Acute Ischemic Stroke Detection and Classification

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Abstract - *Ischemic stroke is more common hence, identification of ischemic stroke and detection of region of brain affected is more important. CT (Computed Tomography) scan images are widely use in rehabilitation process. This paper presents the method to detect the stroke region and classify normal and stroke patient. Preprocessing operation perform on the input CT scan image and skull part removed from the image. Stroke region segmented from the image using morphological operation and highlighted the region on original CT image or if CT scan image is normal case then it shows that patient is normal. Naive Bayes (NB) and k- Nearest Neighbor (k-NN) classifiers are used for classification of stroke patient and normal patient. Classification accuracy of NB and KNN is 92% for 25 image slices of different patient. Processing time of K-NN classifier is 8.80s while for Naive Bayes 5.85 s.*

Key Words: *Computed Tomography, Ischemic Stroke, Naive Bayes, k- Nearest Neighbor, GLCM*

1. INTRODUCTION

Stroke is a Cerebro Vascular Accident (CVA) which is a serious health issue and it is forward in reason of death worldwide. Stroke is becoming main reason in cause of disability, dementia and death in the developing countries. Stroke affects the person who may be disabled and their family also. Stroke is cause by interruption in supply of blood to the brain, generally because of blood vessel burst or blockage due to blood clot as shown in Fig. 1. This interruption in supply of nutrients and oxygen to the brain, results into the damage of brain tissue. Stroke is divided into two types which are Ischemic and Hemorrhagic. Abrupt occlusion of arteries supplying the brain is the main cause of Ischemic Stroke [18]. Hemorrhagic stroke are cause by subarachnoid hemorrhage- bleeding from one of the brain arteries into the brain tissue or intra-cerebral hemorrhage - arterial bleeding.

Almost 80 percent of strokes are ischemic stroke[18]. Hence it is required to detect the stroke in early stages. Computed Tomography Scan images are widely for the diagnosis of stroke. In CT scan dataset Ischemic stroke appears as dark area with the contrast and hemorrhage as bright region.

The proposed method used image processing techniques such as median filtering, segmentation, morphological operation. Naive Bayes and k- Nearest Neighbor (k-NN) classifiers are used for the classification.

Fig -1: Supply of blood to the brain through vessel Obstructed

2. LITERATURE SURVEY

Stroke can be diagnosed, if immediate treatment is available. Damage to the brain depend on severity of the stroke and amount time period for which the stroke occur. CT(Computed Tomography) scan and MRI(Magnetic Resonance Imaging) used in the rehabilitation process of stroke, whereas CT scan is easily available, less costly and widely used.

P. R. Mirajkar [4] proposed an algorithm to detect of an acute ischemic stroke utilizing CT scan and MRI dataset. CT scan images and Diffusion Weighted MRI are fused which results in a composite image. This image provides more information than single modality which is accomplished using DWT. The algorithm is tested on 18 cases and for 16 cases stroke region is identified precisely. A. F. Z. Yahiaoui [5] derived a method for the segmentation of the Ischemic Stroke from CT scan images. FCM clustering technique is used to segment the stroke region of the brain. 10.46 s is average processing time achieved. Dr. Menaka R [6] derived an algorithm for the detection of an Ischemic Stroke from MRI dataset utilizing wavelet transform. Classification of Normal and abnormal brain is attain using watershed segmentation. Texture analysis is performed using Grey Level Co-occurrence Matrix (GLCM) and wavelet features extracted. Neural Network is applied on FPGA by making Xillinx Simulink Blocks. Jeena R S [7] analyzed the MRI and CT images of brain for stroke diagnosis. The computational of the algorithm time is very less. Md Tabish raza [8] derived a comparison based technique for detection of Ischemic tissue, by utilizing CBV and MTT perfusion map. Status of tissue is classified. T. L. Tan [9] derived a technique to enhance the contrast of CT brain images for the detection of acute ischemic stroke. Proposed method enhanced contrast of soft tissue and achieved EMEE is 3.9409, PSNR is 32.7426. Kiran Parmar [10] analyses the fusion of CT scan and MRI images using wavelet transform. Maximum fusion rule achieved least MSE and higher PSNR values. Mayank Chawla [11] derived a technique to detect and classify the stroke using CT scan images of the brain. Histogram plot is used to detect the abnormal slices. Daubechies-4 is used for classification. Ming sian, Lee [13] derived an algorithm which increases the visual perception of stroke detection system. Anisotropic filter removes noise. Brain images extracted using Mathematical morphology. Region growing technique is used to extract stroke region. 85% success rate is achieved by the proposed system.

