Computer Aided Diagnosis of Stroke from Brain CT Images

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Abstract— This paper presents an automated method to detect and classify an abnormality into infarct and hemorrhagic or normal in brain CT images. Firstly, the original image is converted into gray scale and noise is removed by median filter. Then skull regions are removed by a morphological function. Image is classified into infarct or hemorrhagic stroke or normal image based on features from gray-level co-occurrence matrix (GLCM), mean, standard deviation and area. The abnormality contained hemisphere is also detected based on these features. The different brain parts are segmented by using modified canny edge detection method. Histogram-based thresholding method is applied to extract region of interest (i.e., abnormality) from the parts of brain. The accuracy of the classification results can be compared with the specialists' decision. The results are segmented images for abnormal region and its abnormal type. Experiments done on real CT images show the efficiency and accuracy of the proposed classification method.

Key words: CT, Hemorrhagic, Infarct, GLCM

I. INTRODUCTION

Medical imaging refers to the techniques and processes used to create images of the human body for various clinical purposes. Medical image analysis and processing has great significance in the field of medicine [1]. Medical imaging issues are so complex owing to high importance of correct diagnosis and treatment of diseases in health care system [2]. The success of medical image diagnosis depends on the quality of segmentation process. Computed Tomography (CT) image is a typical source for classification and detection the correct infected regions of the brain. CT images are widely used in diagnosis of stroke due to wider availability, lower cost and sensitiveness to early stroke [4]. The success of medical image analysis depends heavily on accurate image segmentation algorithms [5].

Stroke is a disease which affects vessels that supply blood to the brain. A stroke occurs when a blood vessel either bursts or there is a blockage of the blood vessel. Due to lack of oxygen, nerve cells in the affected brain area is not able to perform basic functions and cause sudden death. Stroke results in serious long term disability or death. According to the World Health Organization, 15 million people suffer from stroke, of these 5 million die and another 5 million are permanently disabled. Strokes are mainly classified in two categories: 1) Ischemic stroke or infarct (due to lack of blood supply) and 2) Hemorrhagic stroke (due to rupture of blood vessel). Between these, ischemic stroke accounts for about 80 percent of all strokes. However, it is also possible that both these types co-occur. During treatment, differentiation between ischemic and hemorrhagic stroke is of fundamental importance. Computed tomography (CT) and magnetic resonance imaging (MRI) are the two modalities that are regularly used for brain imaging. CT imaging is preferred over MRI due to wider availability, lower cost and sensitiveness to early stoke. In most instances, CT provides information required to make decisions during emergency. In CT images, a hemorrhage appears as a bright region (hyper dense) well contrasted against its surrounds. On the other hand, an ischemic stroke appears as a dark region (hypo dense), with the contrast relative to its surround depending on the time elapsed since the stroke occurred. Sample images are shown in Fig. 1. The contrast starts by being poor in the early stages and improves over time as seen in Fig. 2. This is due to the fact that the density of the infarct region changes with the passage of time until it approaches the density of the cerebro-spinal fluid (CSF). Fig. 2 shows instances of early and late-stage of ischemic stroke.

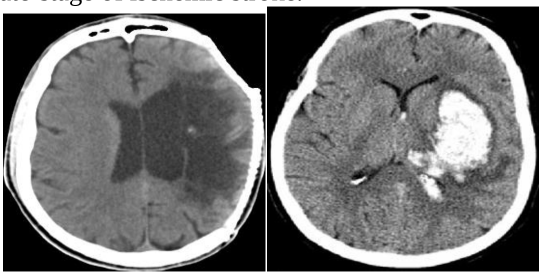

Fig. 1: (a) Ischemic stroke(shown as dark black area) (b) Hemorrhagic stroke(shown as bright white area).

Automatic detection of stroke is thus challenging as the structures vary in contrast with time and shape (see Fig. 3(a)). Complex combinations as shown in Fig. 3(b) can also occur.

