Med Auxiliator

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ACKNOWLEDGMENT

"The company of learned men is the key to the gates of wisdom".
The satisfaction and euphoria that accompany the completion of any task would be incomplete without the mention of the people who made it possible, whose constant guidance and encouragement ground our efforts with success.

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ABSTRACT

Image processing is an expanding field with its applications spreading across several domains. There is extensive use of digital images for medical purposes which involves critical decisions to be made based on the elucidation of medical images such as MRI scan, CT scan, X-ray etc., and calls for substantial research. This paper is based on the project aimed at processing of MRI scans of brain. The proposed system performs content based retrieval of cases similar to the MRI scan loaded as query using Gabor wavelet based edge detection on hexagonal resampled grid, and proposes an algorithm for identification of ailment, if present. The work is restricted to identification of three brain pathologies viz. tumor, bleed and infarction. The project intends to assist doctors in identifying the abnormalities.

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Chapter 1

Preamble

1.1 Introduction

Content based image retrieval, CBIR, involves looking for similar images based on the content of the images rather than the metadata as in text based image retrieval. Features such as colour, shape and texture are extracted from the image and these serve as basis for further processing. Normal images are found to be in rectangular lattice, transforming them to hexagonal grid using re-sampling delivers improved feature parameters which in turn enhances the retrieval performance. Supporting factor being the resemblance of retina of human eye with the hexagonal grid space helps in replicating natural behaviour in computer vision. Feature extraction starts with detection of edges which provides shape parameters. Gabor wavelet based edge detection technique is used in this work. Frequency and orientation representations of Gabor filters are similar to those of the human visual system, and they have been found to be particularly appropriate for texture representation and discrimination. Gabor filter has the unique property of orientation selectivity that differentiates it from other edge detection techniques that can be represented as summation of different filters. In this work, Gabor filter is applied along three orientations 0^0, 60^0 and 120^0 and the individual responses are superimposed to get the final edge map. This resulting edge map is used to obtain the shape features using moment invariants. Moments can provide characteristics of an object that uniquely represents its shape. In this work Hu set of invariant moments is used which comprises of seven simple properties such as moment of inertia, skew invariant etc., of an image. To extract the texture parameters Gray Level Co-occurrence Matrix (GLCM) method is used. Summarily, GLCM is a second order statistical texture features extraction technique followed in this work. Based on the generated GLCM matrix, texture features energy, entropy, correlation and homogeneity are calculated.

To get the detailed images of inner parts of the body, Magnetic Resonance Imaging (MRI) can be used. It employs radiology techniques involving radio waves and magnetism to generate the images. MRI scan has proven to be an extremely precise method for defect detection throughout the body. This work is concerned with following three brain pathologies tumour, bleed and infarction. A brain tumour is an abnormal growth of tissue in the brain. Since there is limited space in intracranial cavity, growth of tumour is intrusive causing it to be essentially critical and has a high probability of being fatal. Bleed is the condition where there is leakage of blood through the break in the tissue walls over the brain surface. It can cause disastrous cerebral haemorrhage causing paralysis or even death. Infarction refers to death of tissues due to blockage of blood supply to that part thereby causing deficiency of oxygen. The project aims at detection of the above explained abnormalities related to brain and giving visual indications of the same. Thus finds significant role in assisting medical practitioners. This work is divided into two parts, first, content based image retrieval and second, detection of ailments, if any, in the given MRI scan of brain. We implement a texture segmentation algorithm involving multi-channel filtering theory for visual information processing in the early stages of the human visual system. Texture segmentation refers to segmenting an image based on textural cues. To analyze the image texture we are using multi-channel filtering technique. Multi-channel filtering gives texture features using simple statistics of gray values in the filtered image. For characterization of channels Gabor filters is used and each filtered image is subjected to bounded non-linear transformation that helps in detection of affected area.

1.2 Problem Definition

The purpose is to design a system for enhancement of medical images along with diagnostic capabilities. The processing of medical images is finding more importance day by day with the growing field of image processing. It has got more social impact since it deals with the real time issues. The doctors and medical practitioners can make use of this system in analyzing the scan images so that they can give better prediction with high degree of confidence.

1.3 Objectives of the project

- To extract the features such as colour, texture and shape using the gabor filter.
- To transform a discrete image which is defined at one set of coordinate locations to a new set of coordinate points i.e., converting from rectangular to hexagonal grid.
- To enhance the scans of medical images for better visibility.
- To diagnose the ailment.
- To provide visual indication of the affected area.
- To provide a brief description of the problem detected.
- To retrieve images of similar cases for reference.

Chapter 2

System Study

2.1 Existing System

OsiriX is an image processing application dedicated to DICOM images (".dcm" / ".DCM" extension) produced by medical equipment (MRI, CT, PET, PET-CT). The OsiriX project started in 2004 at UCLA. OsiriX has been developed by Rosset, working in LaTour Hospital (Geneva, Switzerland) and Joris Heuberger, a computer scientist from Geneva. OsiriX has been specifically designed for navigation and visualization of multimodality and multidimensional images.

2.1.1 Advantages Of Existing System

- DICOM and Non-DICOM Files Support
- 2D Viewer
- 3D Post-Processing
- MPR (Multi-planar Reconstruction)

2.1.2 Disadvantages Of Existing System

- Runs under Mac OS X only
- Limited to navigation and visualization. No diagnostic capabilities.

2.2 Proposed System

2.3 Advantages Of Proposed System

- The computational cost is considerably low when compared to similar processing in the rectangular domain.
- Enhances the images for better visibility.
- Automates the diagnostic procedure to assist the doctor in problem identification.

2.4 Constraints

- Does not support remote access.
- Does not support 3D visualization.

Chapter 3

Software Requirement Specification

3.1 Introduction

3.1.1 Purpose

The Purpose of the project is to design a system which enhances the quality of medical scans and has some diagnostic capabilities in order to identify the defect. The proposed system should also retrieve visually similar images for reference.

3.1.2 Scope Of Project

By consulting the output of this system, the physician can gain more confidence in his/her decision or even consider other possibilities. Our proposed system helps in automating the diagnosis process for set of medical scans preferably MRI scans. The system should be able to analyze approximately 16-18 images of different views, produced in one scan to give results.

3.1.3 Intended Audience

- Clients (doctors)
- Team
- Evaluators

3.1.4 References

- An Integrated Approach to Software Engineering, Pankaj Jalote, 3rd edition.
- Gabor Wavelet Based Edge detection on Hexagonal sampled Grid, Vidya P., Dept. of Telecommunication Engineering, Dayananda Sagar College of Engineering, Bangalore, India

3.2 Overall Description

3.2.1 Product Perspective

CBIR system is different from traditional retrieval system based on text mode. Image is described by some visual features not only by text, such as color, texture, shape, space and other features. CBIR system is a system that extracts properties of the image, such as color, texture and shape to construct a Feature vector to compare query image to image in the images database.

The project aims at helping the doctors to do better analysis and can gain more confidence in his/her decision or even consider other possibilities.

3.2.2 User Classes And Characteristics

Medical Students/ Doctors: Practitioners from medical stream can make use of this to analyze the process involved in interpretation of scans to detect the ailment and better visualization of the scans.

3.2.3 Operating Environment

Hardware Requirements

- Core 2 Duo processor or above
- Processor speed: 1.6 GHz
- Physical Memory (RAM): 2.0 GB
- Disk Space: 6.00 GB

Software Requirements

- Development OS: Windows XP/7
- MATLAB 7.5 or above

3.2.4 Design and Implementation constraints

Used for standalone system. Not used in distributed systems.

3.2.5 Assumptions and Dependencies

Assumptions

- The scanned images are in the .dcm format. The proposed system needs the images to be in the jpg or jpeg format. Hence, a .dcm to .jpg or.jpeg image converter is required.
- Database consists of only MRI scans of brain organized in the order: patient ID ->body part ->MRI scan series name ->images.

Dependencies

- Retrieval efficiency depends on image database.
- Diagnostic efficiency of the system depends on the knowledge of the assisting medical professional.

3.3 Requirement Specification

3.3.1 Functional Requirements

- The user shall be able to load a query image.
- The system shall be able to extract the features such as colour, texture and shape using the Gabor filter.
- The system shall be able to transform a discrete image which is defined at one set of coordinate locations to a new set of coordinate points i.e., converting from rectangular to hexagonal grid.
- The system shall be able to enhance the scans of medical images for better visibility.
- The system shall be able to diagnose the ailment.
- The system shall be able to provide visual indication of the affected area.
- The system shall be able to provide a brief description of the problem detected.
- The user shall be able to retrieve images of similar cases for reference.

