Indian Journal of Science and Technology, *Vol 11(1), DOI: 10.17485/ijst/2018/v11i1/120361, January 2018*
ISSN (Print) : 0974-6846
ISSN (Online) : 0974-5645

Brain MRI/CT Images Feature Extraction to Enhance Abnormalities Quantification

Rupal Snehkunj[1], Ashish N. Jani[2] and Nalin N. Jani[3]

[1]Department of Computer Science, Shree Ramkrishna Institute of Computer Education and Applied Sciences, Surat – 395001, Gujarat, India; rupal.snehkunj@gmail.com
[2]Department of Computer Engineering, P. P. Savani University, Kosamba – 394125, Gujarat, India; aashishjani@yahoo.com
[3]Department of Computer Science, Kadi University, Gandhinagar – 382023, Gujarat, India; drnnjanicsd@gmail.com

Abstract

Objectives: The research initiative in this paper focused on brain image feature extraction and its organized storage filtered of from abnormalities located on the brain Magnetic Resonance (MR) and Computer Tomography (CT) scan images which are preprocessed. **Methods/Statistical Analysis:** For this study, abnormalities such as brain tumor & brain hemorrhage are taken into consideration as they share many common characteristics which can be diagnose using same implementation methodology. The MRI & CT brain images were studied so as to explore various phases such as brain image extraction, brain image transformation and brain image progression on it. **Findings:** This work integrates the phases in a computer based system which facilitates the use of the processes in an integrated, distinctive and sequenced manner with ease and comfort in its uses. The brain image extraction and brain image transformation phase inculcates merging of patient's MRI or CT Dicom image slices into single image, noise reduction by three different methods, noise selection based on Peak Signal to Noise Ratio (PSNR) and Mean Squared Error (MSE) error metrics, skull removal and lastly image enhancement. The outcome of this stage is inputted to brain image progression phase where image is characterize into T1-weighted, T2-weighted and PD-weighted for segmentation where uncommon areas are fragmented using T1-w, T2-w and PD-w brightness and intensity values. Finally based on segmented results, the features are extracted and selected for empowering classification capacity and detection accuracy. **Application**: Experiments are conducted on more than 200 brain MRI/CT image datasets and promising results were reported.

Keywords: Brain Abnormalities, Brain Image Progression, Feature Extraction, Feature Selection

1. Introduction

Brain images processing followed by analysis has remain challenging in respect of more accurate detection of abnormalities along with extraction of hidden but vital information contained in image data. The undertaken work is inclined towards the accuracy enhancement of feature extraction and selection from image data to have better understanding of images in respect of abnormalities detection. This work has taken additional care of improved classification of abnormalities to support inspection in better way. As per our understanding, abnormalities in the brain are classified based on location and type of tissues that facilitates detection of cancerous or non-cancerous abnormalities. The brain abnormalities are of various types such as infections, trauma, hemorrhage, hematoma, seizures and tumors, etc.

Medical Resonance Imaging (MRI) and Computer Tomography (CT) have established most prevailing medical imaging modalities for detection of neurological abnormalities and diagnosis of hemorrhage, ischemic stroke, and tumors with support of image data analysis and visualization. MRI supports superior soft tissues differentiation, contrast, high spatial resolution, and does

**Author for correspondence*

not use harmful ionizing radiations. These characteristics have made MRI to be a valuable tool in clinical and surgical environments diagnosing particularly tumors. Another modality, CT scans are predominantly used for differentiating hemorrhage caused by bleeding in the brain or ischemic stroke caused by a blockage of blood flow in the brain. CT scan facilitates sensitive information with quicker scanning time that makes it more suitable for detection of hemorrhage and stroke.

The intended work is targeted to two major brain abnormalities: Tumor and Hemorrhage. Lesions (abnormalities) in medical images do not take any particular shape and predefined size. They are often highly textured and therefore texture analysis becomes crucial in medical image extraction. Texture analysis of brain images is mainly based on contrast, brightness and intensities. These image characteristics allow the medical professionals to differentiate the structures and determine which structures are abnormal to the tissue function. The detection of such abnormalities by way of image segmentation and feature extraction from MRI/CT scan image data is challenging as well as time consuming because of manual intervention in semi-automated approaches. The enhancement of the level of automated detection is in demand which can be fulfilled by deploying the methodologies of segmentation and feature extraction in integrated domain.

The previous work in this area is segmented for research based on pre-processing, segmentation and feature extraction techniques for Brain Tumor and Brain Hemorrhage.