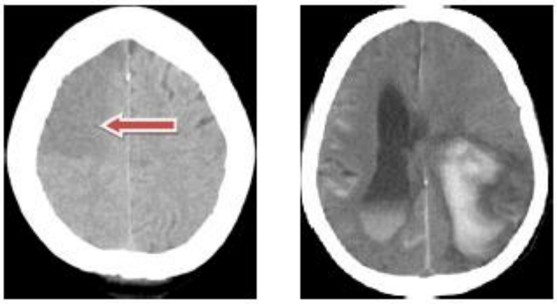

Fig. 2 (a) acute infarct (as pointed by arrow) (b) Hemorrhage (bright region) with infarct like edema (dark region)

In this paper, we present a unified method to detect both types of strokes from a given CT volume data. The novel feature with our approach is that it is able to distinguish between acute, chronic infarcts and hemorrhages, which has not been addressed by any previous work. In the next section, we briefly review the existing work on stroke detection from non-contrast CT data.

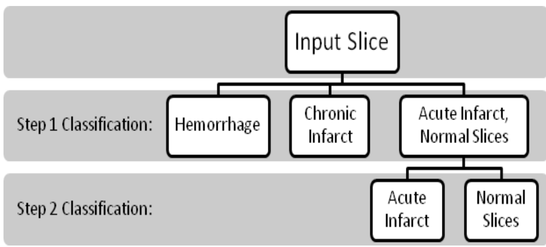

Fig. 3: Classification flowchart.

II. PROPOSED SYSTEM

Medical image are deteriorated by noise due to various source of interferences and it can be false detection of infarct and hemorrhagic region so this noise must be removed before it is used for diagnosis purpose. Firstly, the original CT image is converted into gray scale and noise or film artifacts are removed by using median filter. A median filter is more effective than convolution when the goal is to simultaneously reduce noise and preserve edges. The median is much less sensitive than the mean to extreme values (called *outliers*).And then skull regions that can cause the wrong detection during segmentation stage are removed by a morphological function. Image is classified into infarct or hemorrhagic stroke based on mean, standard deviation and features from GLCM. The disease affected hemisphere is also detected based on these features.

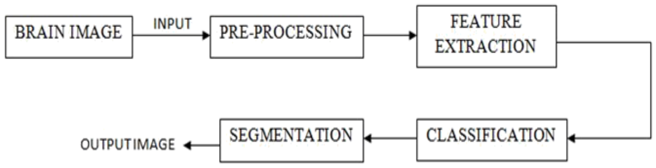

Fig. 4 Proposed System

A. Pre-Processing

Filtering is a nonlinear operation often used in image processing to reduce "salt and pepper" noise. Each output pixel contains the median value in the m-by-n neighbourhood around the corresponding pixel in the input image. The CT brain image consists of film artifacts or label on the CT such as patient name, age and marks. The high intensity value of film artifacts are removed by median filter. And then some extra portions are also cropped.

The steps to perform median filtering are as follows:

1) Assume a 3x3 empty mask.
2) Place the empty mask at the left hand corner.
3) Arrange the 9 pixels in ascending or descending order.
4) Chose the median from these nine values.
5) Place this median at the centre.
6) Move the mask throughout the image.

Thus, in median filtering, the grey level of the centre pixel is replaced by the median value of the neighbourhood. The brain's skull regions that are not required for further processing have similar intensity distribution with hemorrhage region. So it is difficult to remove only skull region from the image. The skull regions can cause the wrong detection during segmentation stage. So the skull portion is removed from an image by a morphological function. It removes from a binary image all connected components (objects) that have fewer than 'P' pixels, producing another binary image.

B. Feature Extraction

A statistical method of examining texture that considers the spatial relationship of pixels is the gray-level co-occurrence matrix (GLCM). Some of the most commonly used texture measures are derived from GLCM. The gray-level co-occurrence matrix can reveal certain properties about the spatial distribution of the gray levels in the texture image. The four texture features derived from the co-occurrence matrix is used as part of developing CAD system for early detection of stroke. The GLCM functions characterize the texture of an image by calculating how often pairs of pixel with specific values and in a specified spatial relationship occur in an image, creating a GLCM, and then extracting statistical measures from this matrix.

