Smart Brain Hemorrhage Diagnosis Using Artificial Neural Networks

Santosh H. Suryawanshi, K. T. Jadhao

Abstract: The fundamental motivation behind this study is to identify the brain hemorrhage and to give accurate treatment so that death rate because of brain hemorrhage can be reduced. This project investigates the possibility of diagnosing brain hemorrhage using an image segmentation of CT scan images using watershed method and feeding of the appropriate inputs extracted from the brain CT image to an artificial neural network for classification. The output generated as the type of brain hemorrhages, can be used to verify expert diagnosis and also as learning tool for trainee radiologists to minimize errors in current methods.

Index Terms: Medical Image Processing, Neural network, Watershed, Brain Hemorrhage Diagnosis, Computerized Tomography [CT], Magnetic Resonance Imaging [MRI], TBI (Traumatic Brain Injury)

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1. INTRODUCTION

A Brain hemorrhage is a type of a stroke which is caused by an artery in the brain bursting and causing bleeding in the surrounded tissues. This bleeding kills brain cells. The known factors of cause of brain hemorrhages are Smoking, High blood pressure, alcohol usage etc., while heredity is also a major factor in causing brain hemorrhage.

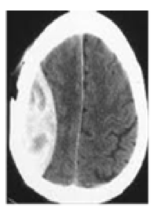
There are four types of hemorrhage, named according to where the bleeding occurs.
These are:

a) Subdural haemorrhage
b) Extradural haemorrhage
c) Subarachnoid haemorrhage
d) Intracerebral haemorrhage

1.1 Some images of Brain Hemorrhages are shown

Normal CT Image

Intercerebral Hemorrhage CT Image



Subdural Hemorrhage CT Image

Subdural and extradural hemorrhages are the most common type after TBI (traumatic Brain Injury), and they are a cause of further brain damage that can lead to more long-term effects. When the brain bleeds it is referred to as an intracerebral hemorrhage or brain hemorrhage. However according to medical specialist's early diagnosis of the condition and obtaining immediate and relevant treatment can be a lifesaver for acted patients. The main techniques and tools which help in diagnosing of this disease is the human brain Computed Tomography [CT] image obtained from the CT scan and an expert such as an experienced doctor who will be able to extract the important symptoms of the disease from the image by naked eye.

2. CURRENT METHODS

Even though a lot of research on medical image processing has been done, we believe that, still there is room for further research in the area of brain hemorrhage due to the low accuracy level in the current methods and algorithms given above, coding complexity of the developed approaches such as simulated annealing algorithms, impracticability in to the real environment when calculations are being done according to the genetic biological values and lack of other enhancements which may make the system more interactive and useful. Additionally most of the approaches have been taken in diagnosing a few limited types of brain hemorrhages such as Intracerebral Hemorrhage. Hence doctors go for manual system for detection of hemorrhage.

3. MANUAL SYSTEMS

Computerized Tomography [CT] or Computerized Axial Tomography [CAT] will be used to obtain the CT images. This is based on a combination of X-rays as they can be passed through the different parts of a patient's body. Varying amount of X-rays will be passed through and exit the body depending on the amount that can be absorbed in a particular tissue such as a muscle or lung. During conventional X-ray imaging, the existing X-ray will interact with a detecting device, which contains X-ray image or other image receptors to provide a two dimensional image of the required part of the patient's body. CT image will use a rotating X-ray device and detectors to make a slice. Magnetic resonance imaging [MRI] is based upon signals resulting from water molecules, which contains between 70% and 80% of the average human brain. There are two types of MRI scanners.

1) Anatomical which is fast to acquire, with excellent structural detail e.g. white and grey matter,
2) Pathological which is slower to acquire, therefore usually