In[1] proposed the framework which is automated diagnosis system to accurately report brain abnormalities in malignant and benign format. The research focuses on two abnormalities tumor and hemorrhage as they share same diagnosis treatments and parameters for analysis. In[2] has introduced strategy to detect and extract brain tumor from patient's MRI scans brain images. The methodology includes pre-processing, segmentation, morphological operations to differentiate types of tumor and growth with its plotting graph. In[3] proposed a computer based method for highlighting tumor region from MRI brain images. It incorporates seven stages such as pre-processing, image segmentation, feature extraction, neural network, Region of Interest (ROI) and decision implemented on 102 images. In[4] proposed the method involves feature extraction, feature reduction followed by classification by SVM. The method classify the brain MRI image into categories such as normal and abnormal (clot, bleed, tumor, trauma and acute-infract). The future work will try to combine LDA and PCA for better results. In[5] reveals comparative analysis of classifier performance of brain tumor MRI images. The high precision rate define accuracy rate in tumor diagnosis. The precision rate, sensitivity rate, specificity rate are used for performance analysis. In[6] compare the research of various techniques of brain tumor from MRI images. The two procedures are followed in this research (1) NN classification with extracted features in terms of moment invariance2) AR based NN classification with binary AR based feature selection and rule pruning techniques. The latter method achieves high accuracy, high sensitivity and specificity rates than NN classification. The suggestion is to use AR based NN classification for better decision making. In[7] proposed the fast and scalable automatic medical image classification system for brain hemorrhage. It can help to build a medical image search system according to syndrome, types of brain images, the syndrome types. The data was collected using image via picture archives and communication system hardware. The 35 CT images collected from Singapore hospital contains 15 EDH, 9 SDH, 6 ICH and 5 normal data. In[8] presents a truly automatic segmentation method and the use of histogram analysis instead of a random initialization leads to an important improvement in the choice of center of clusters. The future work is making robust method against all artifacts present in CT images and comparing this method with some well-known image segmentation method. In[9] emphasized their work on diagnosis of Astrocytoma(brain tumor) by classifying it as low grade or high grade using K-NN classifier and its performance is measured using three metrics such as accuracy, severity and specificity and parameters as False Negatives(FN), False Positive(FP), True Negative(TN) and True Positive(TP). The methodology followed is pre-processing, automatic thresholding, feature extraction, classification and diagnosis. The result shows that 93 % accuracy of proposed approach is achieved and the database used is BRATS. In[10] authors presents a system for MRI brain images classification into healthy or affected brain area using region growing, segmentation watershed algorithm and Euclidean distance classifier for fast computation. The work was tested on 25 images and in future the system will be checked on 100 MRI images for performance and speed. In[11] focused on research for brain hemorrhage diagnosis using computer aided system. The classifiers such as neural network, SVM, decision trees were compared and accuracy measure were tested using parameters such as precision, recall, f-measure and AUC. Moreover to make results quiet achieving, the author will use ensemble classifier in future. In[12] has concentrated on describing design & development of content based image retrieval system such as feature extraction using GLCM, feature reduction using PCA and classification using SVM. The work was tested on small dataset and intended to test on large datasets in future. In[13] evaluated the effectiveness of feature extraction and feature selection techniques. The stages segmented as Principal Component Analysis (PCA), genetic algorithm, and sensitivity analysis. The seven datasets were used for research where feature extraction and feature reduction results were inputted to neural network classification algorithm for performance evaluator. The most effective techniques in the study were found to be PCA and sensitivity analysis. In[14] authors worked on human brain tumor area calculation. The research is divided into following modules such as image pre-processing, feature extraction, segmentation using k-means and fuzzy c-means algorithm, tumor area calculation, classification and position calculation of tumor using neural network. The output of k-means was used as input for fuzzy c-means algorithm. The future work will be classification using neural network. In[15] had emphasized on segmentation and morphology operations for detection of brain tumor. In total, approx. 500 datasets were pre-processed, morpholize and segmented using OTSU method. In[16] proposed a novel method to classify a given MR brain image as normal or abnormal. The work flows as wavelet transform to extract the features, applying PCA for feature reduction and lastly the reduced features were submitted to Kernel Support Vector Machine (KSVM). The results were compared with methods from literature and results shows that our DWT+PCA+KSVM with GRB kernel achieved best results. In[17] has undertaken research work to identify brain hemorrhage. The methodology followed is converting CT to .jpeg image, pre-processing, segmentation and classification. The parameters such as sensitivity, specificity, accuracy and MCC were used to check efficiency of the proposed research. The neural network classifier gives higher accuracy as 95.97%. In[18] have developed MRI Image Pattern Detection Framework (MIPDF) for visual analytics of brain diseases in the open source software known as MIPAV tool. The results were displayed in three planes as coronal, sagittal and axial for displaying better brain patterns. In[19] have made survey on various existing techniques for feature extraction and feature selection on brain images. For comparison, the techniques were simulated in Matlab tool and its results were discussed. The literature review findings specify the need for developing and refining the single automated process for pre-processing, feature extraction/selection and segmentation for better machine learning capabilities to enhanced level of accuracy of detection and improved support of diagnosis for brain abnormalities such as brain tumor and hemorrhage.