3. METHODOLOGY

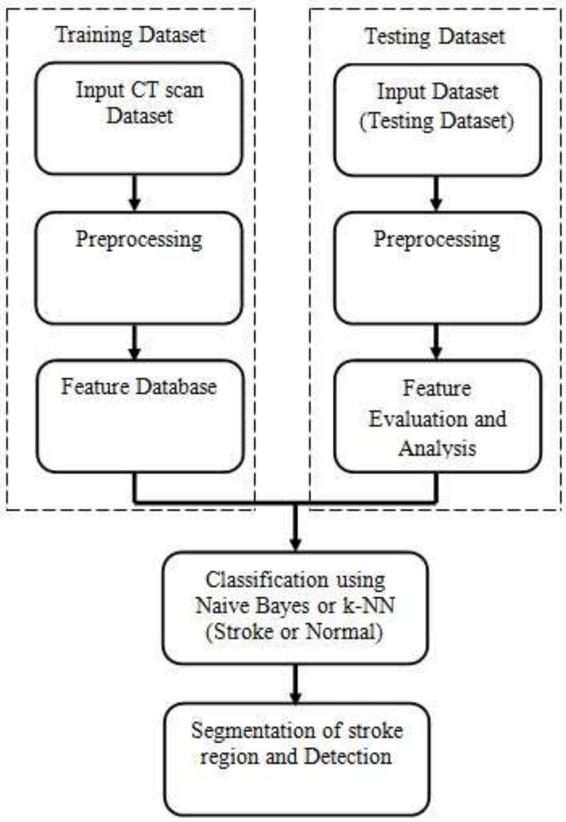


Fig -2: Complete Block diagram of the System Implemented

3.1 Pre-processing of CT scan Images

The purpose of the pre-processing step is to produce data which are compatible with the ischemic stroke region detection and classification system.

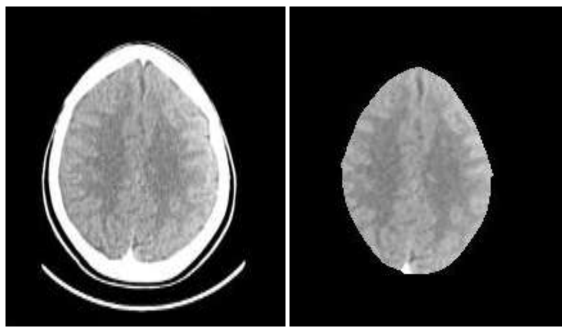
Input image is converted into grey image and resize operation performed to get specific size image for further operation. Histogram plot operation is perform to calculate the number of pixel and grey level of image. Image converted to black and white (binary) image to find the region of interest with certain threshold value. Small specks remove that have fewer pixel than specific value. Small holes filled to get cleaned binary image.

1. Median Filtering

Image Enhancement involves filtering, resizing and adjustment operation. Median filtering removes unwanted noise from the image. Median filtering is one of the popular image enhancement techniques.

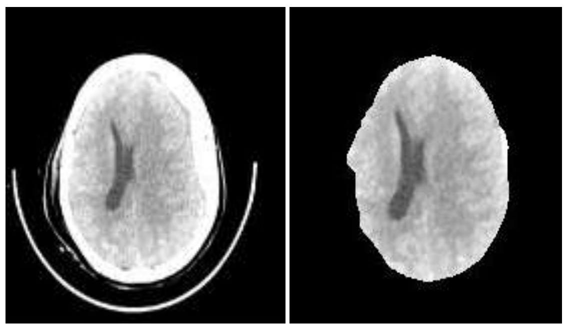
2. Skull Stripping

Skull is unwanted part of the brain, to eliminate this skull stripping is implemented. Skull part of the brain image is unwanted which is removed using erosion operation as shown in Fig 3.



(a) (b)

Fig -3: (a) Original Input Image of Normal Patient
(b) Preprocessed and Skull stripped of Original Image



(a) (b)

Fig -4: (a) Original Input Image of Stroke Patient
(b) Preprocessed and Skull stripped of Original Image

3.2 Feature Extraction

Feature extraction can be explained in terms of features database created after loading the training dataset and feature evaluation and analysis performed after loading testing dataset. Feature extraction consists of Miscellaneous Feature such as Mean and Texture based feature such as Entropy and Grey Level Co-occurrence Matrix (GLCM).

Entropy: Entropy is the statistical measure of randomness that can be used to calculate texture of the input grey scale image.

E= -sum(p.*log2(p))

Mean: Mean calculates the mean intensity of the gray level of an image. Mean can be calculated by summing up the intensity values of all the pixels in the source image, then dividing by the total number of pixels.