Use Case Diagram

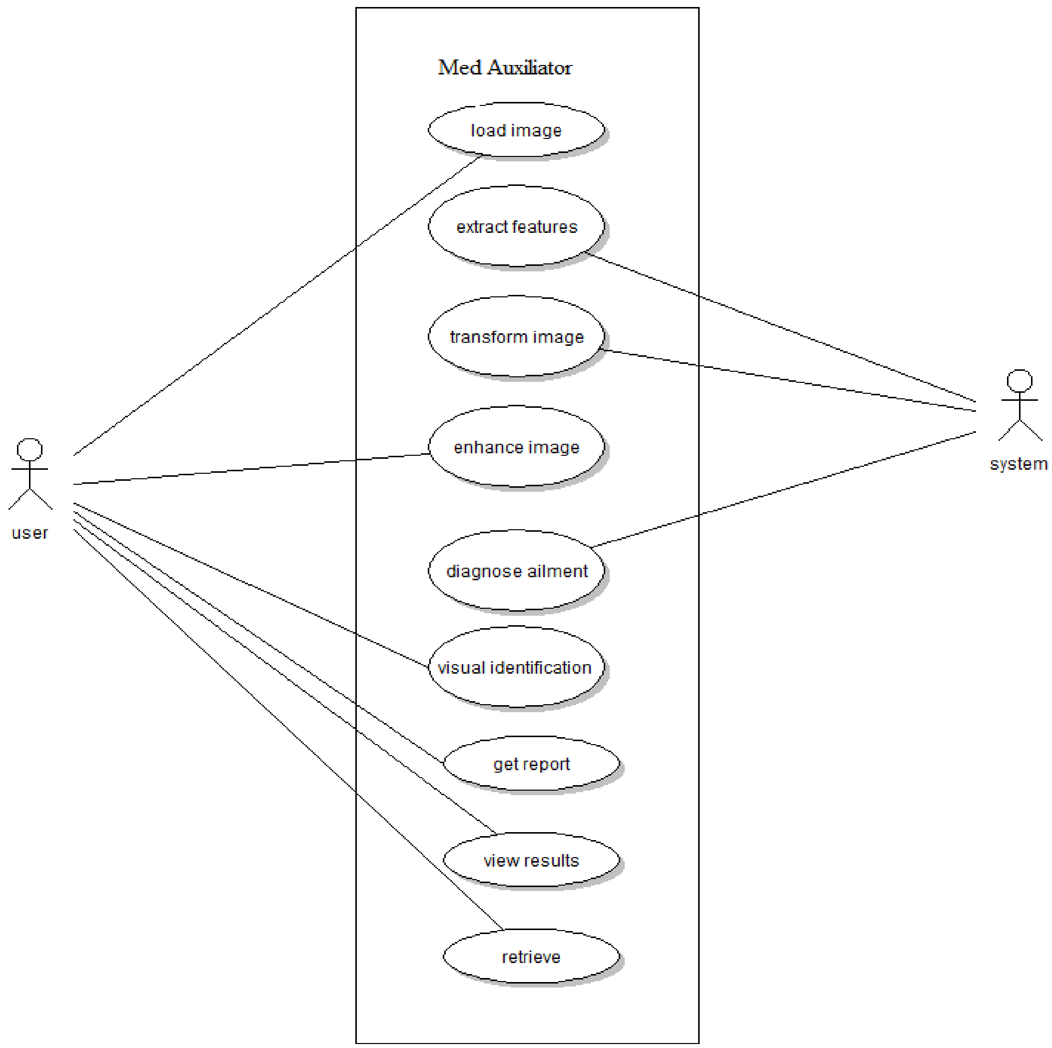

Figure 3.1: Use Case Diagram

Use Case 1:

Scope: Load image.
Primary Actor: User.
Pre-Condition: The system is powered on and the product software is running.
Post-Condition: Image has been uploaded to the system.
Main Success Scenario:

- User browses his/her image.
- User uploads the image.

Exception Scenario:

- If the user uploads invalid query image, system will not accept.

Use Case 2:

Scope: Extract the features.
Primary Actor: System.
Pre-conditions:

- The query image should be uploaded by user.
- The image database should exist.

Post-conditions: Features of the query image and database images are extracted and feature vector is constructed **Main Success Scenario:**

- System extracts feature vector of the query image.

Use Case 3:

Scope: Enhance image
Primary Actor: User
Pre-conditions: System has processed, and re-sampled the query image.
Post-conditions: Display Enhanced image.
Main Success Scenario:

- Noise in the Query image is removed using filters.
- The image is re-sized to the standard size for processing.

Use Case 4:

Scope: Transform Image.
Primary Actor: System
Pre-conditions: System has processed the query image.
Post-conditions: The query image is transformed to hexagonal grid view.
Main Success Scenario:

- The query image will be re-sampled from rectangular grid view to hexagonal grid view.

Use Case 5:

Scope: Diagnose Ailment
Primary Actor: System
Pre-conditions: System has processed, computed the feature vector and resampled the query image.
Post-conditions: Diagnose the ailment based on the query image.
Main Success Scenario:

- The query image is compared with normal image.
- The ailment if any will be detected in the query image.

Exception Scenario:

- There are no details of the defect found in the image.
- Message will be displayed that an unrecognized disorder has been found.

Use Case 6:

Scope: Visual Indication of the affected area.
Primary Actor: System
Pre-conditions: System has processed, computed the feature vector, re-sampled, and diagnosed the ailment based on the query image.
Post-conditions: Visually indicate the ailment for the query image.
Main Success Scenario:

- Visual indication of the affected area based on the diagnosis for the query image is provided.

Exception Scenario:

- The system may not find details of the defect for a particular query image.
- The system displays a message that the defect is unknown.

Use Case 7:

Scope: Retrieve images of similar cases.
Primary Actor: System
Pre-conditions:

- System has stored the previously processed images in the database.
- System has processed, computed the feature vector and resampled the query image.

Post-conditions: Images with similar case are retrieved.
Main Success Scenario:

- Images with similar case as that of query image are retrieved, sorted and displayed.

Exception Success Scenario:

- Images with similar case as that of query image may not be available in the database
- Hence no images will be displayed.

Use Case 8:

Scope: Display the Precision and Recall.
Primary Actor: System.
Pre-conditions: System has processed the query image, computed and compared the feature vector of the query image and database images and has retrieved the similar images.
Post-conditions: Display precision and recall.
Main Success Scenario:

- System displays the most similar images as that of query image on the screen.
- System calculates the precision and recall to determine the performance.

3.3.2 Nonfunctional Requirements

Performance Requirements

- Response time - For any given query image, the relevant information is retrieved within 5 seconds
- Efficiency Systems performance should be above 80%.

Safety Requirements

- The user should take periodic backups of the scans to prevent the loss of any data.

Security Requirements

- Users will not be able to use the system without proper authentication.

3.3.3 Software Quality Attributes

Usability:

- The user needs to go through users manual for understanding the operability of the system.

Modifiability:

- Image database can be extended for larger size.
- The proposed system can be modified for use over a network.

3.3.4 User Documentation

User manual for understanding of the operability of the system is provided for the intended audience i.e. doctors.

3.4 Other Requirements

- Approx. 200 real-time MRI scans in .dcm format.

Chapter 4

System Design

4.1 Architectural Design

Block diagram representation of the system is given in Figure 4.1. The system can be broadly classified into three modules presentation, application and database. The presentation module deals with the user interaction to the system. It covers the functionality of receiving the input from the user transferring the input to application module and receive the output from the application module and display the outputs to the user. Application module has the components performing the desired operations to produce the results to be displayed. The third module is a collection of MRI scans of brain.

4.2 Detailed Design

4.2.1 Logical View

Figure 4.2 gives more detailed view of the system. T also illustrates how one component is connected to the other component. The query image loaded by the user is passed to the system for processing. The loaded query image is enhanced and transformed to hexagonal sampled grid. Features of resampled image is extracted and a query feature vector is formed. This query feature vector is compared with the pre-calculated database feature vector and the results are displayed.

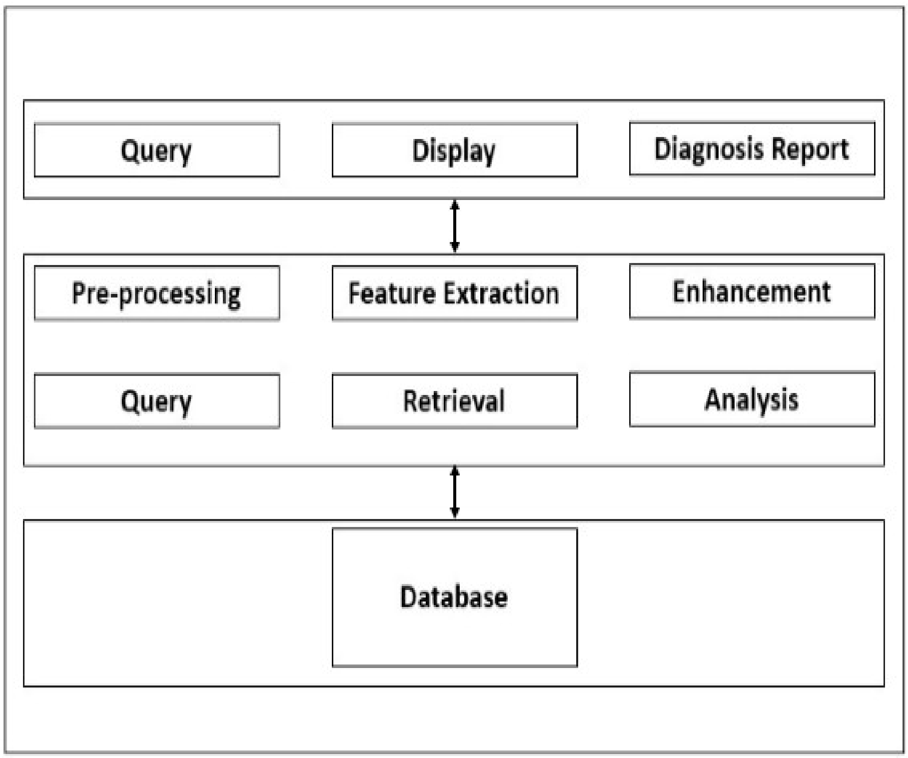

Figure 4.1: Block Diagram

Also if the using the features in the feature vector defected region is searched and a visual indication for the same is provided if it is present. Text report for the diagnosis is generated.

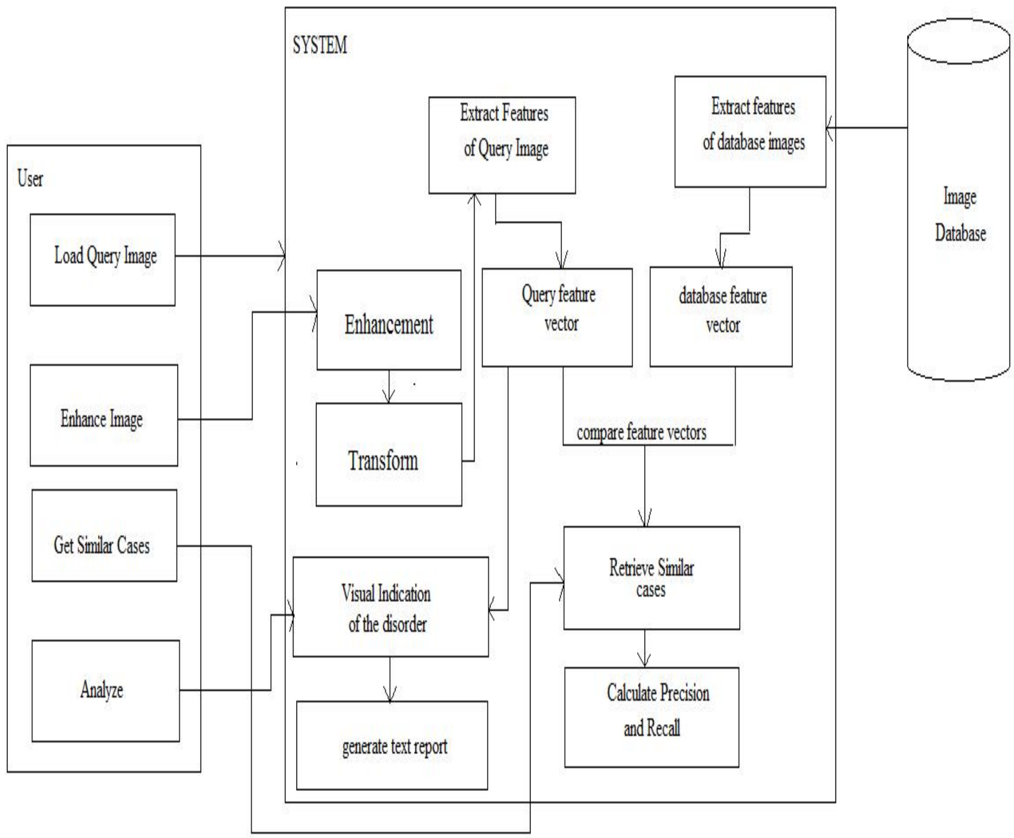

Figure 4.2: Logical view of the system

4.2.2 Data Flow Diagrams

- **Pre-processing:**
  This step is to be performed during installation of the application. All the images of the database are enhanced, transformed and their feature

values are extracted and store in the database feature vector. Figure 4.3 shows the data flow diagram for the pre-processing purpose.