2. Proposed Methodology

The core work in this paper is to implement the published framework scientifically for the extraction of features from image data followed by analytics to empower classification capacity and detection accuracy. The objective of this research is to enhance the accuracy of feature extraction and selection from image data to have better understanding of images in respect of abnormalities detection. The proposed implementation methodology is designed based on published framework[1]. This research integrates various phases viz brain image extraction, brain image transformation and brain image progression with its steps such as image extraction, image slices management, three different noise reduction techniques, selection of optimum noise removal technique, image enhancement, skull and artifacts removal, image recognition, image segmentation, feature extraction, feature selection represented in Figure 1.

The Algorithm designed for implementation of above diagram for feature extraction/selection for brain abnormalities quantification is described as follows and the results for the same are analyzed. This research work targeted to carry out experiment work till the brain image progression phase to enhanced accuracy of feature extraction and selection for brain abnormalities identification.

Step 1: Browse/load to given the Brain MRI/CT Images ([Dicom or .jpeg]-file format)

The image datasets comprise of primary data of clinical laboratories and secondary data from repositories. The organized data storage is in the structure of DICOM/JPEG files. The primary data were acquired from Clinical Laboratory of the MRI, CT SCAN Diagnostic Center located at General Civil Medical Hospital, Surat and Medical College, Surendranagar, Gujarat[1] and secondary

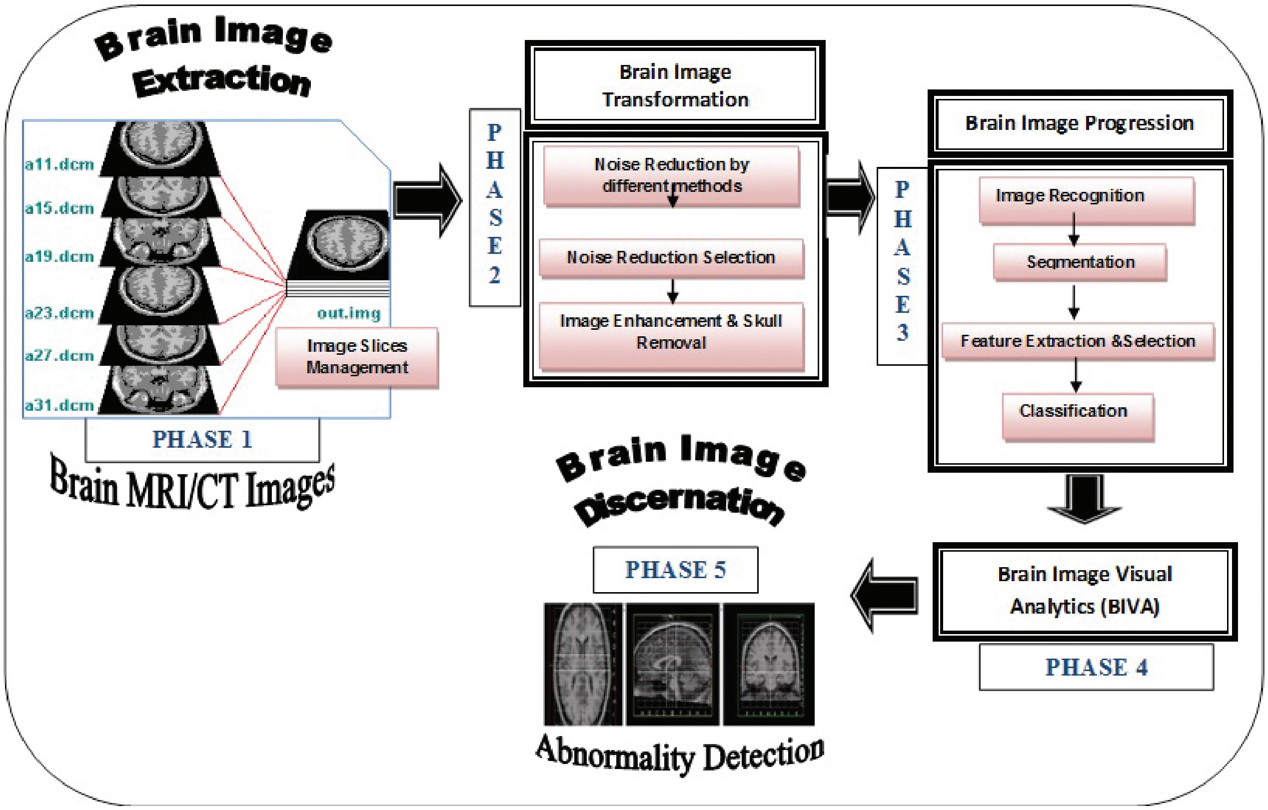


Figure 1. Block Diagram for Implementation of Brain Abnormalities Quantification.

