

Diagnosis & Classification of Brain Hemorrhage

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Abstract: Brain Hemorrhage is a type of stroke which is caused due to bursting of the artery in the brain and thus causing bleeding in the surrounding tissues. In this system, CT images of brains are used to identify the type of hemorrhages. The images are first preprocessed, performed morphological operations and then segmented using watershed algorithm. This extracted image is given as input to artificial neural network for classification. It also gives information on the hemorrhage area and the hemorrhage percentage.

Keywords: CT, MRI, Intracerebral Hemorrhage, Subdural Hemorrhage, Extradural Hemorrhage, Subarachnoid hemorrhage, ROC, GA, Watershed Algorithm, ANN, GLCM

1. Introduction

Brain Hemorrhage is a type of stroke, which occurs due to the bleeding in or around the brain tissues as a result of ruptured artery. Due to an accident, trauma may affect the brain tissues thus causing swelling which may lead to edema pooled blood from surrounding tissues. This will accumulate to form a mass known as hematoma in brain. The symptoms of brain hemorrhage vary depending on the amount of tissue affected, location of the bleeding & the severity of the bleeding. Medical experts usually advice Computed Tomography (CT) scan than a Magnetic Resonance Imaging (MRI) scan for checking internal bleeding or blood accumulation. A CT scanner transmits X-ray beams in an arc thus taking many pictures. This allows sensing of different levels of density and tissues inside a solid organ, and can provide detailed information about the body. Thus bleeding in the brain, especially from an injury, can be seen well on a CT scan than on a MRI scan. In this proposed system, CT images are used. These image after being pre-processed, are made to undergo certain morphological operations. Morphological image processing is a collection of non-linear operations related to the shape or morphology of features in an image. This technique probes an image with a small shape or template called as structuring element. The structuring element is positioned at all possible locations in the image and it is compared with the corresponding neighbor of pixels. Dilation and erosion are the two operators used here. In dilation, if the origin of the structuring element coincides with the 'black' pixel in the image, all pixels are made black, from the image covered by the structuring element. Similarly in erosion, the pixels are turned to 'white'. After this, the image is segmented using Watershed Algorithm. Image segmentation is a process of partitioning the image into non-intersecting regions, so that each region is homogeneous. Exact location of required objects and boundaries in images can be found through image segmentation. In Watershed Algorithm, we consider the image as a topographic relief, where the height of each point is directly related to its gray level, thus the watershed lines separates the catchments basins that are formed. The watershed transform is computed on the gradient of the original image, so that the catchment basin boundaries are located at high gradient points. The classifier used in this process is an Artificial Neural Network (ANN). It is a

computational model based on structure and function of animals nervous system in particular brain which is capable of machine learning and pattern recognition. ANNs are presented as system of interconnected neurons which exchange between each other. The neuron has two modes of operations: The training/learning mode and the using/testing mode. In a feed forward neural network, information flows in one direction along connecting pathways, from the input layer via the hidden layers to the final output layer.

2. Types of Hemorrhage

As per bleeding in the brain, it can be divided into four types:

A. Intracerebral Hemorrhage (ICH)

A stroke occurs when the brain is deprived of oxygen due to an interruption of its blood supply. The location of ICH can be close to the surface or in deep areas of the brain. It is a type of stroke caused by bleeding within the brain tissue itself.

B. Subdural hemorrhage (SDH)

It is the collection of blood accumulating in the potential space between the dura and arachnoid mater of the meninges around the brain. The meninges are the connective tissue membranes that line the skull and vertebral canal. It encloses the brain and the spinal cord.

C. Extradural Hemorrhage (EDH)

It is the bleeding between the inside of the skull and the outer covering of the brain called as "dura". It is often caused by a skull fracture during childhood or adolescence. An extradural hemorrhage occurs when there is a rupture of a blood vessel, usually an artery, which then bleeds into the space between the "dura mater" and the skull.