Grey Level Co-occurrence Matrix (GLCM): The GLCM used to characterized the images on the basis of texture. GLCM calculates how often a pixel with grey level value occur either horizontally or vertically. The co-occurrence matrix can be given as P(i,j|d,θ) where i and j are the grey level values at a distance d with an angle θ.

μ= Mean value of P

μ_x& μ_y = Mean value of P_x& P_y

σ_x & σ_y = Standard Deviation of P_x& P_y

G = Size of co-occurrence matrix

Energy: Provides the sum of squared elements in the GLCM. Also known as uniformity or the angular second moment.

$$\text{Energy} = \sum_{i=0}^{G-1}\sum_{j=0}^{G-1} P(i,j)^2$$

Correlation: Measures the joint probability occurrence of the specified pixel pairs.

$$\text{Correlation} = \sum_{i=0}^{G-1}\sum_{j=0}^{G-1} \frac{\{i,j\} \times P(i,j) - (\upsilon_x - \mu_x)}{\sigma_x \times \sigma_y}$$

Contrast: Measures the local variations in the gray-level co-occurrence matrix.

$$\text{Contrast} = \sum_{n=0}^{G-1} n^2 \left\{ \sum_{i=0}^{G-1}\sum_{j=0}^{G-1} P(i,j) \right\}, |i-j| = n$$

Homogeneity: Measures the closeness of the distribution of elements in the GLCM to the GLCM diagonal.

$$\text{Homogenity} = \sum_{i=0}^{G-1}\sum_{j=0}^{G-1} \frac{P(i,j)}{1 + |i-j|}$$

Feature Extraction is an important stage before any classification. Features of the normal patient and stroke patient CT scan image have been calculated as shown in Table I. From the calculated feature values it is found that there is a slight difference between the stroke and normal patient feature values. Mean, Entropy and GLCM show a significant difference in the features of both the images.

From these feature values, images of the stroke patient and the normal patient can be classified.

Table -1: Feature Database of Stroke and NormalPatient

Features	Stroke Patient	Normal Patient
Mean	35.043	28.689
Entropy	0.701	0.684
Contrast	0.344, 0.431	0.215, 0.292
Correlation	0.962, 0.952	0.964, 0.952
Energy	0.655, 0.653	0.671, 0.668
Homogeneity	0.971, 0.966	0.974, 0.969

3.3 Classification

Classification of the stroke patient and normal patient is achieved using Naive Bayes and KNN classifier. Classification is mainly based on features extracted from training dataset. To classify accurately training dataset should be proper and perfect. CT scan slices of 14 stroke patient and 32 normal patients collected from local hospital.

1. Naive Bayes

A Naive Bayes classifier assumes that the presence of a particular feature in a class is unrelated to the presence of any other feature. Naive Bayes classifier particularly based on Bayes theorem which is illustrated below:

$$P(A/B) = \frac{P(B/A)P(A)}{P(B)}$$

Where,

P(A/B) is the probability of event A given event B is true.

P(B/A) is the probability of event B given event A is true.

P(A) is prior probability of event A.

P(B) is prior probability of event B

2. K Nearest Neighbor (KNN)

K nearest neighbors is a simple algorithm that stores all available cases and classifies new cases based on a similarity measure (e.g Distance function). It belongs to the supervised learning domain and finds intense application in pattern recognition, data mining and intrusion detection.

Let m be the number of training data samples. Let p be an unknown point.

KNN Algorithm

1. Store the training samples in an array of data points array. This means each element of this array represents a tuple (x, y).

2. Calculate Euclidean distance d.

$$d = \sqrt{\sum_{i=1}^{k} (X_i - Y_i)^2}$$

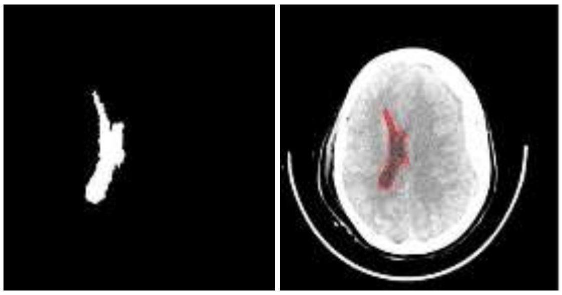
3. Make set S of K smallest distances obtained. Each of these distances corresponds to an already classified data point.

4. Return the majority label among S.

Dataset of 21 patients i.e. 21 CT scan image slices is used for training of both classifiers. Performance of both classifiers tested on dataset of 25 patients image slices.