data were obtained from web repositories www.radiopaedia.com. The proposed work is experiemented and tested on more than 200 datasets for brain tumor and hemorrhage. Dicom MR and CT slices are extracted in Matlab workspace version R2017b. Brain image extraction phase includes loading of images to merging of brain slices steps of an algorithm.

Step 2: Merging of Brain Images Slices

The image(s) of patient are extracted either in dicom(.dcm) or .jpeg format. Dicom file consists of image slices where each image slice contains some necessary information which can be beneficial for brain abnormalitites detection and analysis. Selecting one of all slices may not give proper information and lead to unclear judgement. This research merge all image slices of single patient into one .jpeg file so that all information from different slices can be retain in single image for further diagnosis work.

Step 3: Pre-processing of Brain Images

Brain image transformation phase inculcates pre-processing of brain images step of an algorithm. The main objective of pre-processing is to improve the image quality so that unwanted features gets eliminated and optimistic features can be highlighted for training the classifier. The pre-processing stage follows the application of three noise reduction methods such as Median filter, Gaussian filter and Low pass filter, selecting best method of noise reduction based on different parameters such as Mean Standard Error (MSE) and Peak Signal to Noise Ratio (PSNR), Image Enhancement and Skull Removal.

The presence of noise in modern MRI and CT scans is very less but due to thermal effect on the image it is necessary to remove noise and other artifacts present in the image for quality information retrieval. The work used three different noise reduction techniques: Median filter, Gaussian filter and Low pass filter. All three methods were applied on image extracted and the method reducing precise noise was selected based on two error metrics such as Mean Square Error (MSE) and the Peak Signal to Noise Ratio (PSNR). PSNR is the parameter which measures quality reconstruction of an image. It requires original data and noisy data as input for image compression. Another parameter, MSE represents the cumulative squared error between the compressed and the original image. It is examined that the higher PSNR

value and the lower MSE value indicate the improved quality of an image. PSNR and MSE can be used collectively with following formula.

$$MSE =$$
$$sum(sum((Input\,Image - Reconstructed\,Image).\wedge 2))/(rows * columns)$$
$$PSNR = 10 * log10(256 * 256 / MSE)$$

Another step of pre-processing is image enhancement which enhances the level of contrast as it is an important factor in evaluation of image quality. After noise reduction, Histogram equalization is used for image enhancement in this research. Skull is one of the most parts of the brain but for research purpose it is not helpful for attaining some information so it is essential to remove skull from the brain image so skull is stripped by applying mathematical morphology on an image. The Morphological parameters such as dilation and erosion were applied to the brain images for removing the imperfections produced by thresholding. The pre-processing stage proposed here benefit into maximum achievement of improved image for better feature extraction. The improved resultant images from this stage were used as input to the process of feature extraction, selection and classifier for accurate classification and better diagnosis.

Step 4: Recognize the Images as T1-w, T2-w, and Proton dDnsity (PD) Images

Brain image progression phase includes Image Recognition, Segmentation and Feature extraction and selection steps of an algorithm. Image Recognition is the step where the given image is identify as t1-weighted (T1-w), t2-weighted (T2-w) or Proton Density (PD) image. The process of identifying brain abnormalities depends on features extracted from an image so the better feature extraction the accurate will be the result of image recognition. The paramount features of the brain image can be acquired from various tissues of the brain structure such as Cerebrospinal Fluid (CSF), fat, White Matter (WM), Grey Matter (GM) and water present in the brain. This tissue reveals different characteristics for T1-WeightedIimages (T1W1) and T2-Weighted Images (T2W1) based on the brightness and intensity values. Hence, image recognition turn out to be crucial stage before feature extraction is performed on any image. The rules for how the tissue appears on T1-weighted, T2-weighted and Proton density images are : a) The CSF is dark on T1W1 and CSF is bright on T2W1 whereas Grey matter is grey and white matter is white on T1W1 and relationship is reversed on T2W1**. b) The FAT is bright on T1W1 and FAT is less bright on T2W1**. c) The Water is white in T2-scan conversely a T1-scan shows fat as being white described in Table 1.