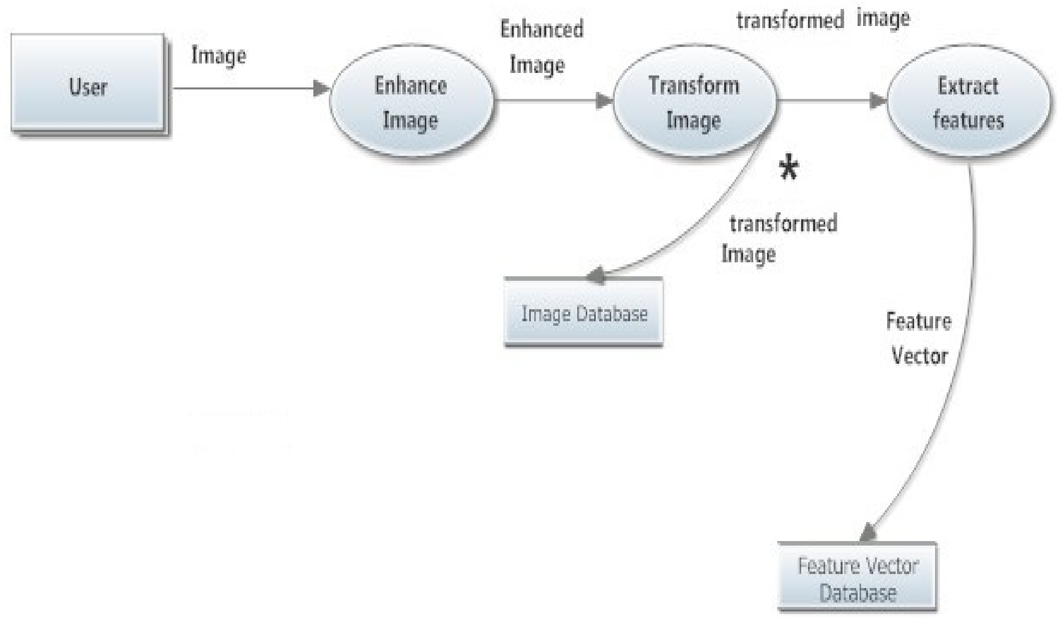

Figure 4.3: DFD for pre-processing module

The images that will be stored in the database need to be enhanced (noise removal) and resampled.

- **Complete System:**
  Figure 4.4 shows the dataflow diagram of the system. The query image loaded by the user is enhanced and transformed and its features are extracted to form a query feature vector. Using the query feature vector and already available database feature vector the images similar to the loaded query image are retrieved and the results are displayed after sorting the comparison results based on the priority. The query feature vector is passed to analyze module to detect the ailment, if any, provide visual indication of the same and produce the textual report. The retrieval data is sent for generation of precision and recall graph, which gives the efficiency of the system.

Complete DFD Of The System

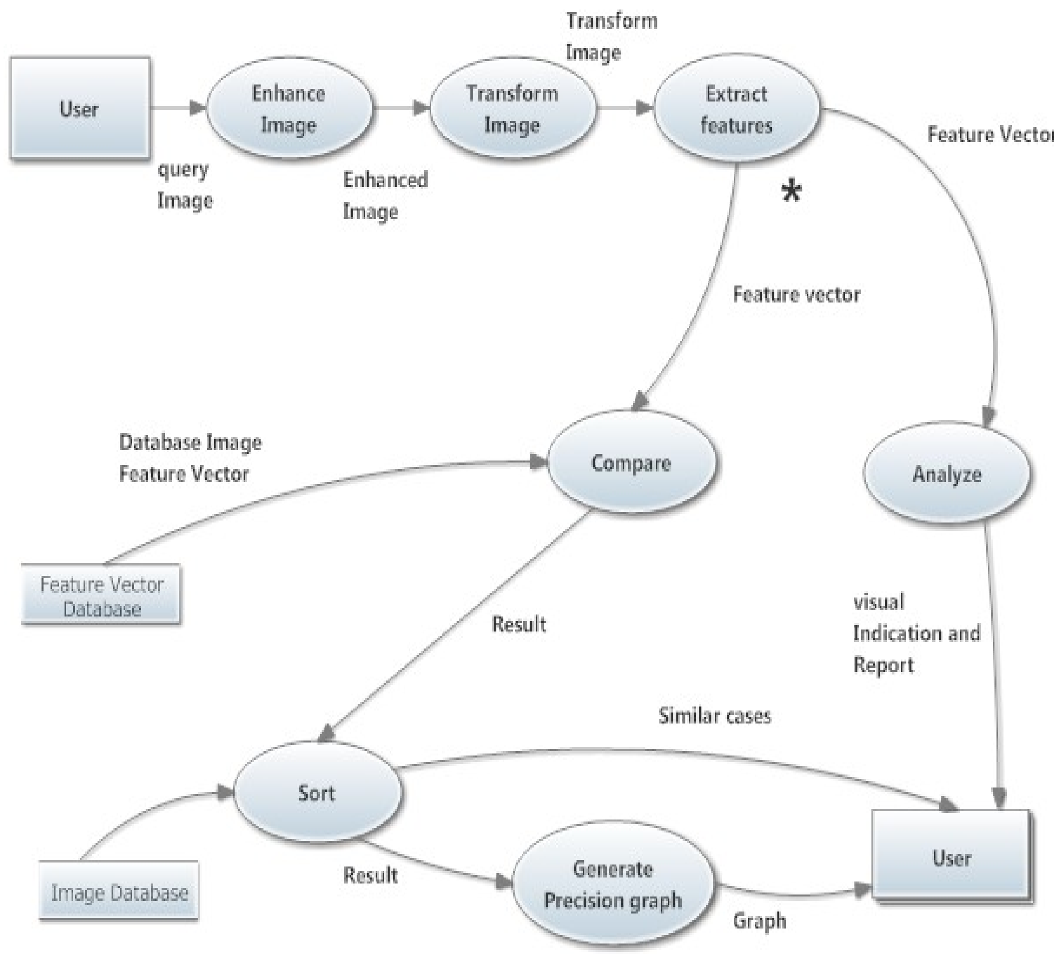

Figure 4.4: DFD of the complete system

4.2.3 Algorithm

Resampling

Input: query image, I_Q
Output: resampled image, I_R

step 1: For each odd row, discard the pixel values at even columns and retain the odd column values

pnew (x ,2 y +1) = pold (x ,2 y+1) , y = 0,1,2. . ..

step 2: (a) For each even row, each even column value is set as the average of the left and right pixel values.

pnew(2x,2y) = (pold (2x,2y-1)+ pold(2x,2y+1))/ 2 ,
x=1,2,3 and y=1,2,3. ..

(b) Discard the left and right, keeping only the mid values.

Edge Detection

//**Input:** resampled image, I_R
//**Output:** image with edges detected, I_{RESULT}
//**Description:** this sends the resampled image to gabor filter to generate edge-maps. Finally superimposes them to produce the final result.

step 1: create 2-D filter for horizontal edge emphasizing, F1

step 2: $I_P \longleftarrow I_R$ filtered using F1

step 3: create 2-D filter for contrast enhancement, F2

step 4: $I_U \longleftarrow I_R$ filtered using F2

step 5: $I_1 \longleftarrow$ gaborFilterFunc(I_P)

step 6: $I_2 \longleftarrow$ gaborFilterFunc(I_U)

step 7: $I_{RESULT} \longleftarrow$ superimpose I1 and I2

step 8: return I_{RESULT}

function: gaborFilterFunc

//**Input:** resampled image
//**Output:** edgemap
//**Description:** : Initialize the scale and orientation values in this function. And apply gabor filter to the image in the function gabor() with required parameter values, scale, orientation, phase offset, Gaussian envelope and spatial aspect ratio

step 1: Initialize different scale values

step 2: Initialize different orientations

step 3: For each scale value

(a) for each orientation value

i) gabor output $\longleftarrow$ gabor (image, gaussian envelope, orientation, scale, phase offset, aspect ratio)

ii) stdMean $\longleftarrow$ mean of gabor output

iii) stdDeviation $\longleftarrow$ standard deviation of gabor output

iv) difference $\longleftarrow$ absolute value of (mean of gabor output - standard deviation of gabor output)

(b) if difference <50 then

i) k1 <- 2.5

ii) temporary edgemap $\longleftarrow$ gabor output $<$(-1 $*$stdDeviation $*$k1) | gabor output $>$(stdDeviation $*$k1)

iii) Final edgemap $\longleftarrow$ Final edgemap | temporary edgemap

step 4: Return Final edgemap

function: gabor (img, sigma, theta, lambda, psi, gamma)

//**Input:**
// img : Input image
// sigma: Variance
// theta : orientation
// lamda : wavelength of sinusoidal factor
// psi : phase offset
// gamma : spatial aspect ratio
//**Output:**
//gb: gabor filtered image
//**Description:**
In the spatial domain, a 2D Gabor filter is a Gaussian kernel function modulated by a sinusoidal plane wave. Integration of time/space and frequency data allows analysis of time frequency, which is termed as Gabor expansion. The filter has real and imaginary component representing orthogonal directions. The two components may be formed into a complex number or used individually. In this project only the real component of the filter has been used.

$$g(x, y; \lambda, \theta, \psi, \sigma, \gamma) = exp(\frac{-x'^2 + \gamma^2 y'^2}{2\sigma^2}) \cos(\frac{2\pi x'}{\lambda} + \psi)$$

where,
$x' = x\cos(\theta) + y\sin(\theta)$
$y' = -x\sin(\theta) + y\cos(\theta)$

In this equation, λ represents the wavelength of the sinusoidal factor, ϑ represents the orientation of the normal to the parallel stripes of a Gabor function, ψis the phase offset, σ is the sigma of the Gaussian envelope and is the spatial aspect ratio, γ and specifies the ellipticity of the support of the Gabor function.

