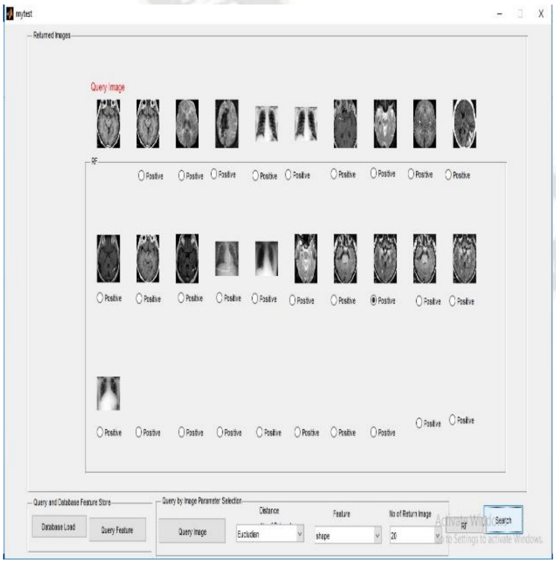


Fig. no.20. Retrieval result (15) with shape features for brain query image of MCBIR

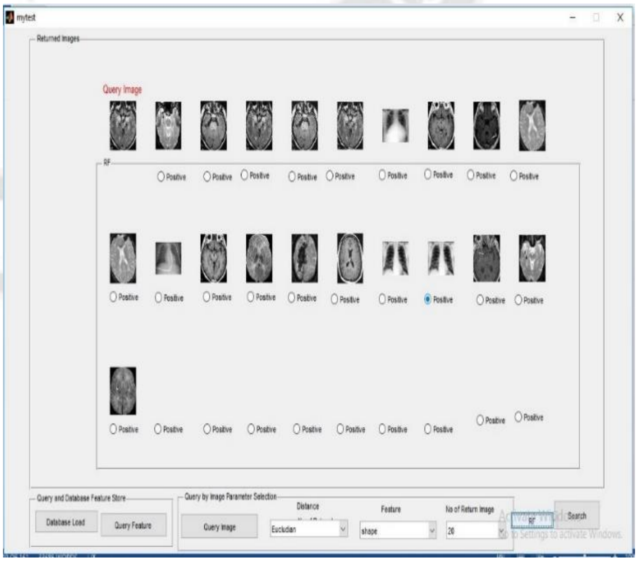


Fig. no.21. Retrieval result (16) with shape features with RF for brain query image of MCBIR

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Fig. no. 22 Retrieval result (20) with composite features for brain query image of MCBIR

Sr.No.	Algorithm	Image Type	True (Relevant) image	False(Non Relevant) image	Precision (%)
1	Texture	Heart(15)	10	5	66
2	Relevance Feedback Texture	Heart(15)	11	4	73
3	Shape	Brain(20)	15	5	75
4	Relevance Feedback Shape	Brain(20)	16	4	80
5	Proposed System(Composite)	Heart(15)	15	0	100
6	Proposed System(Composite)	Brain(20)	20	0	100

Table no 5: Comparison of relevance feedback and proposed system

SR. No	Existing System Online	No of Relevant Retrieved image(Heart)
1	Tin Eye	10
2	Bing	1
3	Google	4
4	Proposed System	20

Table no 6: Comparison of existing system and proposed system

In this work, we have proposed a novel algorithm for the medical CBIR and classification. We have named our system with medical CBIR with neural network classification. We considered medical images with 6 categories, more number of features and different distance formula in our work. Our algorithm used texture and shape features with combination for the retrieval result and classification accuracy.

In the general to get the maximum retrieval relevance feedback approach is used but it is nothing but iterative search. In the research paper system work with texture and shape composite feature and Euclidian and Manhattan distance for the retrieval accuracy it is nothing but iterative search with both features. So there is no human interaction in between the system. With the help of low-level feature of texture and shape we get the semantic like relevant, not relevant, normal and abnormal image. With the help of Euclidian and Manhattan distance research get the nearer same result.

