Early Detection of Brain Stroke using MRI Images

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Abstract - *Medical imaging is a well developing and demanding technology in today's medical field. Early Brain stroke detection plays an important role as it can limit the brain damage and also reverse the long term repercussions caused by the complexity of the stroke .However, the location of ischemic stroke in the MRI image is not apparent and the physical identification of lesion area takes additional epoch. The purpose of this paper is to develop an automated stroke detection algorithm using machine learning. The proposed methodology describes a series of novel techniques to detect & categorize brain stroke. The entire process is divided into six distinctive stages. Subsequent to preprocessing the image to functional standards, Gabor Filters are utilized to improve the quality of the MRI image. Adaptive histogram equalization (AHE) is the technique adapted for enhancement. Finally Fuzzy C Means technique is used to fragment the image and GLCM is applied for extracting features. These features are trained and considered for classification process through Multiclass SVM. From the experimental results, the accuracy of the proposed module is found to be higher than 90%. The algorithm proposed is simple, efficient and less time consuming.*

Key Words: **MRI images, Preprocessing, Filtering, Enhancement, Fuzzy c means, Gray Level Co-occurrence Matrix (GLCM), Multi SVM.**

1. INTRODUCTION

Being an imperative organ, human brain is dependent to a durable blood supply analogous to our heart for durability. The malfunctioning of the arteries that supply blood to the brain roots a brain stroke. This brain attack can be disengaged into two, the ischematic stroke and hemorrhagic stroke which disarray the brain function. The visual representation of the interior human body can be caused by bio medical imaging technique. Multifarious imaging techniques are used in medical monopoly such as x-ray, ultra sounds, Computed Tomography (CT) scan and Magnetic Resonance Imaging(MRI) scan. . On comparison with the other medical imaging, The MRI plays a vital role in dispensing analogous images of the brain with equivalent resolution in various projections. On obtaining images in multiple planes, augment the versatility in diagnosing utility. This gives a beneficial advantage for radiation or surgical treatment planning. The former part of the paper delineates the background of the brain stroke recognition using image processing techniques and posterior, its output is given admittance into the filtering part. Later, estimations of various features are ascertained. The system has undergone a series of testing phase with peculiar MRI images and the findings demonstrate gratifying outcomes. Also, the full length agenda is done with a minimal expense of time.

2. PROPOSED METHODOLOGY

The proposed methodology describes a series of novel techniques to detect brain stroke. Fig 1 shows the flow of the process. The entire process is divided into six different stages. At each stage the image is worked upon at various levels to extract detailed information .Firstly, Magnetic Resonance Imaging (MRI) of the brain has been collected as data sets for further training and testing. Secondly, Preprocessing is performed to improve the quality of the MRI image and make it in a form suited for further processing .It also helps to improve certain features of MRI image such as improving the signal-to-noise ratio, enhancing the visual appearance. The third part is to filter the image to remove noises. Contrast in the image is also enhanced .Then; the essential features are extracted from the segmented image. This image is then classified according to the trained data set and information is provided on the class and severity of the problem.

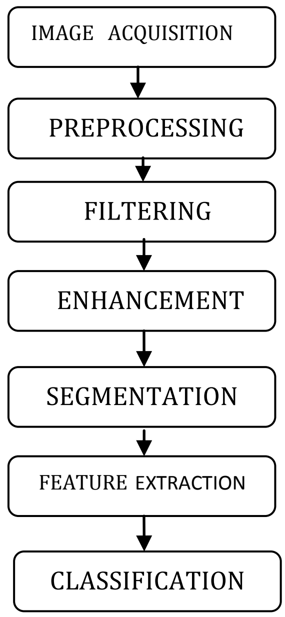

Chart-1: Flow chart of Model

2.1 Image Acquisition

The first stage of any system is the image acquisition stage. If the image is not acquired satisfactorily, then the indented tasks will not be achievable. Image Acquisition includes compression, storage, printing and display of the data sets.

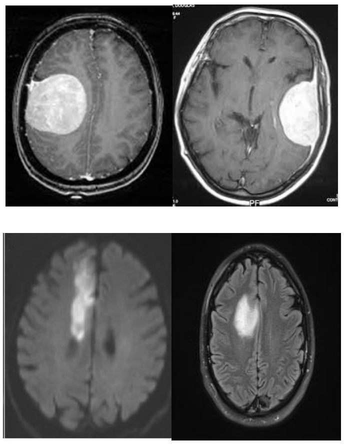

Fig -1: Datasets

2.2 Preprocessing

Preprocessing is a name for operations with images at the lowest level of abstraction. It is a process which is used to boost the precision and interpretability of an image. This involves processes like conversion to gray scale image, noise removal and image reconstruction.