Step 5: Segmentation based on T1-W, T2-W, and Proton Density based on Rules

Image segmentation separates the uncommon brain tissues from normal brain tissues (grey matter, white matter, Cerebrospinal Fluid (CSF), fat and water) using different methods such as thresholding, region growing, watersheds and contours. Here, the segmentation is performed based on the image recognition and intensity values. Automatic thresholding is the iterative method used for segmentation of brain images. This method segments different regions based on the threshold value which is automatically calculated based on input. The threshold values and intensity values are compared to classify the image into different regions image and highlight the area with uneven intensity values. It is used for automatic binarization level decision, based on the shape of the histogram. The histogram is initially used for segmenting into two parts using starting threshold value as 0=2B-1 which is half the maximum dynamic range. One sample mean (mf,0) is for foreground pixels while other sample mean(mb,0) is for background pixels both for gray values. A new threshold value is calculated based on average of these two sample means. The process is repeated till threshold value become static.

Table 1. Tissue Appearance in T1-w, T2-w and PD Images

Image Types	Gray Matter	White Matter	Ventricles	Fat
T1 Weighted	Dark	Bright	Black	Bright
T2 Weighted	Bright	Dark	White	Bright
Proton Density(PD)	Depends on the T1 or T2 weighting mix above characteristics			

Step 6: Feature Extraction and Selection on Segmented Image and save it .mat file

Image features are the characteristics of the brain image which contains maximum information needed to analyse the tumor and hemorrhage. Feature extraction techniques analyse images to extract the most prominent features that are representative of the various classes of objects. Features are used as inputs to classifiers which further assign them to the class that they represent. There are various types of features such as shape based, color based and texture based feature, etc. The texture based features depicts important characteristics used for identifying Region of Interest (ROI) in an image. Some texture features used in this research are detailed below: contrast, energy, entropy, homogeneity, correlation, etc. Once the features are extracted using feature extraction techniques and brain images brightness and intensity rules, feature selection techniques are applied. Feature selection is a process applied for selecting appropriate features from all extracted features. The irrelevant features are omitted in this process because excessive features cannot produce satisfying results and can even mislead the classifier from producing better results. Feature selection does not generate more features but remove unneeded features so that further process can use relevant features and can generate reliable and accurate results. The features whose values are taken into consideration for our study are contrast, correlation, energy, homogeneity, mean, standard deviation, entropy, kurtosis and skewness etc

3. Experimental Results

This section illustrates the experimental results of proposed methodology using brain MR images for tumor diagnosis and brain CT images for hemorrhage diagnosis. The primary work in this paper is to enhance the process in such way that accurate features can be extracted to empower classifier capability. The results highlights that the same implementation methodology is suitable for both brain tumor and brain hemorrhage abnormalities. The experimental work has been implemented with 200 brain MR/CT image datasets. The research paper demonstrates 8 datasets of which first 5 datasets are for various brain hemorrhages such as Epidural Hemorrhage (EDH), Subdural Hemorrhage (SDH), Subarachnoid Hemorrhage (SAH), Intracerebral Hemorrhage (ICH) and Intraventricular Hemorrhage (IVH) and remaining 3 datasets are for brain tumor abnormality identification as benign (non-cancerous) or malignant (cancerous) in nature tabulated in Table 2.