In the paper result show with heart and brain query image with texture, shape and composite feature. That heart and brain retrieval result with composite feature give nearer 100% precision and recall in the result compare to texture and shape feature. That shown in fig no 27 to 28.

In the research paper first CBIR tested with texture feature and get the precision and recall in between 50 % to 80%. In that case when the number of images is increased in database then precision and recall is decrease. That show in fig no 23

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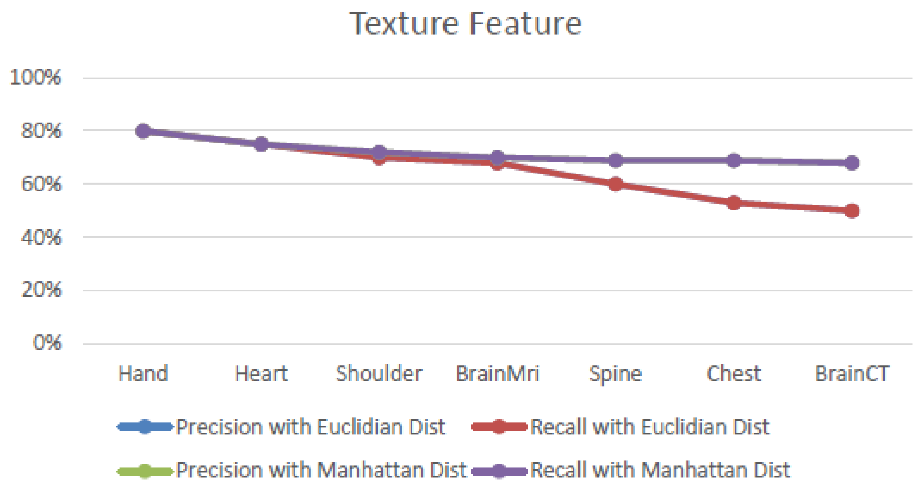

Fig. no. 23 Precision and Recall with Texture Feature

In the research paper second CBIR tested with shape feature and get the precision and recall in between 55 % to 80%. In that case when the number of images are increased in database then precision and recall is decrease. That shown in given fig no 24.

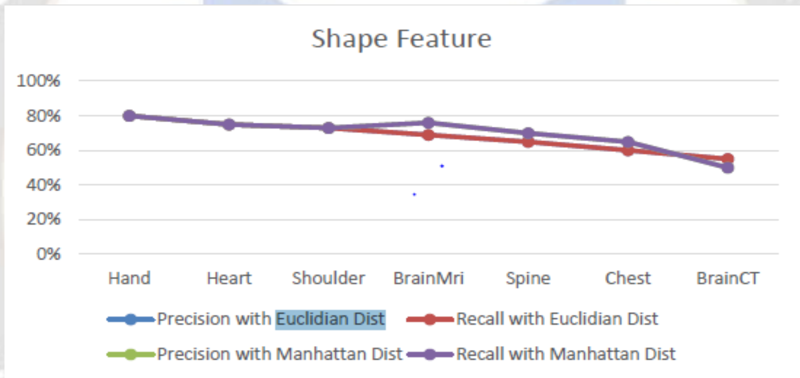

Fig. no. 24 Precision and Recall with Shape Feature

In the research paper third CBIR tested with composite feature and get the precision and recall in between 97 % to 100% . In the research paper the classification accuracy also we get more 100% for the composite feature. In that case when the no of image are increased in database then retrieval accuracy and classification accuracy is not decrease. That show in fig no 25 and 26.
The main advantage of our system that with the help of composite feature precision and recall we get nearer to 100% and classification with neural network with composite feature give 100% accuracy.