$sigmaX \longleftarrow sigma$
$sigmaY \longleftarrow sigma$
//Bounding Box
$bound \longleftarrow 3$
$xmax \longleftarrow maximum\ \ of(absolute\ \ value\ \ of(bound * sigmaX * \cos(theta)),$
$absolute\ \ value\ \ of(bound * sigmaY * \sin(theta)))$

$xmax \longleftarrow upper\ \ bound\ \ of(maximum\ \ of(1, xmax))$

$ymax \longleftarrow maximum\ \ of(absolute\ \ value\ \ of(bound{*}sigmaX{*}\sin(theta)), absolute\ \ value\ \ of(bound{*}$
$sigmaY * \cos(theta)))$

$ymax \longleftarrow upper\ \ bound\ \ of(maximum\ \ of(1, ymax))$

$xmin \longleftarrow -xmax$
$ymin \longleftarrow -ymax$
$[x, y] \longleftarrow$ replicates the grid vectors (xmin to xmax) and (ymin to ymax) to produce the coordinates of a rectangular grid (X, Y)

//Rotation
$xTheta = x * \cos(\theta) + y * \sin(\theta)$
$yTheta = -x * \sin(\theta) + y * \cos(\theta)$

$gb \longleftarrow \exp(0.5\ *\ (xTheta^2/sigmaX^2\ +\ yTheta^2/sigmaY^2)) * \cos(2{*}\pi/lambda{*}$
$xTheta\ +\ psi)$

$Imgabout \longleftarrow convolution\ \ of(image\ \ and\ \ imaginary\ \ part\ \ of\ \ (gb))$
$Regabout \longleftarrow convolution\ \ of(image\ \ and\ \ real\ \ part\ \ of\ \ (gb))$

$gb \longleftarrow square\ \ root\ \ of(Imgabout * Imgabout\ +\ Regabout * Regabout)$

Shape Feature Extraction

//**Input:** Final edgemap
//**Output:** Shape features are stored in feature vector table.
//**Description:**
For 2D continuous function $f(x, y)$ the moment of order $(p\ +\ q)$ is defined as

$$M_{pq}\ =\ \int\int\ x^p y^q f(x, y) dx dy$$

For $p, q\ =\ 0, 1, 2, ...$ Adapting this to scalar (greyscale) image with pixel intensities $I(x,y)$, raw image M_{ij} are calculated by

$$M_{ij} = \sum\sum x^i y^j I(x,y)$$

A uniqueness theorem states that if $f(x,y)$ is piecewise continuous and has nonzero values only in a finite part of the xy plane, moments of all orders exist, and the moment sequence (M_pq) is uniquely determined by $f(x,y)$. Conversely, (M_pq) uniquely determines $f(x,y)$. In practice, the image is summarized with functions of a few lower order moments. Next, central moments are calculated using the following equations

$$\mu_{pq} = \sum\sum (x-\bar{x})^p (y-\bar{y})^q f(x,y)$$

Where $\bar{x} = \frac{M_{10}}{M_{00}}$ and $\bar{y} = \frac{M_{01}}{M_{00}}$ are the components of the centroid. Using these central moments up to the desired order can be calculated. Moments $\eta_{i,j}$ where $i+j \geq 2$ can be constructed to be invariant to both translation and changes in scale by dividing the corresponding central moment by the properly scaled (00)th moment, using the following formula

$$\eta_{ij} = \frac{\mu_{ij}}{\mu_{00}^{(1+\frac{i+j}{2})}}$$

Hu set of moment invariants for moments which are invariant under rotation, scaling and translation, are defined as

$$I1 = \eta_{20} + \eta_{02}$$

$$I2 = (\eta_{20} + \eta_{02})^2 + 4\eta_{11}^2$$

$$I3 = (\eta_{30} - 3\eta_{12})^2 + (3\eta_{21} - \eta_{03})^2$$

$$I4 = (\eta_{30} + \eta_{12})^2 + (\eta_{21} + \eta_{03})^2$$

$I5 = (\eta_{30} - 3\eta_{12})(\eta_{30} + \eta_{12})[(\eta_{30} + \eta_{12})^2 - 3(\eta_{21} - eta_{03})^2] + (3\eta_{21} - \eta_{03})(\eta_{21} + \eta_{03})[3(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2]$

$I6 = (\eta_{20} - \eta_{02})[(\eta_{30} + \eta_{12})^2 - (\eta_{21} + eta_{03})^2] + 4\eta_{11}(\eta_{30} + \eta_{12})(\eta_{21} + \eta_{03})$

$I7 = (3\eta_{21} - \eta_{03})(\eta_{30} + \eta_{12})[(\eta_{30} + \eta_{12})^2 - 3(\eta_{21} - eta_{03})^2] - (\eta_{30} - 3\eta_{12})(\eta_{21} + \eta_{03})[3(\eta_{30} + \eta_{12})^2 - 3(\eta_{21} - eta_{03})^2]$

Texture Feature Extraction

//**Input:** Resampled Query Image
//**Output:** Texture features are stored in feature vector table.

step 1: Gray-Level Co-occurrence matrix is created from the image by calculating how often a pixel with gray-level (grayscale intensity) value i occurs horizontally adjacent to a pixel with value j The outcome of GLCM for each element (i, j) is computed by summing the pixel with the value i occurred in the particular spatial relationship to a pixel with value j in the input series. The co-occurrence probability between gray levels i and j, C_{ij} is defined as

$C_{ij} = \frac{P(i,j)}{\sum P(i,j)}$

Where, $P(i, j)$ represents number of occurrences of gray levels, i and j varies within the given image window for certain pairs of inter-pixel distance (δ) and orientation (θ).

step 2: After the computation of Gray-level Co-occurrence Matrix, the desired statistical texture measure can be found using co-occurrence probabilities. This probability measure can be defined as

$Pr(x) = \{C_{ij} \mid (\delta, \theta)\}$

step 3: The statistical texture measures used for this process include energy, entropy, correlation, contrast. These texture parameters are appended to the feature vector containing shape parameters. The texture features can be calculated using the following equations

$$Energy = \sum P(i,j)^2$$

$$Entropy = -\sum P(i,j)\log(P(i,j))$$

$$Correlation = \sum \frac{(i-\mu_i)(j-\mu_j)P(i,j)}{\sigma_i \sigma_j}$$

$$Contrast = \frac{1}{(G-1)^2} \sum (i-j)^2 P(i,j)$$

Texture Feature Extraction

step 1: Using the K-means clustering, the images in the database are clustered based on their shape and texture features. More similar images, having similar features will belong to the same cluster.

step 2: Euclidean distance between the query feature vector and the images in the cluster to which it belongs to is calculated.

step 3: The smaller the distance, more similar are the two images. Hence the top ten results are retrieved and displayed.

Analysis

step 1: Image is divided into two equal halves.

step 2: The highest difference between pixel intensities of either side of the brain is calculated.

step 3: Based on the learning from known cases of the defected MRI scans and the normal brain a range is set for each of the defects.

step 4: If the difference lies in the range of Infarct go to step 5, else go to step 8.

step 5: The image is segmented using multi-channel filtering based on energy values.

step 6: The segmented image is compared with the energy values to be found in that of an infarct.

step 7: The region having maximum matches is indicated.

step 8: Energy pattern of bleed and tumor are matched in the query image.

step 9: If there are regions having more than 80% match to the energy pattern of these cases are indicated else step 10

step 10: The MRI scan is of a normal brain.

4.3 User Interface Design

4.3.1 User Interface Overview

Initially when the application is run, load query Image screen, Figure 4.5, appears. User can browse and load MRI scans of the brain from the right location.

If the user tries to press the Enhance image button without selecting an image an error message will appear notifying the user that there are no images to enhance. Figure 4.6. In case the user tries to load an image which having a format other than .jpg/.jpeg another error message will be shown. Figure 4.7. All these error messages and warning messages are there to assist user with the smooth usage of the application.

Once the user has loaded an appropriate MRI scan of brain, clicking on Enhance Image button will take the user to enhanced image Screen, Figure 4.8. This screen displays the enhanced result of the loaded query image.

From enhanced image screen, either user can click on view similar Images button to get the results images similar to the loaded query image, Figure 4.9. Or user can click on Analyze button to perform diagnostics on the loaded