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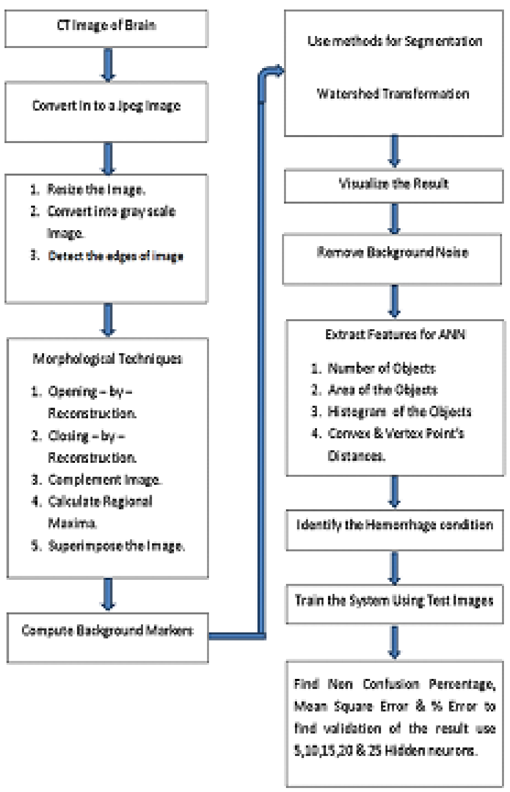
lower resolution than Anatomical.

4. CT IMAGE AND MRI

Comparing both CT and MRI images, MRI is the most frequently used method for brain imaging and related research. At the same time bones can be well segmented in CT data using simple thresholding techniques because of the contrast between the bones and the surrounded tissues. In contrast, soft tissues are not well recognized in CT images and thresholding is inadequate. Similarly there are alternate reasons for using CT scan regarding the following: Patients who are too large for the MRI scanner may have to go through the CT scanner. Claustrophobic patients and those with metallic or electrical implants may have issues in going through MRI scan.

Patients who are unable to remain motionless for the duration of examination due to age, pain or medical conditions will also have to go through CT scans excluding MRI scans.

5. PROPOSED METHOD FLOWCHART



6. PROPOSED METHOD

The overall design of this system consists of six major modules.

- Once the brain CT soft image is converted in to a jpeg, the image will be uploaded to the system.
- Then in the next module, image will be pre-processed in order to get a clear image to be processed in the segmentation module.
- The image segmentation module will isolate the objects in the brain image, in order to extract features of each object in the next module.
- Set of image processing activities will be carried out to super impose the image with the required features.
- Then the unnecessary noise and objects will be removed if it is needed and will mark the objects that will be used to extract features.
- The features will be extracted to feed the neural network as an input to train or recognize the type of the hemorrhage.
- Finally the type of the hemorrhage will be identified according to the trained neural network which is being created in the training phase of the system.
- Once the network is created, saved network can be used for training of the next images once the input features are extracted and output result is generated using the previously created network file.
- If the user is satisfied with the result, user will be able to add the test image to train the system to gain better output the next time.
- A new network file will be created once a successful training is done.
- According to the results generated in the plot, user will be able to decide whether the training percentage is better or to try out once again just by training the system with the same input and output features.

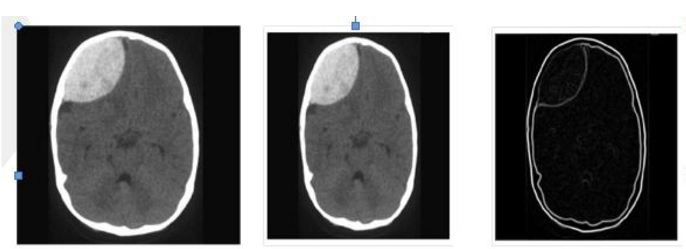
6.1 Image is pre-processed by performing the Following steps:

- Resizing the image is done so it fits on the system user interface.
- Convert in to grey-scale image to make it contrast.
- Detect edges of the image

6.2 Edge Detection

- Gaussian edge detectors are symmetric along the edge, and reduce the noise by smoothing the image.
- Canny algorithm is an optimal edge detection method based on a specific mathematical model for edges.
- The edge model is a step edge corrupted by Gaussian noise.
- The Canny edge detector was devised to be an optimal edge detector, which minimize the situations of detecting false edges and missing actual edges, minimize the distance between the detected edges and actual edges and minimize multiple responses to an actual edge, i.e. to ensure there is only one response for an actual edge point.