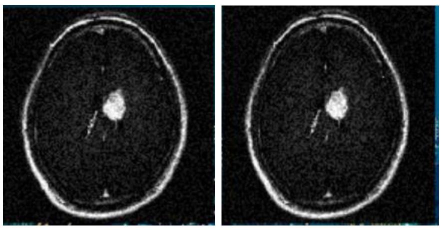

Fig -2: Original Image Preprocessed Image

2. 3 Filtering

Filtering is a technique for modifying or enhancing an image.

Smoothing, Sharpening, and Edge Enhancement are other Image Processing operations that are accompanied along with Filtering.

Gabor filters are designed to resemble the performance of the mammalian visual cortical cells.

The multi resolution sensitivity of such filters are utilized to extract meaningful features .In addition, these filters have shown optimal localization properties in both spatial and frequency domain.

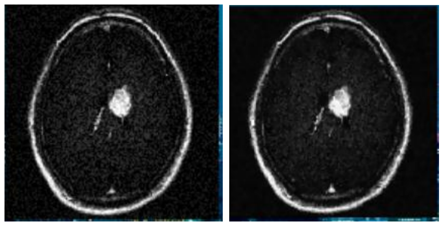

Fig-3: Preprocessed Image Gabor Filtered Image

2.4 Enhancement

Image Enhancement is the process of altering and calibrating the earlier processed image such that the results are more suitable for further analysis.

Adaptive histogram equalization (AHE) is the technique adapted for enhancement in this project. With respect to ordinary histogram equalization, the adaptive method varies by computing several histograms, each corresponding to a distinct section of the image, and uses them to redistribute the lightness values of the image.

AHE is thus found to be more appropriate for improving the local contrast and enhancing the definitions of edges in each region of brain in MRI.

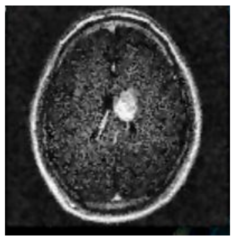

Fig -4(a) : Brain MRI after AHE process

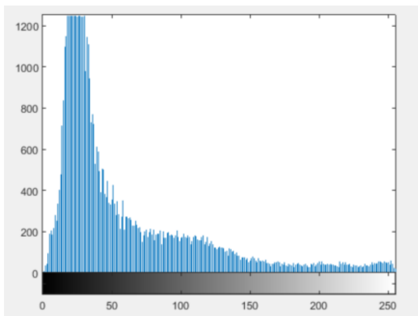

Fig -4(b): Adaptive Histogram

2.5 Segmentation

The goal of image segmentation is to divide the images into subparts and capture the minute details. The Fuzzy C Means Clustering technique is adapted. The image is segmented into different classes where each class has a membership degree. Based on histogram from the earlier step FCM is applied to every cluster formed.

This new enhanced FCM approach is well suited for acute lesions and has also increased the speed of the segmentation process.

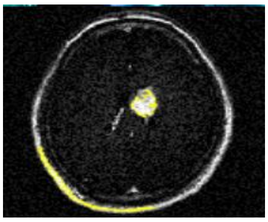

Fig -5: Segmented Image of Stroke

2.6 Feature Extraction

Feature Extraction is a special form of dimensionality reduction which reduces the resources to define the entire information.

Extraction methodologies analyze objects and images to extort prominent features that represent the classes of objects. They are broadly based on Shape, Color, Texture & Intensity.

Texture of the lesion cell highly differs from other biological tissues and thus texture measurement is effective in differentiating the two. The well-known statistical method for extraction, Gray level co-occurrence matrix (GLCM) is adopted here. Also, shape features which provide powerful information for classification of different tumor types is extracted.

2.7 Classification

Image classification is a task that is allied to multi-label assignments. The information extracted from an image is then associated to one or more class labels. Classification algorithms examine the numerical properties to organize data into categories.

Support vector machine (SVM) is a concept for a set of related supervised learning methods that analyze data, recognize patterns and then used for classification. Our system aims to classify the severity of stroke in 3 stages as "Benign", "Malignant" or "Normal" and thus Multi SVM concept is chosen.