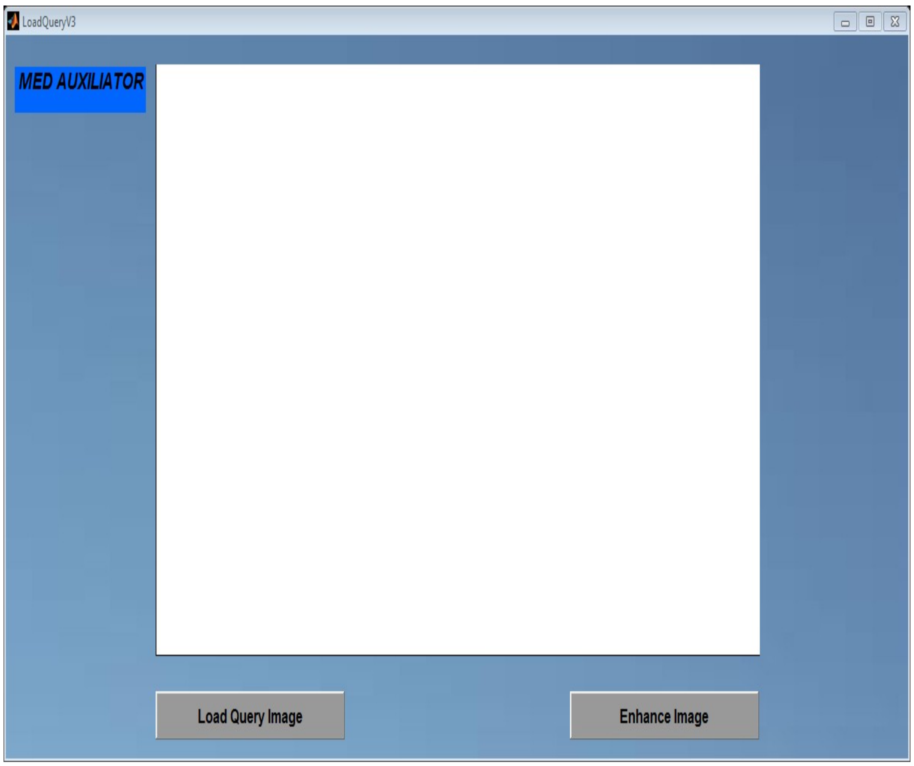

Figure 4.5: Error message if user tries to proceed without loading an image

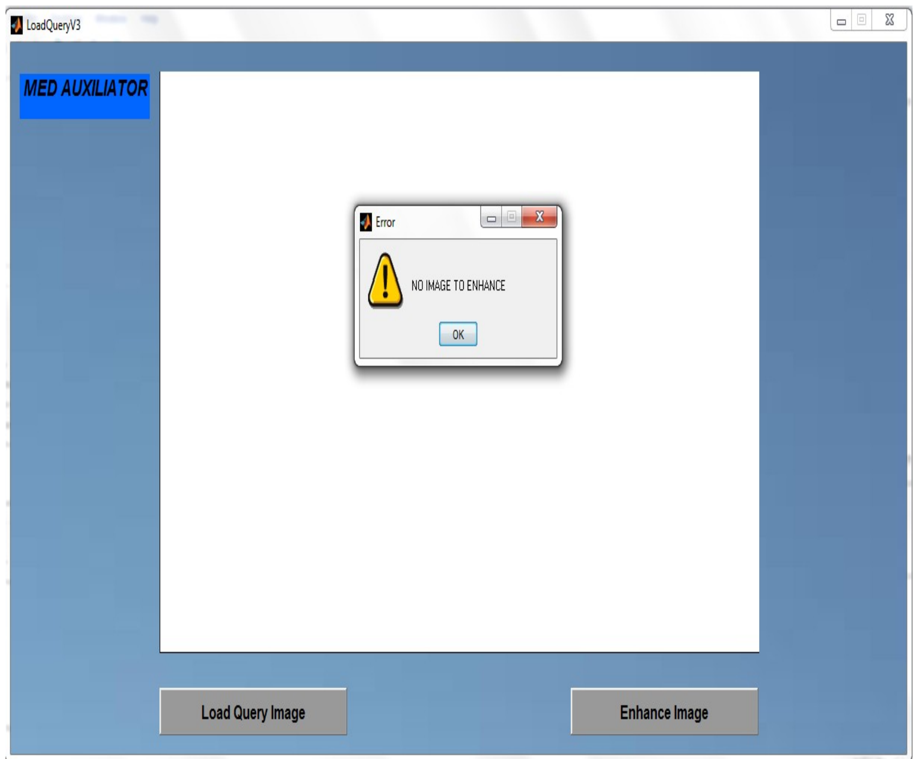

Figure 4.6: Error message if user tries to load an image with invalid extension

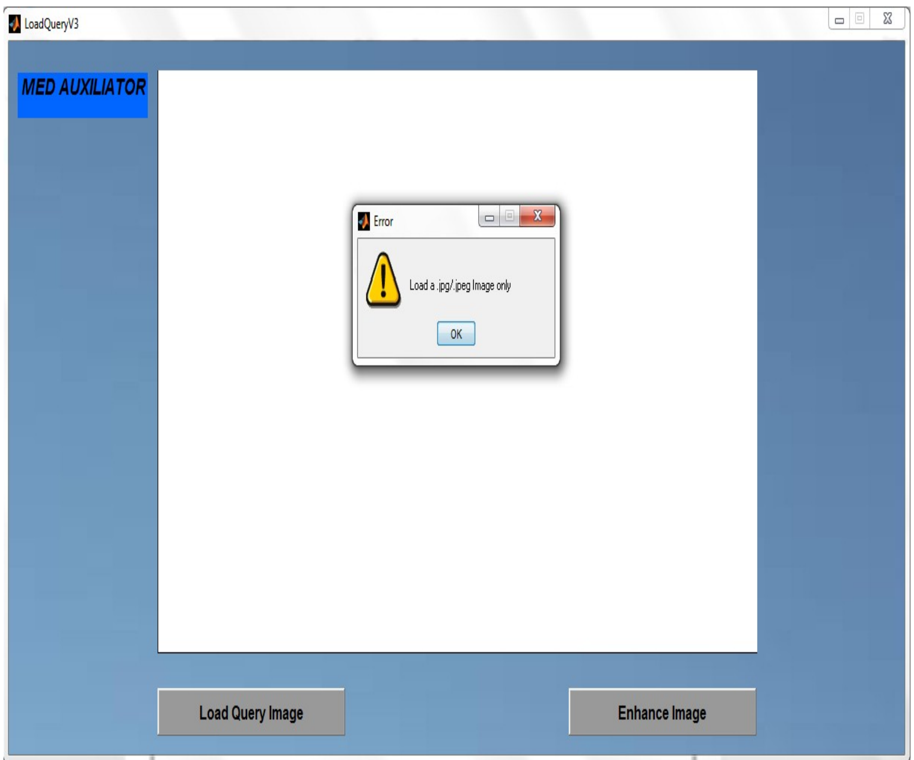

Figure 4.7: Enhanced image screen

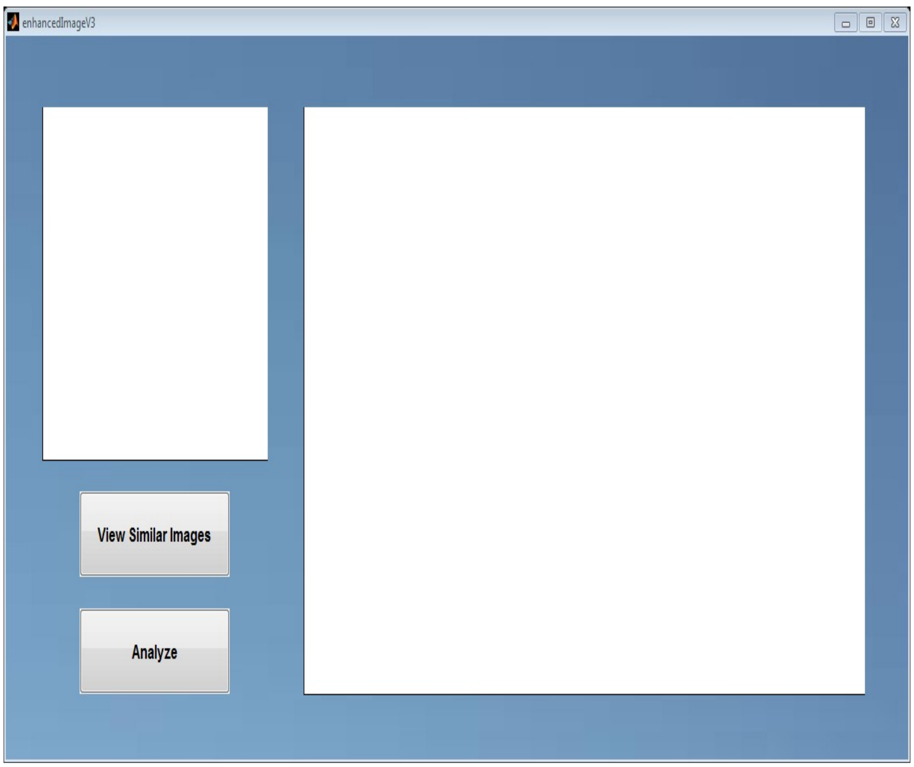

Figure 4.8: Load query image screen

MRI scan. For analysis the system needs eT2W_ TSE series images. In case

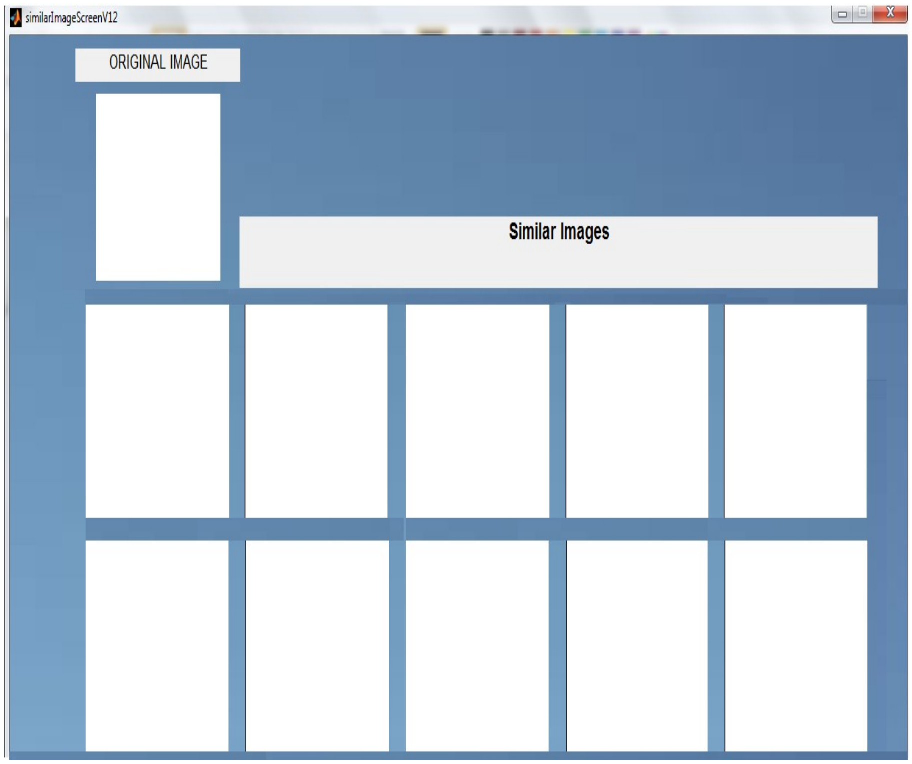

Figure 4.9: Retrieval result screen

the loaded query image is not from that series the user is prompted, Figure 4.10. If user denies to load the eT2W_ TSE series images for analysis or that series is not found in the MRI scan of the patient to whom the loaded query image belongs to, system gives an error message, Figure 4.11, as it is unable to perform analysis. If user allows the application to continue with the analysis user needs to wait, Figure 4.12, until the process is complete.

Once the analysis is complete the affected region is visually indicated on the suitable et2W_ TSE image loaded of that patient, Figure 4.13.
And the user is notified about the defect and requested to consult the doctor.
Also user can view the text report of the analysis.