FEATURES	EXPLANATION
Mean	The average of pixels contrast in the region
Standard Deviation	Variation from mean
Area	Number of pixels in the region
Contrast	Measures the local variations in the gray-level co-occurrence matrix.
Correlation	Measures how correlated a pixel is to its neighbour over the whole image
Energy	Provides the sum of squared elements in the GLCM.
Homogeneity	Measures the closeness of the distribution of elements in the GLCM to the GLCM diagonal.

Table 1: Features

C. Classification

In classification, the important aspect is to select the best features for the identification of abnormality criteria. Image is classified into infarct or hemorrhage stroke or normal image based on these features. These features are delivered to rule-based systems in If-Then form work on the features. These features are served to classify an image and can detect abnormality contained hemisphere. The classification accuracy depends on the types of features that are used.

Normal human brains present an approximate bilateral symmetry. Firstly, the image is segmented into two hemispheres (left and right hemisphere). For each hemisphere, features are computed and extracted. 'Area' means number of white pixels in each hemisphere. A part of rule-based system for hemorrhage is shown below. 'L' is left hemisphere and 'R' is right hemisphere. Input image will be hemorrhagic stroke and abnormality will be found in right hemisphere if it satisfies the following conditions.

1) Area of R > Area of L
2) Contrast || Correlation of R > Contrast || Correlation of L
3) Standard deviation || Mean of R > Standard deviation || Mean of L

A part of rule-based system for 'Infarct' is shown below. 'L' is left hemisphere and 'R' is right hemisphere. 'Area' means number of gray pixels in whole image. Input image will be classified as infarct stroke and abnormality will be found in right hemisphere if it satisfies the following conditions.

1) Area > 50000
2) Energy || Homogeneity of R < Energy || Homogeneity of L
3) Contrast || Correlation of R < Contrast || Correlation of L

D. Performance Analysis

Total 107 CT-scan gray scale images are used and classified into three classes (hemorrhage, infarct, normal) respectively. Hemorrhagic stroke affected image is 74 images, infarct stroke affected image is 21 images and normal image is 12.

Accuracy = (TP+TN) / Total number of images
= (93+10)/107
= 96.26%

– TP is the number of true positives (pixels of the abnormal area correctly classified);
– TN is the number of true negatives (pixels of the normal area classified as normal).
– FN is the number of false negatives (pixels of the abnormal area misclassified as normal or vice-visa).
– FP is the number of false positives (pixels of the one abnormal type misclassified as other abnormal type);

III. EXPERIMENTAL RESULTS

A set of CT-scan Gray-scale image database was used in this experiment each image size is 512×512 pixels. A group of 107 CT images were used that were categorized into 6 classes.