D. Subarachnoid hemorrhage (SAH)

It is a life-threatening type of stroke caused by bleeding in the space surrounding the brain. A stroke is caused when the brain is deprived of oxygen because of an interruption of its blood supply. Subarachnoid hemorrhage is caused by ruptured aneurysm.

In the proposed system, the first two type of hemorrhages

i.e., Intracerebral Hemorrhage (ICH) and Subdural Hemorrhage (SDH) are processed and classified.

3. Literature Survey

R. Ganesan and S. Radhakrishnan (2009) has proposed segmentation of CT brain image using Genetic Algorithm (GA) to segment the image. It has been evaluated using receiving operating characteristics (ROC) curve analysis. Liu et al. has presented an automated detection of CT scan slices which contain hemorrhages. The detection method consists of two parts. The first part splits the scan slices into encephalic region and nasal cavity region. The second part focuses on encephalic region and detects abnormal slices. Both parts use Wavelet and Haralick texture model. Rajesh A. Rajwade uses image enhancement tools and medical filtering to diagnose brain hemorrhages along with geometrical and textural features, which is used as input to neural network and support vector machine. C. Amutha Devi and Dr. S. P. Rajagopalan proposed a method for classifying the brain MRI images into stroke and non-stroke images. In this method features are extracted from MRI images of brain using watershed segmentation and Gabor filter. Alyaa Hussein Ali et al. (2015) recently proposed the detection and segmentation of hemorrhage stroke from brain CT images using textural analysis. In study, the thresholding segmentation process is used to extract stroke region from CT image of brain. The median filter was used to remove noise from image and the statistical feature calculated using first order histogram. The first order histogram represents estimation of probability distribution function (PDF) for selected neighbourhood. The results as mean value represents white color in image. The higher mean gives indication that there is an abnormal part in brain. Mayank Chawla et al. (2009) presented an automated method to detect and classify an abnormality into acute and chronic infarct, and hemorrhage at the slice level of non-contrast CT images. The method consists of three main steps: image enhancement, detection of mid-line symmetry and classification of abnormal slices.

4. Proposed Methodology

In this system, the CT image of the brain undergoes certain preprocessing operations. In these operations, the image is converted into gray scale image, it is re-sized and the edges are detected. This preprocessed image is then made to undergo some morphological operations such that the texture of the image becomes smoother, the small holes are eliminated and gaps filled such that it helps in the next step of segmenting the image. Watershed algorithm helps to classify distinct regions in the system using watershed lines. This segmented image is given as an input to Grey Level Co-occurrence Matrix (GLCM) wherein different features are extracted. These features are given as input to the classifier i.e., ANN. Using the training phase, the superimposed images are compared to the original image, such that the type of hemorrhage is detected and the error calculated.

