Classification of Stroke Using Texture Analysis on CT images

Pramod Bhat, Mandeep Singh

Abstract –Correct diagnosis of the stroke type is very important for proper medication as any delay or wrong diagnosis may become fatal to the patient. Many methods have been developed to diagnose stroke using MRI images. In this work we have used unenhanced CT images for diagnosis stroke using texture features and classifiers. Five different classifiers have been used and they are combined to get better diagnosis accuracy. The accuracy of classifier ensemble output was 85.39% and the area under ROC (AUC) was found to be about 93 % for every classes. The method proves very effective for diagnosis of stroke with good accuracy and able to differentiate acute, chronic and hemorrhage successfully.

Keywords: Texture features, Classifier ensemble, CT scan

I. INTRODUCTION

Stroke is the third largest cause of death in U.S as per World Health Organization survey [1] and the it is increasingly showing its signs in developing countries because of lifestyle change. 0.63 Million people die of stroke in India alone every year. As an estimate 12% of strokes occur in the population aged below 40 years [2].Accurate diagnosis is very important if it is in initial phase as the situation becomes irreversible if the proper medication is not given within first three hours of occurrence of stroke. Much research works have been done on the causes of stroke and prevention of the same. The patients are being diagnosed by conventional methods and they are sometimes erroneous because of lack of adept physicians and very nature of stroke itself. If it is in very initial stage the diagnosis may be highly erroneous. This situation is more prominent in developing and underdeveloped countries. Even though MRI imaging of head gives very good diagnostic results, many hospitals and diagnostic centers are unable to afford them because of its high cost. A research work in this regard is very less and hence it is very essential so that even un-enhanced CT images can be used to yield good diagnostic results. A research work in this regard is presented below.

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II. PREVIOUS WORKS

A number of researchers have worked on diagnosis of stroke. A method of automatic detection of stroke using wavelet analysis and classification was introduced in [3]. A rule based approach for segmenting stroke lesion using seeded region growing was proposed in [4]. Computer aided detection of stroke by calculating cohesive rate (CR) of a series of CT images was proposed in [5]. A novel method was devised using Circular Adaptive Region of Interest (CAR0I) in [6]. Many methods have been used to segment lesion area, enhance the stroke affected area. Barnathan *et al.* [7] proposed a method to identify tissue type in MRI images using vector quantization.

III. METHODOLOGY

In this work CT scan images in TIFF format were used for analysis. 8-bit images of size 512x512 were taken from Govt. Rajindra hospital, Patiala using Siemens Somatom Emotion 6-Slice CT machine.

Slices showing lesion were selected and lesions were marked by the experts in the area. ROIs of size 20x20 were used to extract texture features from the stroke affected areas. In a total of 91 cases were used in this study. Texture values from these images were then used for classification.

A. Texture Analysis:

Texture based analysis has been very successful in diagnosis of medical images. Because of the very nature of irregularity seen in the interested area texture analysis is most suitable in these cases.Haralick *et al.* [8] used textural features for classification of images to find region of interest. They made significant use of the knowledge about the physics of the ultrasound imaging process and tissue characteristics to design the texture model. Chen *et al.* [9] used fractal texture features to classify ultrasound images of livers, and used the fractal texture features to enhance edges in chest x-rays. In our discussed method we have used texture features from Six different models like Spatial Gray-Level-Dependence matrices (SGLDM), Gray-Level Difference Statistics (GLDS), Statistical-Feature Matrix (SFM), Law's Texture Energy Measures (TEM), Fourier Power Spectrum (FPS) and Fractal Feature (FF) [10].

B. Data Pre-processing:

where σ1 and σ2 are the standard deviations and µ1 and µ2 are the means of a feature belonging to two to different classes. The table 1. Shows values of FDR, mean and standard deviation for best six features selected. Higher the ratio between the feature sets is, better will the result we get [11].

C. Classification

The attributes were classified using five different classifiers–SVM,Random Forest, C 4.5, K-NN and CART (classification using regression).

Fisher's Discrimination Ration (FDR) is one of the most widely used dimensional reduction technique. Mathematically it is represented as,

$$FDR = \frac{(\mu 1-\mu 2)(\mu 1-\mu 2)}{\sigma 1^2+\sigma 2^2}$$

Cross-validation of ten was used so that every data set was used for training as well as testing. The classifiers were then combined using voting method for achieving more accurate results.

IV.Results

In order to evaluate the performance of the model, various measurements (TP,TN,FP,FN) were taken and ROC(Receiver operating Characteristic) was drawn.

1) TP (True Positive): The model correctly detects the stroke type, if really shows any symptoms.
2) TN (True Negative): The model correctly detects that the stroke has not occurred.
3) FP (False Positive): The model falsely tells that stroke has occurred.
4) FN (False Positive): The model falsely tells that the stroke has not occurred even when it really exists.