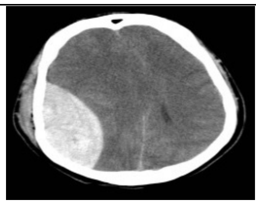
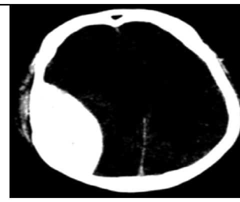
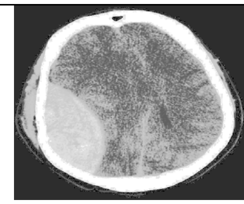
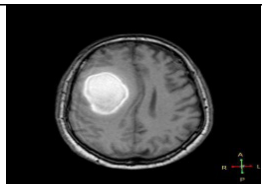
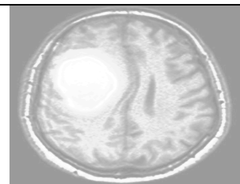
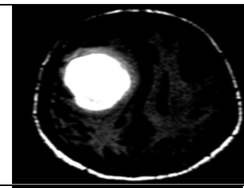
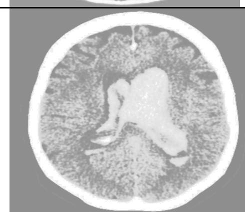
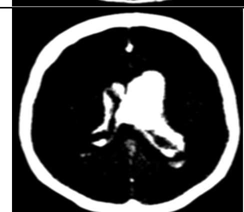
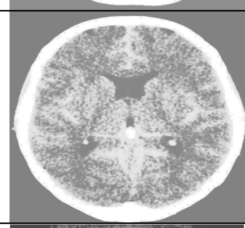
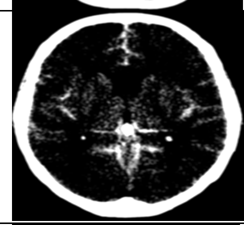
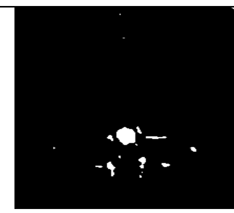
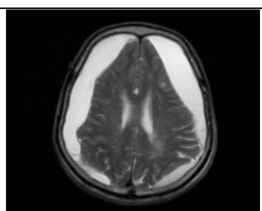
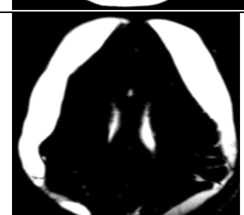
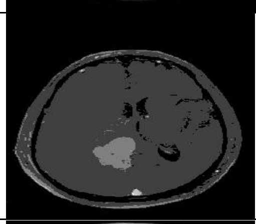
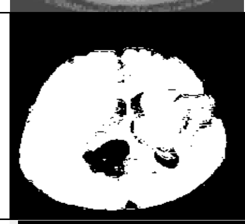
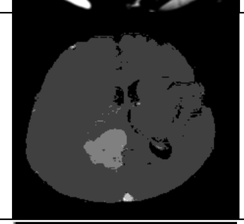
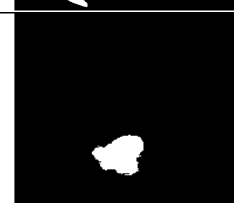
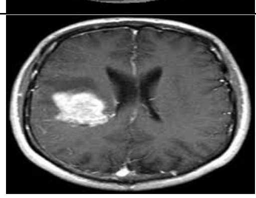
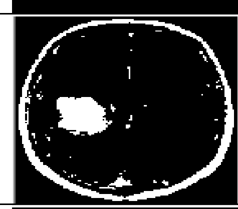
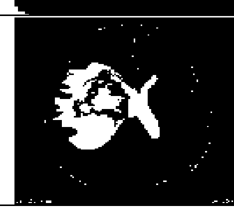
Several brain hemorrhages are predicted by its location/position, shape and size in the brain which can use for accurately detecting brain hemorrhage abnormality. Epidural Hemorrhage (EDH) is typically biconvex in shape and lies between the inner surface of the skull and outer layer of the Dura. Subdural Hemorrhage (SDH) is typically crescent in shape and lies between skull and outer layer of the Dura. Subarachnoid Hemorrhage (SAH) is one of the types of extra-axial intracranial hemorrhage and it lies in the subarachnoid space. Intracranial Hemorrhage (ICH), also known as intracranial bleed, is the bleeding within the skull. Intraventricular Hemorrhage (IVH) represents the present of blood within the ventricular system of the brain in the body. The Figure 2 depicts various brain hemorrhages with its location and shape.

The brain image datasets are extracted and merged with application of three different noise reduction methods such as Median filter, Gaussian filter and Low pass filter. The noise reduction method with high PSNR and low MSE is further considered for research. As the part of pre-processing, skull is removed from the brain image and finally image is enhanced. Image recognition of the brain image is the important step after pre-processing which will lead to better segmentation of the image based on image recognized brightness and intensity rules. From 8 image datasets, 4 images were recognized a T1-w, 3 images recognized as T2-w and remaining 1 was recognized as PD-weighted image depicted in Table 2. Further, the features are extracted from the segmented portion which will be used as parameters values for training and testing the classifiers. The features extracted are depicted in Table 3.