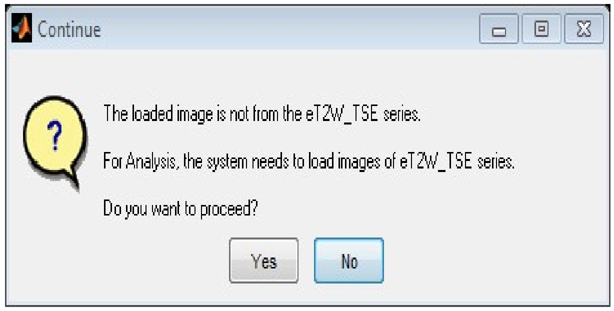

Figure 4.10: Permission to load eT2W_ TSE images for analysis

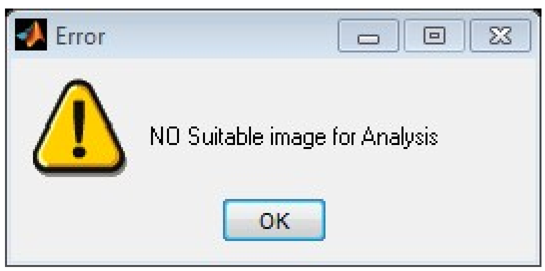

Figure 4.11: Message displayed if system is unable to load eT2W_ TSE series images

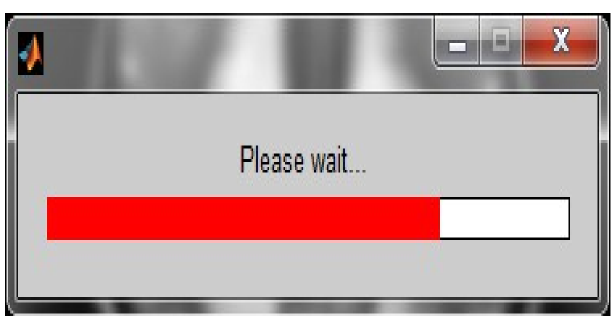

Figure 4.12: Progress in processing

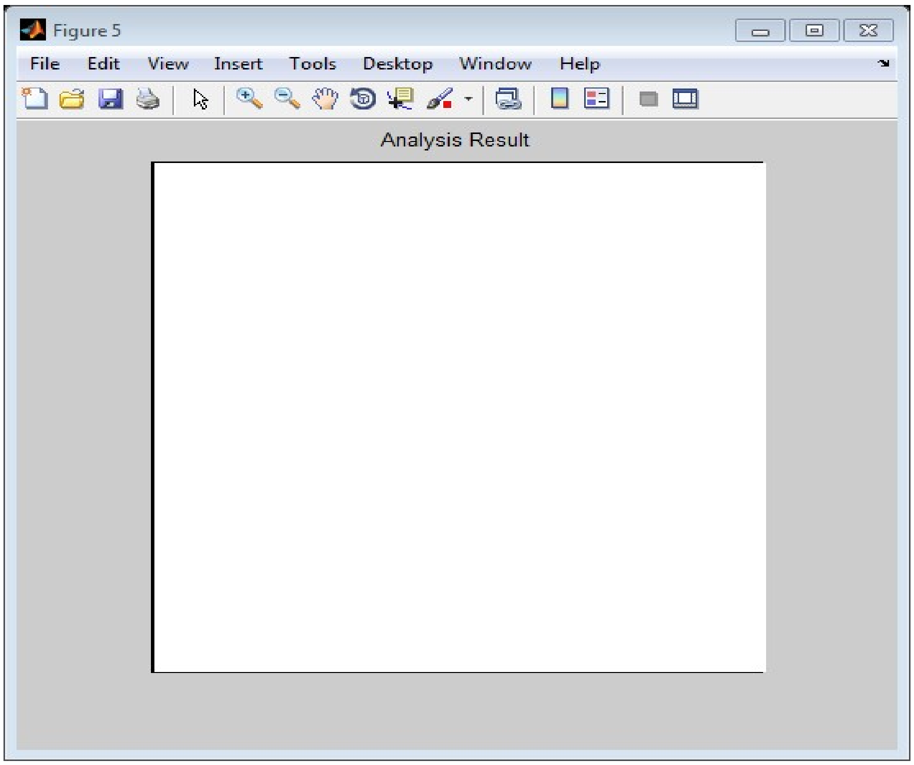

Figure 4.13: Analysis screen

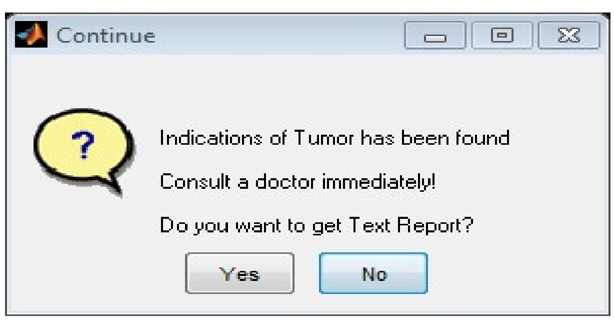

Figure 4.14: Sample message after analysis

4.3.2 User Interface Navigation Hierarchy

Figure 4.15 gives the user navigation hierarchy of the application. Initially when the application is run, Load Query Image Screen is loaded. From this screen user can navigate to enhanced image screen. From here either user can go to retrieval screen by choosing retrieve similar images option or to analysis screen. By choosing the analyze option. From the analysis screen user can go to the textual report that has been generated for the diagnostic done.

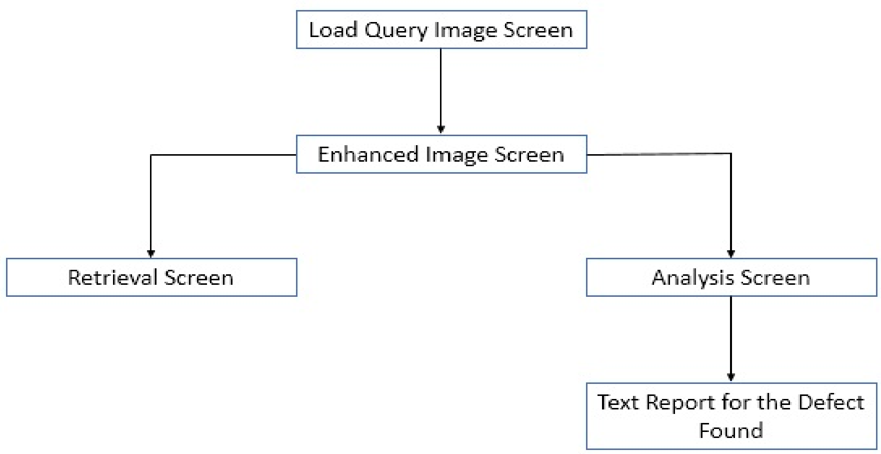

Figure 4.15: User interface navigation hierarchy

4.4 Deployment Diagram

Figure 4.16 shows the deployment diagram for the system. It shows the components involved in the system(e.g. Retrieval, Feature Extraction and Defect Detection) and the interaction between these components.

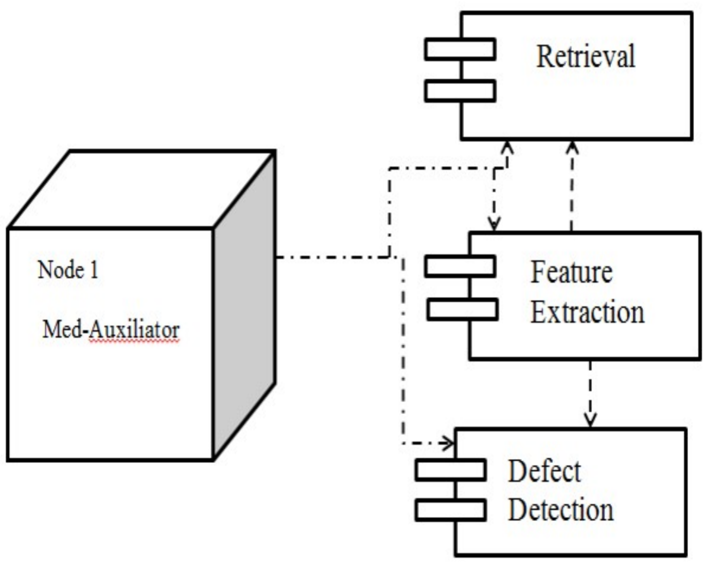

Figure 4.16: Deployment diagram

Chapter 5

Implementation

5.1 Module description with its input and output

5.1.1 Module 1 - Retrieval

1. **Hexagonal Resampling**
   Input: Qyery Image
   Output: Hexagonal resampled image
   Description:

   – This has been implemented in the MatLab file *resampling.m* using the half pixel shift method. For each odd row, each even pixel is discarded and the odd pixels are kept as it is. And for each even row, each even pixel value is replaced with the average of its left and right pixel values.

2. **Shape Feature Extraction**
   Input: Resampled Query Image.
   Output: Shape feature vector Stored in feature vector table.
   Description:

   – The extraction of shape features starts with detection of edges. For this purpose Gabor filter is applied on six scale values 0, 2, 4, 8, 16, 32 and three orientations 0^0, 60^0, 120^0, resulting in 6x3 = 18 edge-maps. Out of these only those satisfying the threshold value are superimposed to get the final edge-map. This have been implemented in the MatLab file *edgedetection.m*.

- The next step is to get the shape features by applying moment invariants. Implemented in *invmoments.m* which extracts the shape features from the edge map of the image by applying moment invariants. The moment invariants are applied to the second-level wavelet decomposition results of the final edge-map. Second-level wavelet decomposition gives four coefficient matrices, namely, approximation, horizontal, vertical and diagonal, results in total of 28 values (7 for each of the 4 components). These values are stored as shape features in the feature vector table.

3. **Texture Feature Extraction**
   Input: Resampled Query Image.
   Output: Texture feature vector Stored in feature vector table.
   Description:

   - Grey Level Co-occurrence Matrix is used for extraction of text feature. The statistical texture measures used for this process include energy, entropy, correlation, contrast, sum of variances, inverse difference moment, information measure of correlation1, information measure of correlation2, sum average, sum entropy, sum variance, difference variance and difference entropy. These texture parameters are appended to the feature vector containing shape parameters. This has been implemented in *calc_ texture_ features.m*.