The table 2. shows the some of the other measurements calculated

Table 1. Table showing FDR, mean and standard deviation values for the best six features selected.

	Acute			Chronic			Haemorrhage		
Features	FDR	µ	σ	FDR	µ	σ	FDR	µ	σ
H2	0.873	0.16	0.062	0.835	0.201	0.083	0.995	0.179	0.028
M	0.909	1.01	0.0035	1.276	1.065	0.035	0.802	0.0049	0.001
Med F	0.896	88.492	19.484	1.537	53.842	20.526	1.427	192.541	33.031
Enty F	0.640	2.676	0.104	0.831	2.922	0.252	0.946	2.96	0.217
Engy F	0.633	0.0798	0.008	0.825	0.064	0.016	0.892	0.061	0.014
Fr	0.894	1867.68	405.109	1.531	1157.705	419.227	0.902	3090.641	821.19

Table 2. Table showing values of TP rate,FP rate,Precision,Recall,F-measure and AUC(Area under ROC) Of the classifier combiner for the feature set Med-F and Enty-F.

Class	TP Rate	FP Rate	Precision	Recall	F-Measure	AUC
Acute	0.897	0.032	0.929	0.897	0.912	0.973
Chronic	0.963	0	1	0.963	0.981	0.998
Haemorrhage	1	0	1	1	1	1
Normal	0.95	0.042	0.864	0.95	0.905	0.967
Weighted Average	0.945	0.02	0.947	0.945	0.946	0.983

The confusion matrix is presented in the table 3. Confusion matrix tells that, if higher the values of the diagonal elements (Shown in red cells) and lower the other values, more accurate is the result.

Table 3. Confusion matrix

Acute	Chronic	Haemorrhage	Normal	Classified as
26	0	0	3	Acute
1	26	0	0	Chronic
0	0	15	0	Haemorrh-age
1	0	0	19	Normal

ROC curve is one of the most effective and widely used methods to evaluate the diagnostic model. It shows trade off between true-positive rate and false-positive rate at various threshold levels. More the curve bulging towards the top-left corner better is the diagnostic model. The ROC curves for acute, chronic and haemorrhage classes are shown in fig 1(a), 1(b) and 1(c) respectively. It was calculated that in all the cases the area under ROC (AUC) was greater than 0.95.

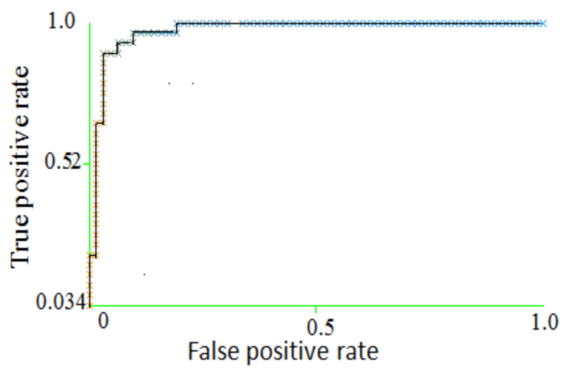

Fig 1(a). ROC curve for the class Acute

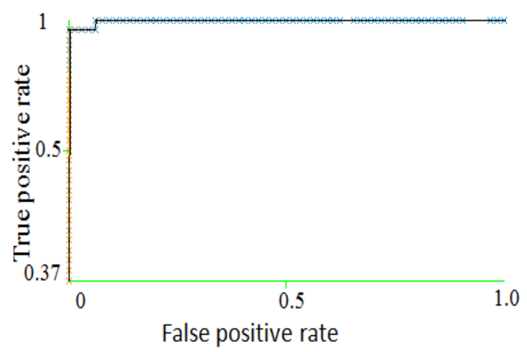

Fig 1(b). ROC class for Chronic

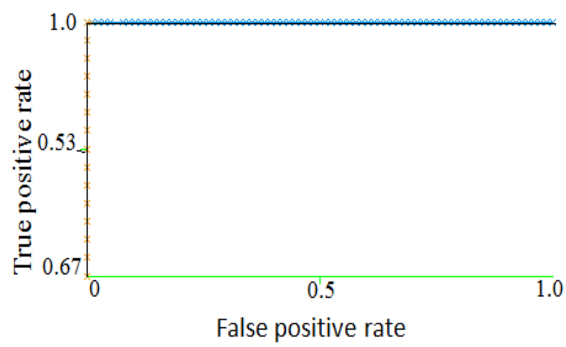

Fig 1(c). ROC curve for the class type haemorrhage.

V. CONCLUSION

The result shows that texture analysis can be efficiently used to detect various types of stroke. It was found that out of ninety-one cases, the model described here could correctly diagnose eighty-six cases. Also the AUCs were 0.973 for the class acute, 0.998 for the class chronic and 1 for the class haemorrhage, which shows that the performance of the discussed model was excellent. Further work can be carried out to segment the lesion area using these results.

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