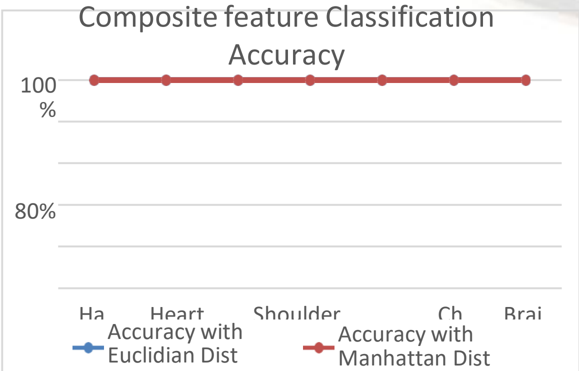

Fig. no. 25 Classification accuracy with Composite

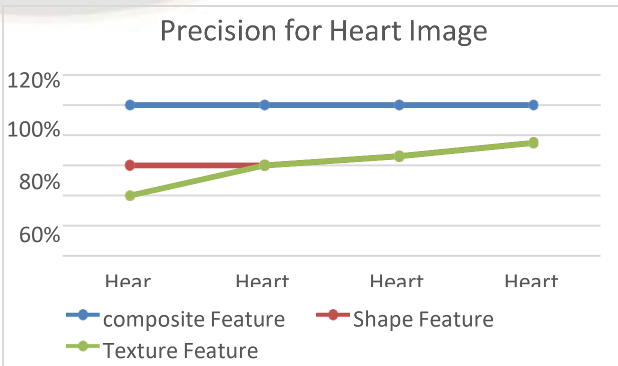

Fig. no. 26 Precision and Recall with Composite Feature Feature

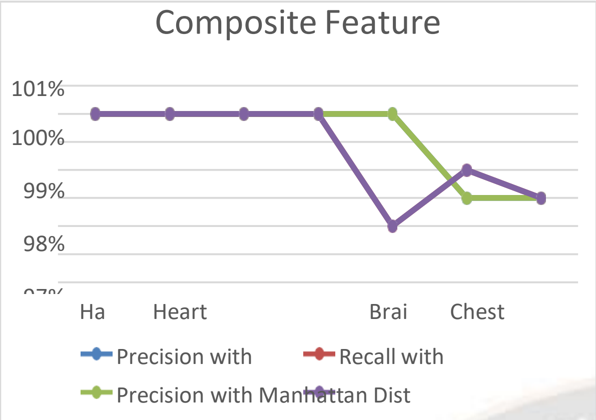

Fig. no. 27 Precision for heart image with all feature

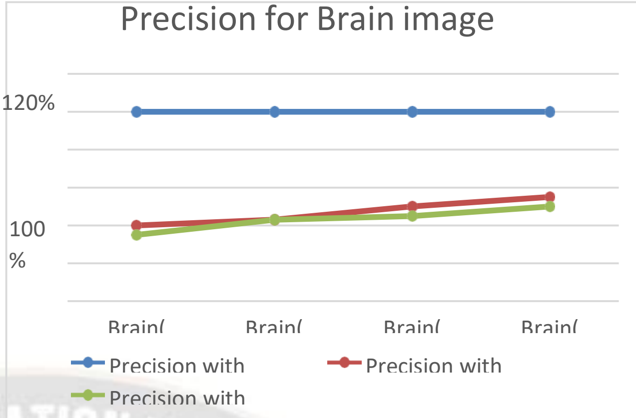

Fig. no. 28 Precision for Brain image with all feature

Conclusions

This research paper has cover information on the CBIR useful in medical area, the popular of the MCBIR systems have emerged as up gradation of the CBIR systems. The purpose of medical image databases is to give an effective resource for managing, penetrating, and indexing with higher collected of medical images. Medical content-based retrieval is a talented method to get retrieval and has generated a various methods using texture and shape feature. CBIR approach provides semantic retrieval and effective feature extraction with precise techniques of shape and texture. The overall performance of neural network algorithms in this research paper was analyzed based on the classification accuracy.

The primary aim of work is maximum retrieval with classification in MCBIR. The research paper gives the maximum retrieval if number of images are higher as per the category. So texture and shape both composite feature are helpful to retrieve the maximum for all the category of image. The neural network give the maximum classification accuracy for medical retrieval image.

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