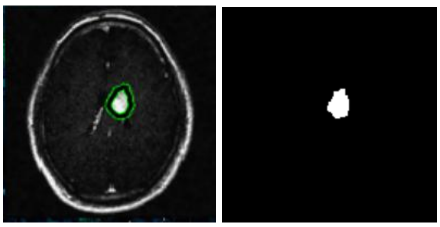

Fig -6: Affected Region located

3. RESULTS AND DISCUSSION

The acute and sub-acute phase of the contrast enhanced axial MRI images of the stroke affected patients is chosen as source images. The results are simulated using MATLAB software.

The input Brain MRI image is loaded and is subjected to pre-processing, and relevant texture features are calculated using the Gray Level Co-Occurrence Matrix (GLCM). The values of the co-occurrence matrix elements present relative frequencies with which two neighboring pixels are separated by distance d appear on the image, where one of them has gray level i and other j.

Expression for the texture attributes are :

$$Correlation = \sum_{i,j=0}^{N-1} P_{ij} \frac{(i-\mu)(j-\mu)}{\sigma^2}$$

$$Contrast = \sum_{i,j=0}^{N-1} P_{ij} (i-j)^2$$

$$Energy = \sum_{i,j=0}^{N-1} (P_{ij})^2$$

$$Homogeneity = \sum_{i,j=0}^{N-1} \frac{P_{ij}}{1+(i-j)^2}$$

Table -1: GLCM Texture Features

ATTRIBUTE	NORMAL	BENINGN	MALIGNANT
Correlation	0.9329	0.8697	0.7841
Contrast	0.1977	0.9933	0.802
Energy	0.3305	0.1105	0.4117
Homogeneity	0.9267	0.8614	0.8368

Table 1 shows the values for different brain stroke cases corresponding to the severity. These four measures provide high discrimination accuracy and can be used for robust, accurate classification.

Region Properties like Area, Perimeter, Centroid etc. refers to the shape features of a particular region of image which vary for different types of stroke and thus are crucial criteria for classifications. These parameters are listed in Table II for classes "Benign" &"Malignant" .For a Normal case ,all the values are 'zero' as no stroke is detected .

Table -2 : Region Properties

PROPERTIES	BENINGN	MALIGNANT
Area	69	163
Major Axis	34.09	17.51
Minor Axis	3.58	12.24
Eccentricity	0.99	0.7152
Orientation	65.51	79.55
Solidity	0.67	0.95
Extent	0.17	0.69
Entropy	5.99	5.6067

These extracted features are fed as inputs to the Multiclass SVM classifier. With these as the measurement frames, the classifier has categorized into classes by a function induced from the trained datasets.

The performance of the classifier is evaluated and reported with the following terminologies defined as

Recall: Fraction of all positive samples correctly predicted as positive by the classifier

Sensitivity ***= TP/(TP+FN)***

Specificity: Fraction of all negative samples are correctly predicted as negative by the classifier.

Specificity =*TN/(TN+FP)*

Accuracy: The fraction of the total samples that were correctly classified by the classifier.

Accuracy =*(TP+TN)/(TP+TN+FP+FN)*

Where TP, FP, FN, TN represent True Positive, False Positive, False Negative and True Negative correspondingly.

Table- 3: Classifier Performance

Sno.	Class	Specificity(%)	Sensitivity(%)	Accuracy (%)
1	Benign	85	100	90
2	Malignant	100	84	90
3	Normal	100	100	100

Table 3 holds the values of Sensitivity, Specificity, Accuracy for each class of stroke and this shows an overall of 90% accurate performance of the Multiclass SVM classifier. Based On classification results, the user is notified with a message prompt correspondingly.

Fig -7: Message Prompt

4. CONCLUSION

This paper provides a detection system of brain stroke at an earlier stage. This system uses machine learning techniques along with more recent and efficient image processing methodologies to propose a novel diagnostic system for stroke patients. The proposed system utilizes Gabor filter and Adaptive histogram technique which provides a much enhanced output compared to the existing system. The project also provides various features as measurement parameters, based on which the degree of severity such as *"Stroke Patient" (Malignant),"Benign" (starting stage and "Normal"* can be diagnosed at a much initial level. These measurements help to define the stroke in a detailed facet which assist in recognizing appropriate treatment for that stage. Also, this model ensures to reduce the workload of radiologists. For Future works, the software system can be embedded onto a hardware prototype which can be interfaced with the MRI Machine for immediate detection and diagnosis.

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