5. Flowchart

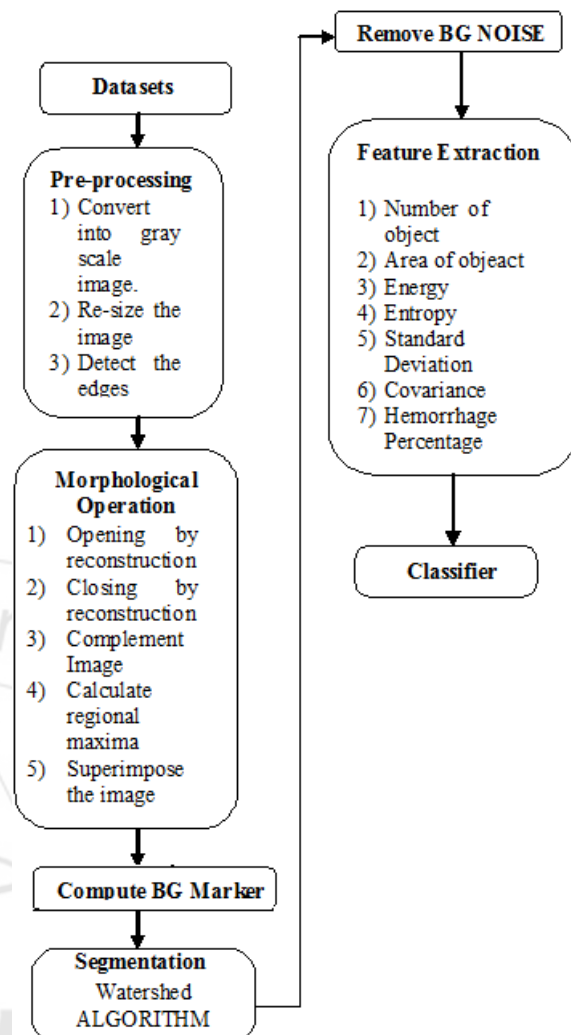


Figure 1: Flowchart of the proposed system

A. Datasets

The dataset consists of 35 CT images of human brain. These images include 12 images of ICH, 9 of SDH and 14 normal images. CT images are used for diagnosis of brain hemorrhages. It will be able to image bone, soft tissues and blood vessels all at the same time. CT images are read first. Then brain CT image is converted into jpeg. This image will be uploaded to the system for pre-processing.

B. Pre-processing

Pre-processing improves the quality of an image. In this system, preprocessing techniques are developed to remove the skull portion surrounding the tissues.

1) Conversion of Image

The CT image is converted into gray scale image to make it contrast. The contrast images gives the exact information about tissues.

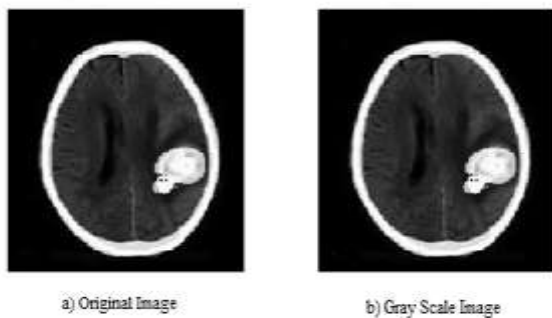


Figure 2: a) Original Image b) Original Image converted into gray scale image

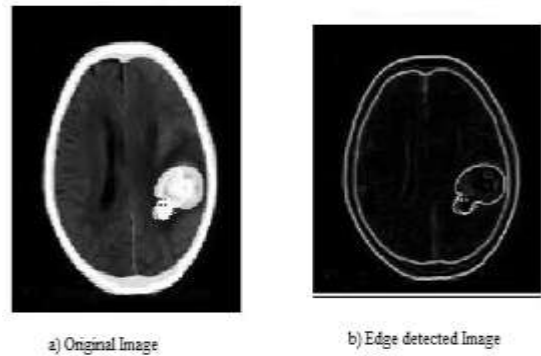


Figure 4: a) Original Image b) Edges of the image is Detected

2) Re-sizing

Resizing is an important step in image preprocessing. It is required for various purposes such as display, storage and transmission of images. While displaying an image, the resolution of the display device imposes constraints on the maximum size of the display screen. The acquired image is resized according to the requirement of the system. Resizing is changing the dimensions of an image. It is done so as it fits on the system user interface. The converted gray scale image is resized to 256 pixels by 256 pixels size.