4. Conclusion

The focused work is on enhancement of features of CT and MRI brain images. These enhanced features are expected to aid medical diagnostic with improved accuracy. The stage in the processing of stated images-pre-processing inculcates merging of patient's MRI/CT Dicom image slices into single brain image. The merging of Dicom image slices into a single image assembles

Table 2. Pre-processing, Recognition and Segmentation of Brain CT/MRI Images

Brain Images Original Data		Noise Reduction & Selection	Image Enhancement	Image Recognition & Segmentation
Image 1 T1-W image EDH hemorrhage				
Image 2 T1-W image ICH Hemorrhage				
Image 3 T2-W image IVH Hemorrhage				
Image 4 T1-W image SAH Hemorrhage				
Image 5 T2-W image SDH hemorrhage				
Image 6 PD-W image Benign				
Image 7 T1-W image Benign				
Image 8 T2-W image Malignant				

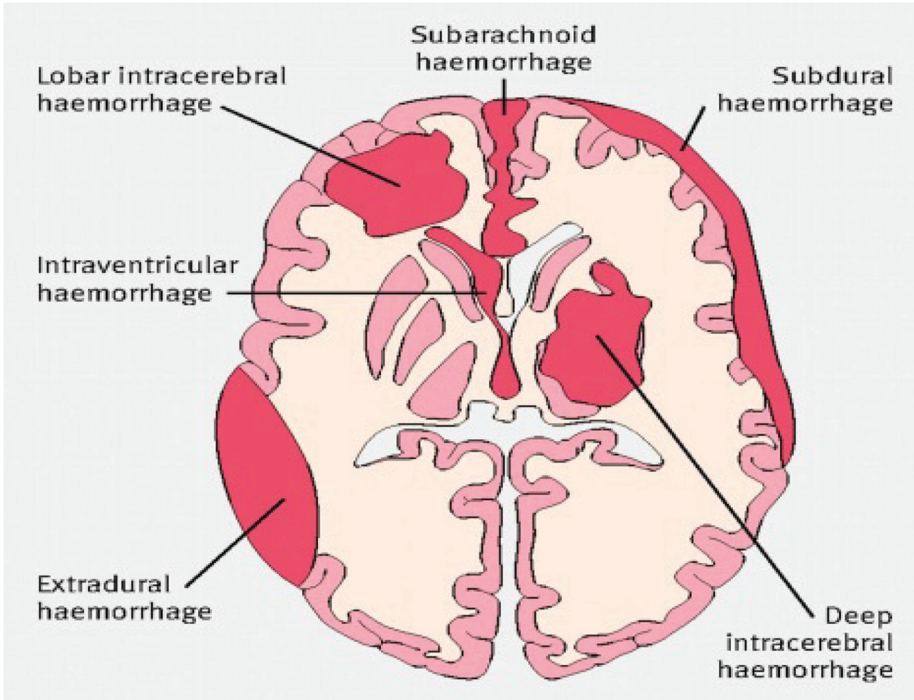


Figure 2. Brain Hemorrhages[20].

Table 3. Feature Extraction of Brain CT/MRI Images

Brain Images	Contrast	Correlation	Energy	Homogeneity	Mean	Standard Deviation	Entropy	Kurtosis	Skewness
Image 1 T1-W image	0.005428	0.039453	0.992412	0.998065	0.000146	0.026997	2.405379	22.470917	0.761244
Image 2 T1-W image	0.008503	0.158444	0.990030	0.997498	0.000212	0.025318	1.955739	51.060880	1.398929
Image 3 T2-W image	0.005264	0.135635	0.992869	0.998205	0.000273	0.025317	2.151405	29.127167	1.036514
Image 4 T1-W image	0.005172	0.045325	0.993305	0.998291	0.000212	0.025318	2.022819	36.985849	1.102510
Image 5 T2-W image	0.003919	0.033990	0.992387	0.998118	0.000164	0.025318	2.098144	10.208269	0.356200
Image 6 PD-W image	0.245829	0.073732	0.763494	0.932532	0.000550	0.089813	3.512842	6.762649	0.611026
Image 7 T1-W image	0.231368	0.107236	0.741808	0.929760	0.004236	0.089715	3.551623	6.061447	0.510428
Image 8 T1-W image	0.305895	0.142097	0.786231	0.937931	0.006309	0.089593	3.205149	12.240782	1.104809

all scattered feature parameters in different slices into merged image. This process part is not only merging slices into a single image which is subjected for noise removal. The noise removal is optimized implement three techniques-Median filter; Gaussian and Low pass filter techniques. The optimized output based on PSNR and MSE parameter values is then subjected for processing ahead. The next interesting process is image recognition. The optimized brain image which contains tissues is subjected for recognition to arrive at a conclusion that whether it is T1-weighted or T2-weighted or PD-weighted image. This tagging to the image will lead to segmentation on correct track. The correctly tagged image is then subjected for feature extraction process part to achieve enhanced accuracy of feature extraction.