4. **Retrieval Of similar Images**
   Input: Query Image.
   Output: Ten images similar to Query image are retrieved.
   Description:

   - This calculation is done when user chooses the retrieve similar images option.
   - The Euclidean distance between the query and each of the database feature vectors is computed using the following equation.

$$d = \sqrt{\sum (X_i - Y_i)^2}$$

Where D_j = Euclidean distance for j^{th} image in the database, $x_i = i^{th}$ feature value of the query image, $y_{ji} = i^{th}$ feature value of the for j^{th} image in the database. Since there are 41 feature vector values n = 41. These distances are sorted in ascending order to retrieve the top 10 similar images. This has been implemented in *retrieveSimilar.m*. The image indices sorted with respect to the Euclidean distance are sent to *similarImageScreenV3.m*, which displays the first 10 results.

5.1.2 Module 2- Identification of the Ailment

Visual Indication of the Ailment:
Input: Query Image.
Output: If any ailment in the query image, it is visually indicated.
Description:

- For classification of defect *classifyDefect.m* is used. In this MatLab file the image is divided into two equal halves. The highest difference between pixel intensities of either side of the brain is calculated. Based on the learning from known cases of the defected MRI scans and the normal brain a range is set for each of the defects.
- If defect is classified under infarct,*infarctDetection.m* is called. Here the image is segmented using multi-channel filtering based on energy values. The segmented image is compared with the energy values to be found in that of an infarct. The region having maximum matches is indicated.
- If the image is classified under tumor or bleed *tumorBleedPatternMatching.m* is called. Here energy pattern of bleed and tumor are matched in the query image. If there are regions having more than 80% match to the energy pattern of these cases are indicated. If there are no such regions after eliminating the matches from the normal brain the MRI scan is of a normal brain.

Chapter 6

Testing

6.1 Unit Testing

Load Image Module

Test Id	Test Case	Input	Expected Output	Actual Output	Test State	Test Priority
1.	Load query image	Query image	Query image is displayed	Query image is displayed	pass	1
2.	Invalid image format	Image with invalid format	image not loaded and error message is displayed	image not loaded and error message is displayed	pass	3
3.	Clicking Load Query Image button	Click on the Load Query Image button	User shall be able to browse the image	User is able to browse the image	pass	2
4.	Clicking Enhance Image button	Click on the Enhance Image button	Enhancement window opens	Enhancement window opens	pass	2

Table 6.1: Unit Test Plan for Load Image Module

Enhancement and Resampling Module

Test Id	Test Case	Input	Expected Output	Actual Output	Test State	Test Priority
1.	Enhancing image	Query image	Query image is enhanced	Query image is enhanced	pass	2
2.	Resampling image to hexagonal grid	Query image in rectangular lattice	Resampled image on hexagonal grid	Resampled image on hexagonal grid	pass	1

Table 6.2: Unit Test Plan for Resampling Module

Retrieval Module

Test Id	Test Case	Input	Expected Output	Actual Output	Test State	Test Priority
1.	Retrieval	Processed MRI scan of the brain	Retrieval of similar cases	Similar cases are retrieved	pass	1

Table 6.3: Unit Test Plan for Retrieval Module

Analysis Module

Test Id	Test Case	Input	Expected Output	Actual Output	Test State	Test Priority
1.	Defect detection	MRI scan of the brain with defect	Visual indication of the defect detected	Defected region is identified	pass	1
2.	Normal brain MRI scan	MRI scan of normal brain	Identifies the scan as normal	The scan is identified as normal	pass	2
3.	Generate text report	Image with defect	Report with details of the defect identified is generated	Report with details of the defect identified is generated	pass	3

Table 6.4: Unit Test Plan for Analysis Module

6.2 System Testing

Test Id	Test Case	Input	Expected Output	Actual Output	Test State	Test Priority
1.	Load query image	Query image	Query image is displayed	Query image is displayed	pass	4
2.	Invalid image format	Image with invalid format	image not loaded and error message	image not loaded and error message	pass	4
3.	Clicking LoadQueryImage button	Click on the LoadQueryImage button	User shall be able to browse the image	User is able to browse the image	pass	5
4.	Clicking EnhanceImage button	Click EnhanceImage button	Enhancement window opens	Enhancement window opens	pass	5
5.	Enhancing image	Query image	Query image is enhanced	Query image is enhanced	pass	4
6.	Hexagonal resampling	Query image in rectangular grid	Resampled image	Resampled image	pass	4
7.	Feature Extraction	Valid query image	Features are stored in a vector	Features are stored in a vector	pass	1
8.	Retrieval	Processed MRI scan of the brain	Retrieval of similar cases	Similar cases are retrieved	pass	3
9.	Visual indication of ailment	Image with ailment	Affected area is highlighted	Affected area is highlighted	pass	2
10.	Text report	Analyzed image	Textual description of the diagnosis	Textual description of the diagnosis	pass	4

Table 6.5: Test Plan for System Testing

Chapter 7

Results and Analysis

In this section the results obtained are shown and the performance evaluation in terms retrieval efficiency is discussed.

7.1 Experimental Setup and Results

The system is tested over 1500 MRI scans of brain images collected from local scan centers form the image database. MATLAB is used as the development platforms. The result of transforming a sample query (Figure 7.1) image into

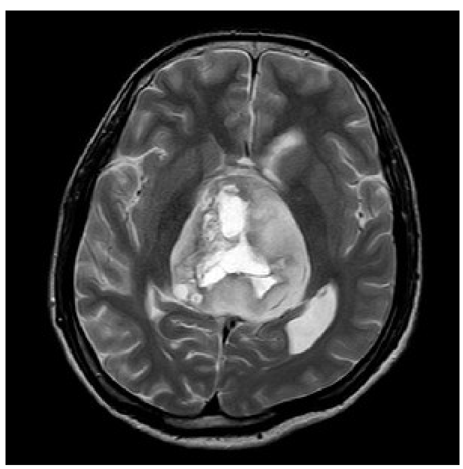

Figure 7.1: Query Image

hexagonal grid is shown in Figure 7.2. Edge detection technique is applied on this resampled image. As previously mentioned Gabor filter will output 18 edge-maps. All these edge-maps are given in Figure 7.3. Out of these responses those satisfying the threshold value are superimposed to obtain the final edge map, given in Figure 7.4.

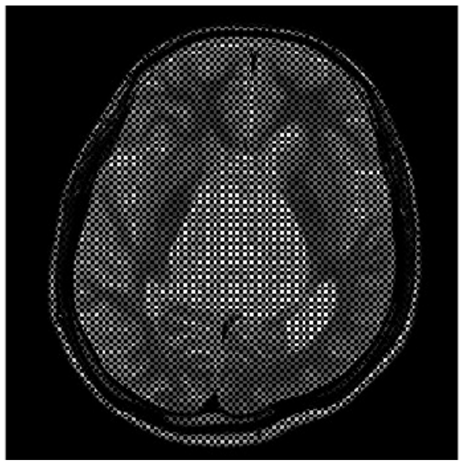

Figure 7.2: Resampling Result

This edge map is subjected to second level decomposition and moment invariants are applied on them to extract the shape features, and store those features in a feature vector. For texture extraction, GLCM is created and statistical measures are calculated. These statistical measures are stored as texture features in the feature vector. The texture values are appended to the previously stored shape feature values in the same vector.

Figure 7.3: Various Gabor Responses

Figure 7.4: Final Edge Map

Results of Retrieval Module

Retrieval results for a sample query images are shown in Figure 7.5. The ten most similar images found after applying the methods discussed are displayed as the results.

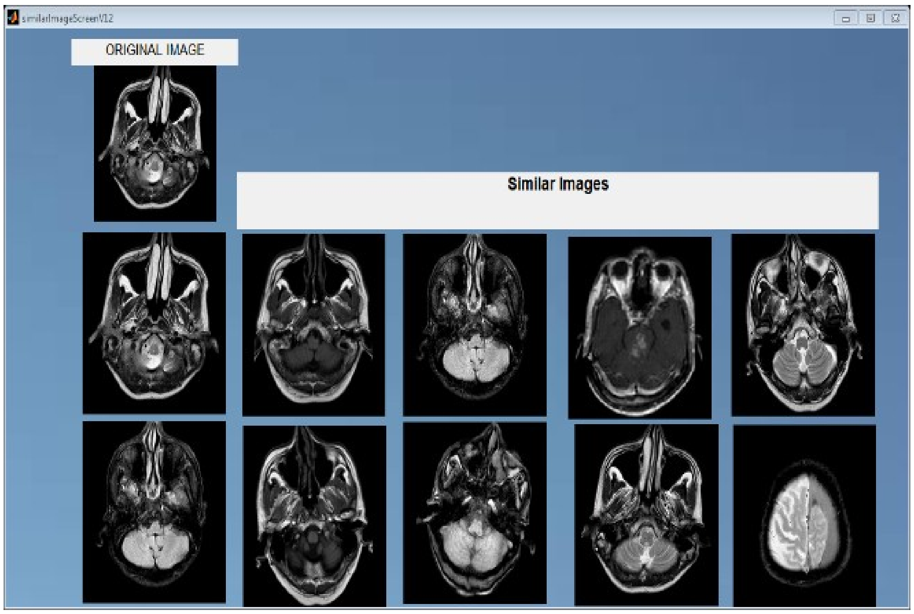

Figure 7.5: Retrieval Output for sample query image 1

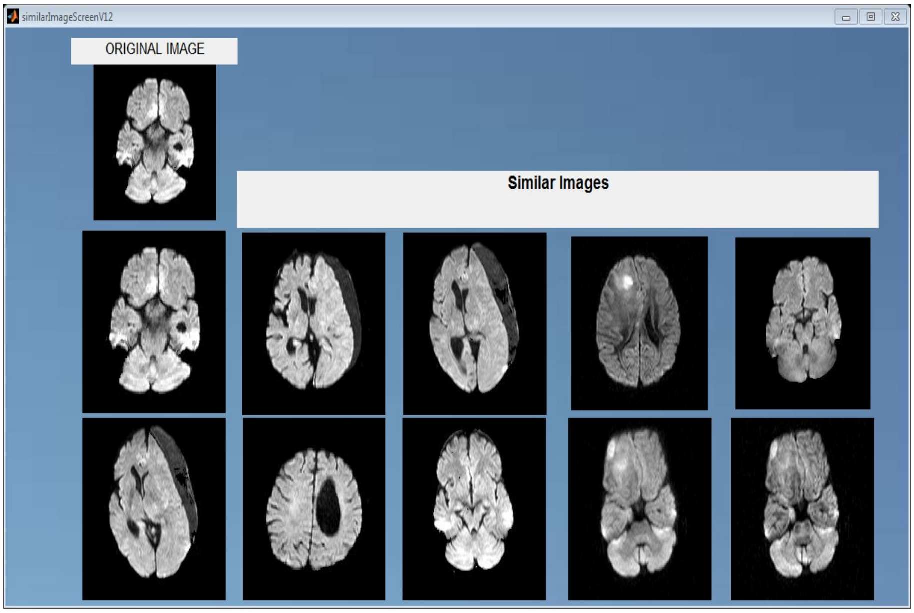

Figure 7.6: Retrieval Output for sample query image 2

Results of Analysis Module

Figure 7.7 shows the analysis result of MRI scan of patient id H. The tumor present in the brain has been identified and the visual indication of the proximity in which it is present has been visually indicated.