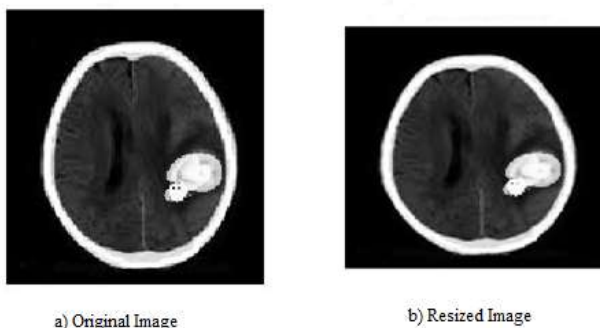


Fig. 3: a) Original Image b) Image resized as 256x256pixels

3) Edge Detection

Edge detection refers to the process of identifying and locating sharp discontinuities in an image. The discontinuities are abrupt changes in pixel intensity which characterizes boundaries of objects in a scene. Edges themselves are boundaries of object surfaces which often leads to oriented, localized changes in intensity in an image. In this work Sobel operator is used for edge detection. The Sobel operator is based on convolving the image with a small, separable, and integer valued filter in horizontal and vertical direction and is therefore relatively inexpensive in terms of computations. Mathematically, the operator uses two 3×3 kernels which are convolved with the original image to calculate approximations of the derivatives - one for horizontal changes, and one for vertical.

D. Morphological operation

Dilation and erosion operators are further used in complex sequences of opening and closing.

- Opening consists of an erosion followed by a dilation and can be used to eliminate all pixels in regions that are too small to contain the structuring element.

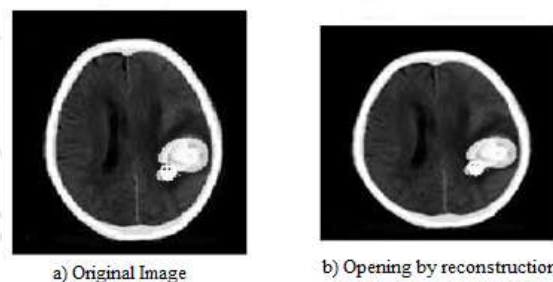


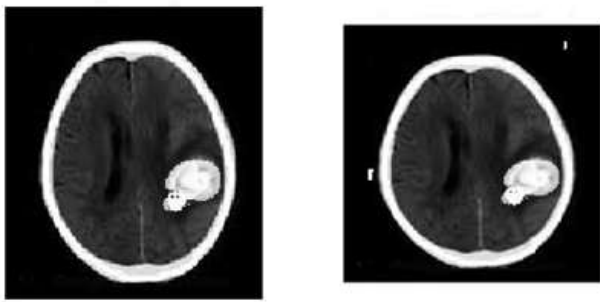
Figure 5: a) Original Image b) Opening by reconstruction – Morphological Operation

- The Closing operation fuses narrow breaks, also eliminates small holes and fills gaps in the contours.

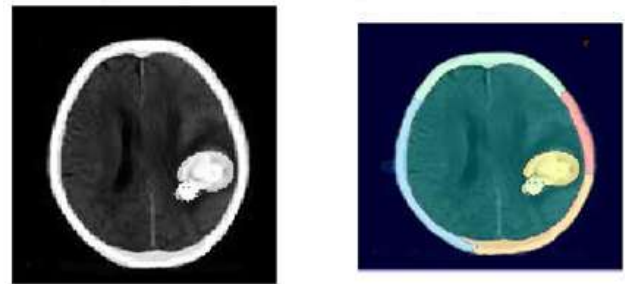


Figure 6: a) Original Image b) Closing by reconstruction - Morphological Operation

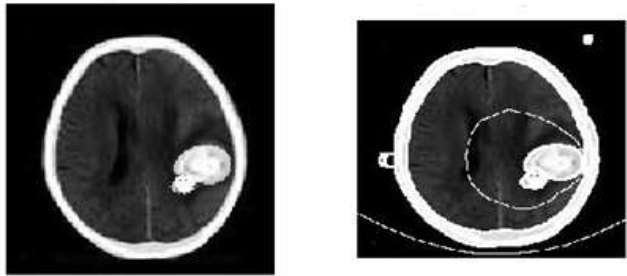
After opening and closing reconstruction operation, we are taken the complement of gray scale image to calculate the regional maxima. Calculating the regional maxima of these reconstructed images is done to get smooth edge foreground objects. Later, we superimposed these markers on the original images.