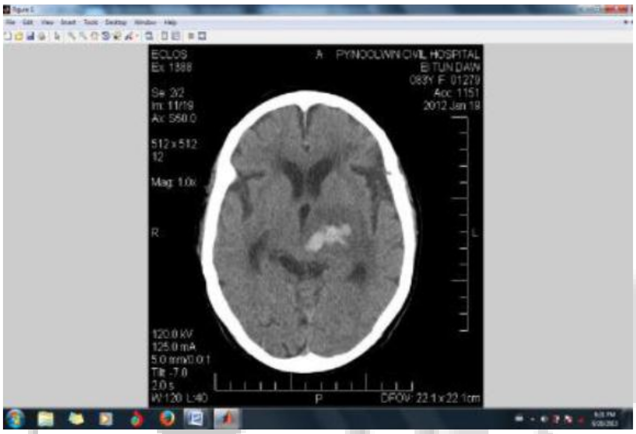

Fig. 5 Original CT image

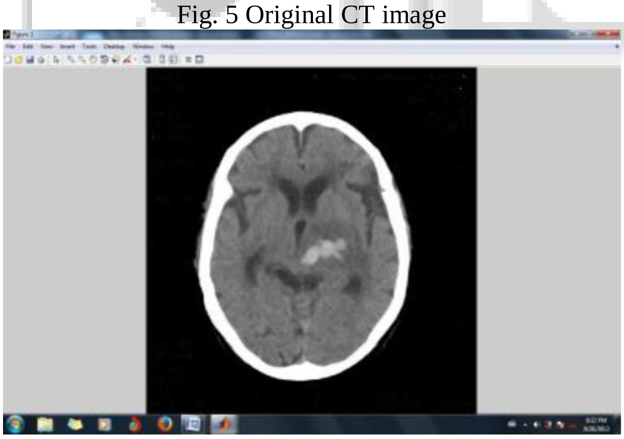

Fig. 6 Image processed by median filter

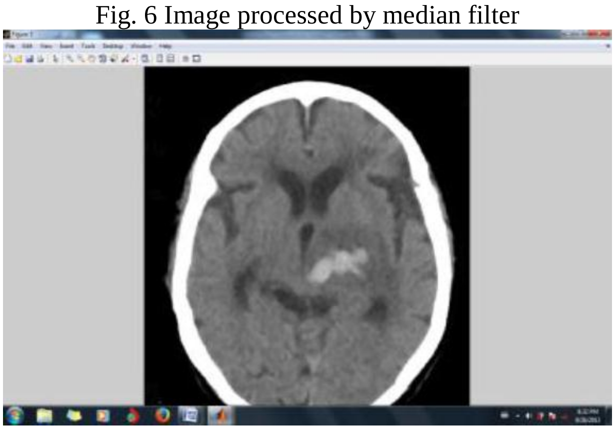

Fig. 7 Image after cropping

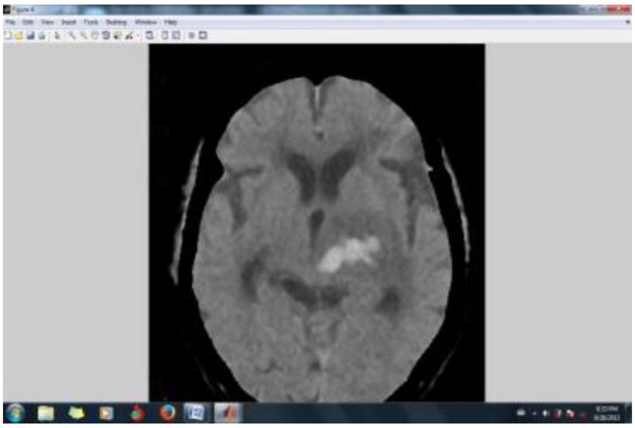

Fig. 8 Image after skull removal

Hemisphere	**Area**	**Contrast**	**Correlation**	**Std**	**Mean**
Left	**10**	0.1056	0.9756	54.73	59.29
Right	833	0.1491	0.9672	55.30	64.95

Table 2: (Extracted Features For Hemorrhage)

Output: The input image classified as hemorrhagic stroke according to rules for the features and abnormality is found in right hemisphere.