The experimental work has been implemented with 200 brain MR/CT image datasets. In this paper, 8 image datasets are reflected in the results of which first five datasets are of different brain hemorrhage and remaining datasets are of brain tumor. The optimization of 8 image datasets in this process part of noise removal that image data is considered for further processing that has highest PSNR and lowest MSE. From 8 image datasets, 4 images were recognized a T1-w, 3 images recognized as T2-w and remaining 1 was PD-weighted image. The tagged images after recognition were segmented on their respective tracks and features are extracted from segmented portion. These parameter values are to be used for training the classifiers. This trained classifier will classify brain hemorrhage such as EDH, ICH, IVH, SAH, SDH and brain tumors as benign and malignant.

5. References

1. Snehkunj R, Jani AN. A systematic approach for brain abnormality identification from biomedical images. International Conference Data Mining and Advanced Computing (SAPIENCE), IEEE. 2016 March; p. 210-213. Crossref.
2. Patil RC, Bhalchandra AS. Brain tumour extraction from MRI images using MATLAB. International Journal of Electronics, Communication and Soft Computing Science & Engineering (IJECSCSE). 2012 April; 2(1):1-4.
3. Badran EF, Mahmoud EG, Hamdy N. An algorithm for detecting brain tumors in MRI images. International Conference on Computer Engineering and Systems (ICCES), IEEE. 2010 November; p. 368-73. Crossref.
4. Pydi V, Josyula SB. Detection of Brain Tumor Using PCA With SVM. IJRCCT. International Journal of Research in Computer and Communication Technology. 2015 August; 4(8):535-39.
5. Thiyagarajan A, Pandurangan U. Comparative analysis of classifier Performance on MR brain images. The International Arab Journal of Information Technology. 2015; 12(6A):772-79.
6. Dhanwani DC, Bartere MM. Survey on various techniques of brain tumor detection from MRI images. International Journal of Computational Engineering Research. 2014 January; 4(1):24-26.
7. Gong T, Liu R, Tan CL, Farzad N, Lee CK, Pang BC, Tian Q, Tang S, Zhang Z. Heidelberg: Berlin: Springer: Classification of CT brain images of head trauma. IAPR International Workshop on Pattern Recognition in Bioinformatics. 2007 October; p. 401-408. Crossref.
8. Sharma B, Venugopalan K. Automatic segmentation of brain CT scan image to identify hemorrhages. International Journal of Computer Applications. 2012 February; 40(10): 0975-8887.
9. Gupta S, Walia P, Singla C, Dhankar S, Mishra T, Khandelwal A, Bhardwaj M. Segmentation, Feature Extraction and Classification of Astrocytoma in MR Images. Indian Journal of Science and Technology. 2016 September; 9(36):1-8. Crossref.
10. Nikam PB, Shinde VD. MRI brain image classification and detection using distance classifier method in image processing. International Journal of Engineering Research and Technology. 2013 June; 2(6):1980-85.
11. Sridevi M, Naaz S, Anjum K. Diagnosis and classification of brain hemorrhage using CAD system. Indian Journal of Scientific Research. 2015 November; 12(1):121-25.
12. Mane MA, Hingane MM, Matkar MS, Shirsat MA. Classification of MRI Brain Image using SVM Classifier. Journal of Emerging Technologies and Innovative Research. 2015 March; 2(3):851-54.
13. Addison D, Wermter S, Arevian G. A comparison of feature extraction and selection techniques. Proceedings of the International Conference on Artificial Neural Networks. 2003 June; p. 212-15.
14. Bangare SL, Patil M, Bangare PS, Patil ST. Implementing Tumor Detection and Area Calculation in Mri Image of Human Brain Using Image Processing Techniques. International Journal of Engineering Research and Applications. 2015 April; 1(5):60-65.
15. Saini PK, Singh M. Brain Tumor Detection in Medical Imaging Using Matlab. International Research Journal of Engineering and Technology. 2015 May; 2 (2):191-96.

16. Zhang Y, Wu L. An MR brain images classifier via principal component analysis and kernel support vector machine. Progress in Electromagnetics Research. 2012; 130:369-88. Crossref.
17. Ge R, Shen H. Researching on Feature Extraction of Brain CT Image. International Journal of Signal Processing, Image Processing and Pattern Recognition. 2013; 6(5):39-48. Crossref.
18. Snehkunj R, Mehta R, Jani AN. Pattern Detection Framework for MRI Images and Labeling Volume of Interest (VoI). New Delhi: Springer: Proceedings of the Second International Conference on Computer and Communication Technologies. 2016; 3:323-32. Crossref.
19. Snehkunj R, Jani AN. A Study of Feature Extraction and Selection Techniques for Brain Abnormalities Classification. International Journal of Advances in Science, Engineering and Technology (IJASEAT). 2017; 5(1-2): 44-46.
20. Brain Hemorrhages. Date Accessed: 13/11/2017: Available from: https://www.medicinenet.com/brain_hemorrhage/article.htm.