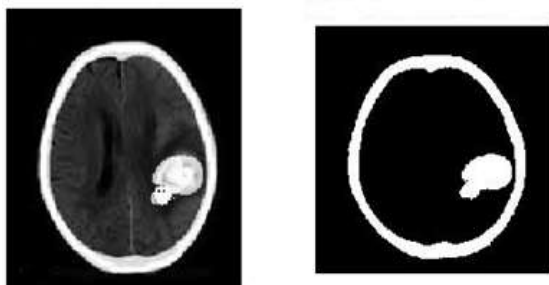
a) Original Image b) Regional Maxima Image
Figure 7: a) Original Image b) Regional Maxima of the image



a) Original Image b) Segmented Image
Figure 9: a) Original Image b) Segmented Image



a) Original Image b) Superimposed on original image
Figure 8: a) Original Image b) Superimposed the previous image



a) Original Image b) Opening-closing by reconstruction
Figure 9: a) Original Image b) Opening-Closing by reconstruction- Morphological Operation

F. Feature Extraction

After segmentation of the image, we extract certain features of the image and input it further to a classifier. The main aim of the feature extraction is to reduce the original datasets by measuring certain features. The classifier used is a GLCM (Grey Level Co-occurrence Matrix). 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, thus creating a GLCM, and then extracting statistical measures from this matrix. A GLCM is a matrix where the number of rows and columns is equal to the number of gray levels, G, in the image.


The following parameters are extracted from the image:

- 1) Number of Objects: It shows the type of hemorrhage. If N is equals to three or more than three, then the type of hemorrhage is ICH. If N is equals to two, then the type of hemorrhage is SDH. If N is equals to one, then it shows the normal brain image.
- 2) Area of Objects: It shows the intensity of bleeding.
- 3) Energy: Measure of energy content in the image.
- 4) Entropy: Entropy is a statistical measure of randomness that can be used to characterize the texture of the input image
- 5) Covariance
- 6) Standard Deviation
- 7) Hemorrhage Percentage: $[(\text{object area}) / (256 * 256)] * 100$

E. Segmentation

Watershed transforms works for images even with low contrast. Thus it helps in separating out the distinct regions.

Table 1: Feature Extraction Parameters

Original Image	GLCM FEATURES						
	No. of Object	Area of object	Energy	Entropy	Std Dev.	Covariance	Hemorrhage %
	3	1817	0.73726	0.59805	0.48404	0.1144	2.7725

G. Classifier

In the training phase of the Artificial Neural Network, 6 input images taken from a given location to extract input features and the known output will be found by naming the images from the type of hemorrhage. Then the net file can be generated using a train tool for the first time after going


through few testing iterations by providing the saved input and output files. Once the input features are calculated and the vector is created, to add the image to train, the output will be defined according to the value that has been received as the output result. Once the input and output files are

saved, system can be trained with them. This logic can be used to train the tested images as well.

6. Results

Thus by using neural network, we can classify the hemorrhages as ICH, SDH or a normal brain image.

Table 2: Output of the Classifier

Original image	Detection		
	Type	Neural Network Output	Error
	ICH	3	0.47838

During training, features are extracted from images. After training is completed, the trained networks are stored to be used in algorithm. Whenever an image is taken as input in the algorithm, it is simulated with trained network and goes for testing the data. All the images are tested by the proposed system.

7. Conclusion

Detecting the type of hemorrhage is a very crucial step in the medical treatment to save life of the patient. Automatic detection of hemorrhage is a very complex task. The segmentation of the images using watershed algorithm smoothens the image. Before application of the watershed algorithm, morphological operations are performed to compute the foreground and background markers. The use of feed-forward network with back propagation has helped in reducing error at the output, thus detecting the hemorrhage efficiently. Even non technical users will find this concept useful since this system is implemented using GUI, thus making the system more easy to operate. This work is better from previous because by using proposed method user can easily classify the type of hemorrhage, its percentage as well as get information on the hemorrhage area, texture and bleeding in the hemorrhage. Thus as per result, it is clear that proposed method is best suitable for ICH and SDH types of hemorrhages.

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