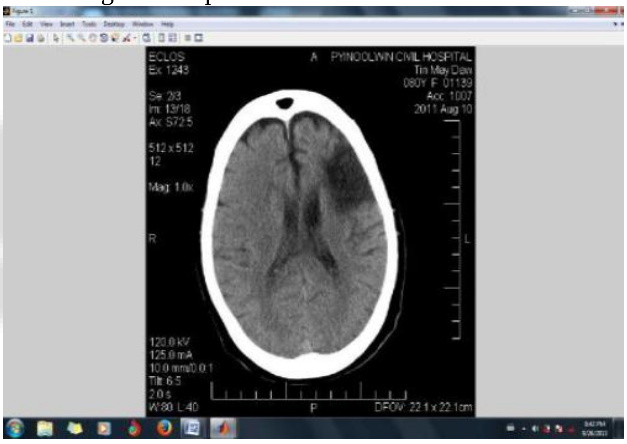

Fig. 9: Original CT image

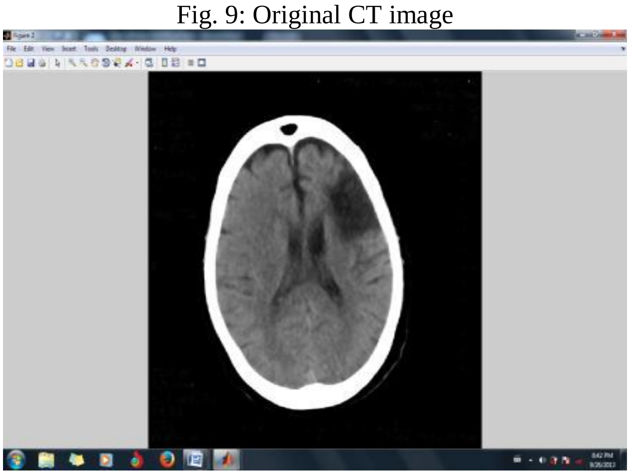

Fig. 10: Image processed by median filtering

Hemisphere	Area	Energy	Homogeneity	Contrast	Correlation
Left	66874	0.3741	0.9796	0.0838	0.9804
Right	66874	0.3272	0.9735	0.1167	0.9698

Table 3: (Extracted Features For Infarct)

Output: The input image classified as hemorrhagic stroke according to rules for the features and abnormality is found in right hemisphere.

IV. EDGE DETECTION AND SEGMENTATION

The parts on which immediate changes in grey tones occur in the images are called edges. Edge detection techniques transform images to edge images benefiting from the changes of grey tones in the images. The most powerful edge-detection method that edge provides is the canny method. For Canny algorithm, the object finds edges by looking for the local maxima of the gradient of the input image. The calculation derives the gradient using a Gaussian filter. The results proposed by canny edge detection method are complicated and is not clear. It is modified by adding two parameters. The different brain parts are detected by modified canny edge detection method and can be found in figure 11. The proposed method gives clearer and better edges of region than the original canny edge detection method.

An image histogram is defined as a plot of the occurrence of each gray level represented in the image. A point on the x-axis is represented by a gray level and the y-axis gives the number of pixels with that specific intensity. The histogram is commonly used in image processing and one application is the so called thresholding technique. Based on the shape of the histogram, i.e. the valleys and peaks, a certain gray scale value can be found and set as a threshold. Among the brain's parts, the region of interest is segmented by thresholding method. The abnormality (hemorrhagic stroke) can be clearly found in figure 12.