3.4 Segmentation of Stroke Region and Detection

Preprocessed image is then converted into binary image by applying certain threshold. All the connected components in the image are removed that having fewer than certain pixel. Components in the image are suppressed which are lighter than their surrounding and connected to image border. Finally, stroke region segmented from original image as shown in figure 5(a). Then boundaries of the segmented image are highlighted on the original image. In this way stroke region is detected as shown in figure 5(b).



(a) (b)

Fig 5: (a) Segmented Stroke Region (b) Stroke Region Highlighted

4. RESULT AND DISCUSSION

Performance of the system is tested on CT scan slices of total 25 patients. Dataset consist of 8 slices of different ischemic stroke patients and 17 slices of different normal patients. Initially Naive Bayes and KNN classifier trained using training dataset of 21 patients CT scan slices. Naive Bayes and KNN classifier gives the accuracy of 100% for the training dataset. Both the classifier tested on testing dataset and achieves the classification accuracy of 92%. All the performance parameters are analyzing using confusion matrix.

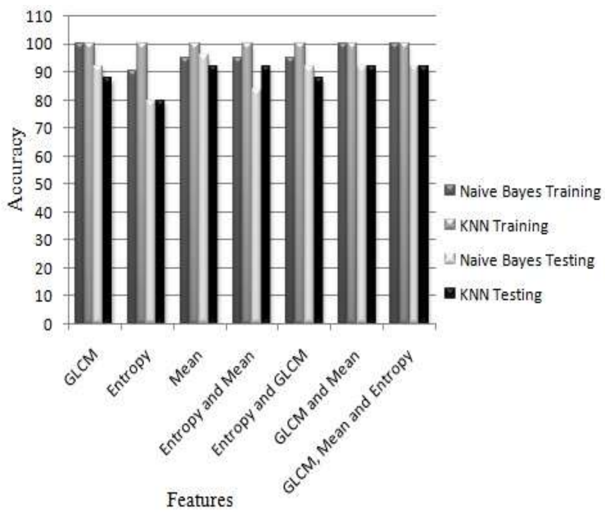


Fig 6: Relation between Features and Accuracy

As shown in figure 7 highest accuracy is achieve for training and testing of both classifiers using combination of GLCM, Mean and Entropy. Hence these features implemented in the system for the classification of normal and ischemic stroke CT scan slices

As shown in the fig confusion matrix, out of 8 ischemic stroke CT scan slices, 1 slice is incorrectly detected and out of 17 normal CT scan slices, 1 slices is incorrectly detected. Hence error rate of 8% has occurred. Accuracy of 92% is achieved by both classifiers, error rate is 8%, sensitivity is 87.5%, specificity is 94.1%, precision is 87.5%, False Positive Rate is 5.9%, False Negative Rate is

12.5%. Processing time of K-NN classifier for testing Dataset is 8.80 second. Processing time of NB classifier for testing dataset is 5.85 second.

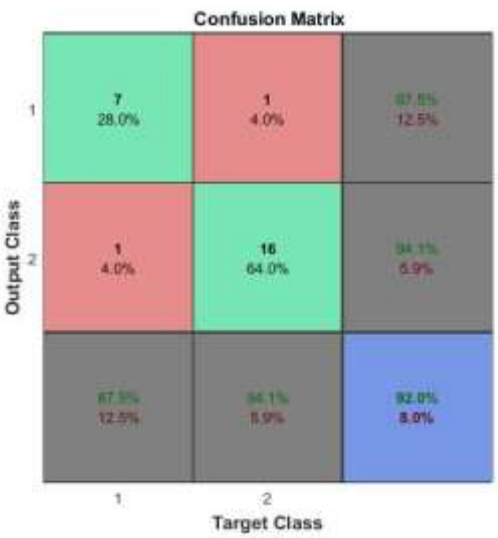


Fig 7: Confusion Matrix of Naive Bayes and KNN

False Positive Rate is due to misclassification of slices. False Negatives Rate is due arise due to a subtle difference between normal and ischemic stroke. As the training dataset is accurate hence all the parameters values achieved are equal for both (Naive Bayes and KNN) classifiers.

5. CONCLUSIONS

The present study demonstrates effectiveness of different features and Naive Bayes and K Nearest Neighbor Algorithm for the acute ischemic stroke detection and classification. Stroke region is segmented on the basis of gray level intensity of CT scan image. Naive Bayes and KNN classifiers achieve the classification accuracy of 92%. Both the classifiers are having equal accuracy according to the features implemented. GLCM, Mean and Entropy are the features used to analyze the texture of the image and plays important role in the classification. Processing time of Naive Bayes classifier is less as compare to KNN classifier.

Finally, to achieve the higher accuracy training dataset must be proper and suitable features are required for the feature extraction. Hence accuracy can be improved in future by implementing various features.

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