Figure 7.8 is a case of Bleed present in the brain. The defect has been appropriately identified and the affect region has been correctly indicated.

Figure 7.9 shows a successful detection of an infarct case and visual indication of the region in proximity of which the defect is present.

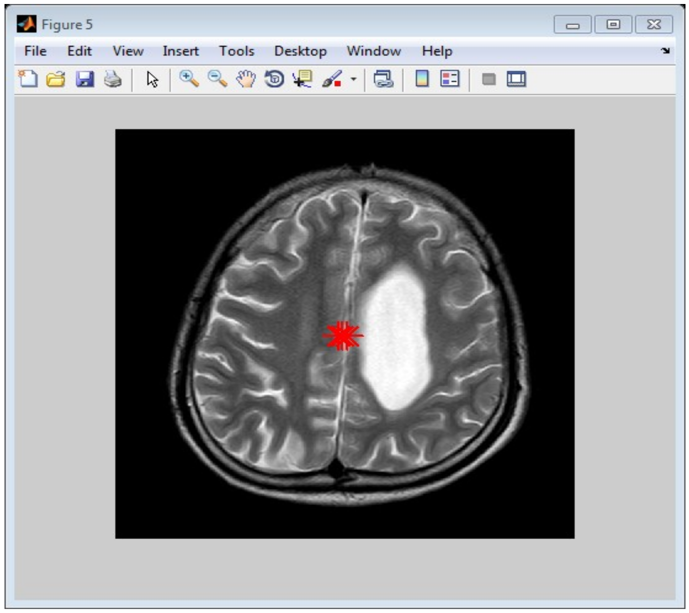

Figure 7.7: Analysis Result of a case with Tumor

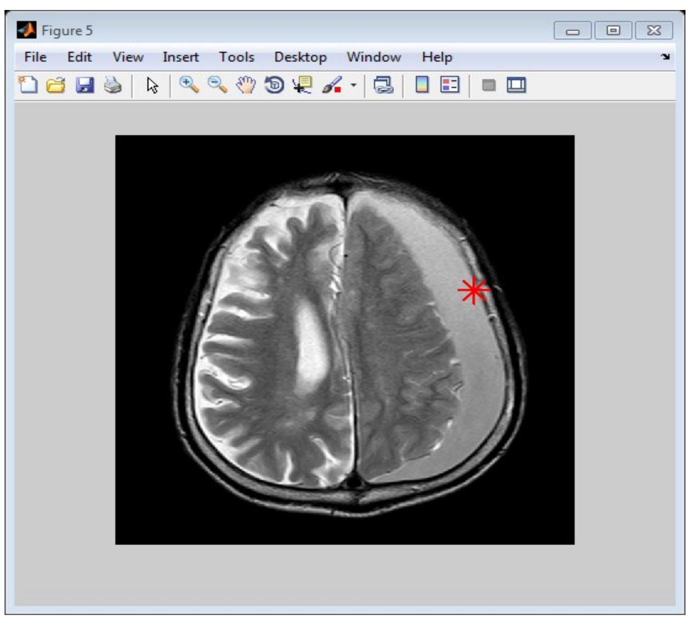

Figure 7.8: Analysis Result of a case with Bleed

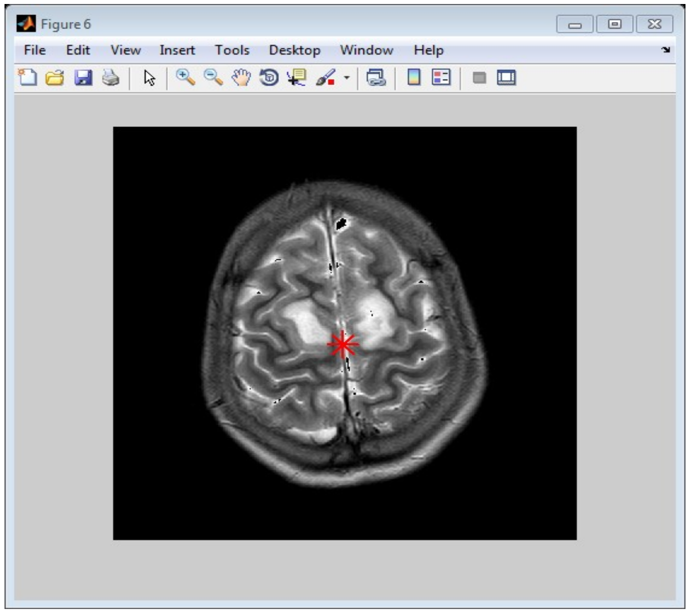

Figure 7.9: Analysis Result of a case with Infarct

7.2 Retrieval Efficiency

For showing the efficiency of retrieval, precision and recall values were calculated for four randomly selected images from the 1500 images of brain MRI scan from MATLAB workspace database. Precision can be defined as the fraction of retrieved images that are relevant to the search. In a similar way recall can be defined as the fraction of images that are relevant to the query that are successfully retrieved. Formulas used for the calculation of precision and recall values are:

$$Precision = \frac{Number\ \ of\ \ relevent\ \ images\ \ retrieved}{Total\ \ number\ \ of\ \ images\ \ retrieved}$$

$$Recall = \frac{Number\ \ of\ \ relevent\ \ images}{Total\ \ number\ \ of\ \ relevant\ \ images\ \ in\ \ the\ \ database}$$

Table 2 shows the precision and recall values for the four query images randomly chosen. Precision varies from 70.0% to 90.0% and recall varies from 13.5% to 51.3%. From these precision and recall values it is possible to evaluate the retrieval efficiency by plotting thee graph of recall versus precision.

Image Id	Precision	Recall
14	80.0	47.4
24	70.0	13.5
37	90.0	24.8
92	80.0	51.3

Table 7.1: Precision and Recall values in %

According to the table values, graphical representation of recall versus precision is shown in Figure 7.10. The recall values on horizontal axis are of image Id 14, 24, 37 and 92, respectively.

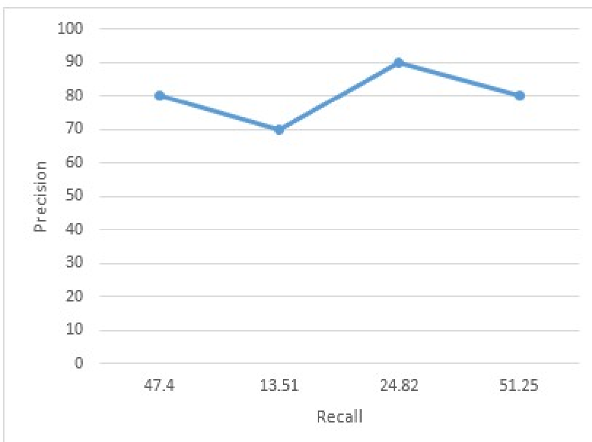

Figure 7.10: Precision vs. Recall graph

Discussions

Hexagonal resampling increases the peak signal to noise ratio, thereby, facilitating better extraction of shape and texture features. Euclidean distance used for distance calculation results in improved retrieval efficiency. For, measuring the performance of the proposed system, traditional parameters such as precision and recall measurements are used and the results are presented in Table 2 and corresponding graphical representation is also presented in Fig. 6. For precision the system gives, minimum 70.0% to a maximum 90.0% of the result and to recall it gives minimum 13.5% to a maximum

51.3% of the result. It shows that the precision gives better performance in relevant image retrieval out of the retrieved images and recall gives its own performance in relevant image retrieval out of total images available in the database. Also the system provides a very good user interface for retrieving the images.

7.3 Efficiency of Analysis Module

Scan Id	Ailment Present	Ailment Found	Affected region correctly identified
H	tumor	tumor	yes
C	bleed	bleed	yes
B	bleed	bleed	no
G	none(normal)	none(normal)	yes
AC	infarct	infarct	yes
ABC1	infarct	infarct	no
D	infarct	infarct	yes

Table 7.2: Results of Analysis Module

Table shows the efficiency of the analysis module of the system. The analysis module of the system can be divide into two parts. First part is responsible for the identification of the defect that is present in the MRI scan. And the second part of the module is to locate that defect and give visual indication. Of the various cases available in the database, the system is able to correctly identify the defect present in the MRI scan, if any. It is also able to identify if none of three ailments are present. 71.42% times the affected region is correctly notified.

Chapter 8

Conclusion and Future Work

This study proposed a model for Content Based Image Retrieval by using shape and texture features of the images. Shape features are extracted from the hexagonal resampled image, which gives improved edge detection, by applying moment invariants on them. Using GLCM various statistical measures, representing the texture features, are computed. Final feature vector table contains both shape and texture features, resulting in improved retrieval. The measure of similarity between the query image and the database images is done by calculating the Euclidean distance. Smaller the distance, higher is the similarity. The second component of the system consists of detection of ailment in the MRI scans of human brain for three pathologies tumor, bleed and infarct. Texture features, calculated above, are used for the identification of abnormalities taken in consideration for this work. Visual indication is provided for the affected region in the brain for assistance to the doctors or other medical professionals in the process of analysis. The system has been developed successfully in an efficient manner to achieve the expected output.This work can be extended to other brain pathologies and to analysis of ailments in other body parts.

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Chapter 9

Appendix

9.1 Glossary

- MPR - Multi-Planar Reconstruction
- MRI - Magnetic Resonance Imaging
- CBIR - Content Based Image Retrieval
- GLCM - Gray Scale Co-occurrence Matrix
- PSNR - Peak Signal Noise Ratio

9.2 Effort Estimation Plan

Sl no.	Phase	Estimated Effort (in hours)	Actual Effort (in hours)
1	Problem Identification	60	40
2	Software Requirement Specification	80	60
3	Software Design	100	70
4	Implementation	250	260
5	Testing	60	45

Table 9.1: Effort Estimation Plan

9.3 Certificates of paper presentation

The subsequent pages contain the photocopies of the certificates of paper presentation.