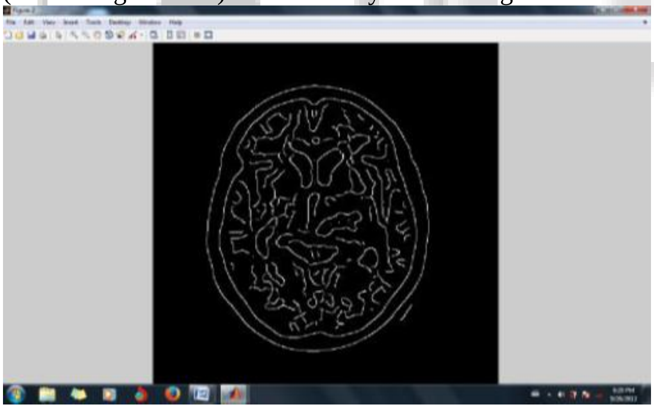

Fig. 11: Image processed by modified canny edge detection

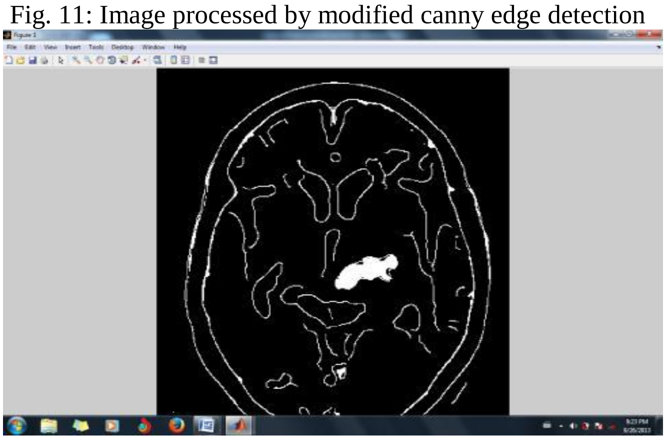

Fig. 12: Image processed by histogram based thresholding

V. CONCLUSIONS

The proposed system is computer aided diagnosis system for classification and detection of abnormalities found in brain CT image. The proposed algorithm for skull removal can completely remove the skull parts in image. The stroke can be correctly classified into infarct or hemorrhagic stroke or normal image with accuracy 96.26%. The proposed system can provide as a learning tool to medical students and trainee radiologists. And the system assists the radiologists in identifying the hemorrhage and infarct in the human brain and to arrive at a decision faster and accurate. Radiologists use the computer output as a second opinion in making the final decisions. This system can be proved to be handy tool for the practitioners especially the physicians who engaged n this field. The system can be extended to detect other brain abnormalities - tumor, abscess and lesion etc. The adaptive algorithms can be applied in other medical images such as lung, liver, and bone to detect their related diseases such as cancer, tuberculosis.

REFERENCES

[1] A. Padma and Dr.R. Sukanesh, "Automatic Diagnosis of Abnormal Tumor Region from Brain Computed Tomography Images Using Wavelet Based Statistical Texture Features",International Journal of Computer Science, Engineering and Information Technology(IJCSEIT), Vol.1, No.3, August 2011.

[2] M. Rastgarpour, J. Shanbehzadeh, IAENG, " Application of AI Techniques in Medical Image Segmentation and Novel Categorization of Available Methods and Tools" , Proceedings of the International MultiConference of Engineers and Computer Scientists, Volume 2011, IMECS 2011, March 16-18, Hong Kong, 2011.

[3] A.Padma & Dr.R.Sukanesh, "A Wavelet Based Automatic Segmentation of Brain Tumor in CT Images Using Optimal Statistical texture Features", International Journal of Image Processing (IJIP), Volume (5): Issue (5): 2011.

[4] Mayank Chawla, Saurabh Sharma, Jayanthi Sivaswamy, Kishore L.T, "A method for automatic detection and classification of stroke from brain CT images".

[5] M. M. Abdelsamea," Unsupervised Parallel Extraction based Texture for Efficient Image Representation" Mathematics Department, Faculty of Science, Assiut University, Assiut, Egypt.

[6] T Kesavamurthy, S SubhaRani, "Pattern Classification using imaging techniques for Infarct and Hemorrhage Identification in the Human Brain", Calicut Medical Journal 2006; 4(3):e1..

[7] Krishna Kant Singh1 , Akansha Singh," A Study Of Image Segmentation Algorithms For Different Types Of Images", IJCSI International Journal of Computer Science Issues, Vol. 7, Issue 5,September 2010

[8] T Kesavamurthy, Subha Rani and N Malmurugan, "EARLY DIAGNOSIS OF ACUTE BRAIN INFARCT USING GABOR FILTER TECHNIQUE FOR COMPUTED TOMOGRAPHY IMAGES", Biomedical Soft Computing and Human Sciences, Vol.14, No.1, pp.11-16 (2009).

[9] J.Jaya, K.Thanushkodi ,M.Karnan, **"**Tracking Algorithm for De-Noising of MR Brain Images", IJCSNS International Journal of Computer Science and Network Security, VOL.9 No.11, November 2009

[10] Dina Aboul Dahab, Samy S. A. Ghoniemy, Gamal M. Selim, "Automated Brain Tumor Detection and IdentificationUsing Image Processing and Probabilistic Neural Network Techniques", International Journal of Image Processing and Visual Communication ISSN 2319-1724: Volume (Online) 1, Issue 2, October 2012.