6.3 Images for Preprocessing and Edge Detection is shown



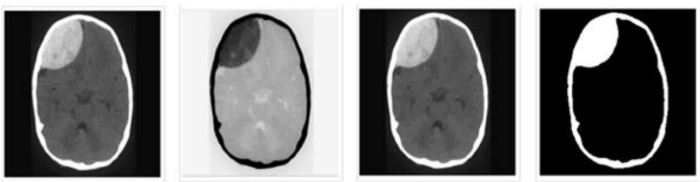
Original RGB Image   Grey-Scale Image   Edge-Detected Image

6.4 Morphological Operations

- Morphological Techniques:
  - Opening- by-reconstruction

- Closing- by-reconstruction
- Complement image
- Calculate regional maxima
- Superimpose the image
- Compute Background Markers
- Watershed Transformation and the Segmentation
- Visualize the Result
- Remove Background Noise

6.5 Images for Morphological Operations is shown



Reconstructed Image followed by Opening | Reconstructed Image followed by Closing | Negative of Reconstructed Image | Negative of Image after using Thresholding

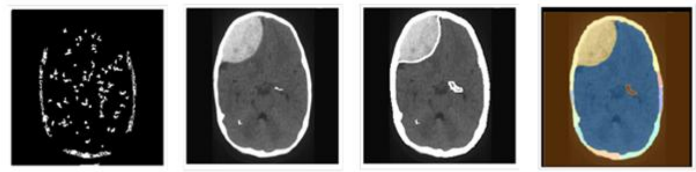
6.6 Watershed Segmentation Algorithm

- The main goal of watershed segmentation algorithm is to find the "watershed line "in an image in order to separate the distinct regions.
- To imagine the pixel values of an image is a 3D topographic chart, where x and y denote the coordinate of plane, and z denotes the pixel value.
- The algorithm starts to pour water in the topographic chart from the lowest basin to the highest peak.

6.7 Markers & Watershed lines

- For resolving the over-segmentation problem in the watershed algorithm, an approach based on the concept of marker is described in.
- A marker is a connected component belonging to an image.
- The markers include the internal markers, associated with objects of interest, and the external markers, associated with the back-ground.
- The marker selection typically consists of two steps:
  - Pre-processing and definition of a set of criteria that markers must satisfy. The pre-processing scheme is to filter an image with a smoothing filter. This step can minimize the effect of small spatial detail, in other words, this step is to reduce the large number of potential minima (irrelevant detail), which is the reason of over-segmentation. The definition of an internal marker is a region that is surrounded by points of higher "altitude". The points in the region form a connected component. All the points in the connected component have the same intensity value.
  - After the image is smoothed, the internal markers can be defined by these definitions, shown as light grey, blob like regions.
- Consequently, the watershed algorithm is applied to the smoothed image, under the restriction that these internal markers be the only allowed regional minima. The watershed lines, defined as the external markers.
- The points of the watershed line are along the highest points between neighbouring markers.
- The external markers effectively segment the image into several regions with each region composed by a single internal marker and part of the background.
- Then the goal is to reduce each of these regions into two: A single object and its background.
- The segmentation techniques discussed earlier can be applied to each individual region.
- The segmentation result of applying the watershed algorithm to each individual region.

6.8 Segmentation and Background marker



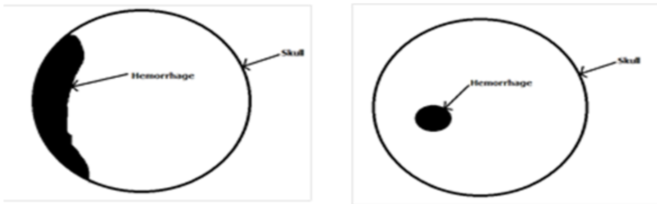
Region Maxima | Modified Region Maxima | Segmented Image Using Watershed Algorithm | Colour filled Segmented Image Using Watershed Algorithm

6.9 Extract Features for ANN

- E.g., If an ICH hemorrhage brain CT Image is given as depicted in figure above
  - Objects = Separated Hemorrhage and Skull
  - Number of Objects = 2
- E.g., If an SDH hemorrhage brain CT Image is given as depicted in figure above,
  - Objects = Skull with the attached hemorrhage
  - Number of Objects = 1
- Therefore the extracted data will be categorized as depicted in table to feed the neural network.

Hemorrhage Conditions	Logic	Output Feature Set
Normal	Objects = 1 Area < Hemorrhage Area	[0;0;1]
ICH	Object = 2	[0; 1; 0]
SDH	Object = 1 Area > Normal Area	[1; 0; 0]
Wrong Image	Objects = 0 OR > 2 & too many colours	Error message

- The following information will be extracted:
  - Number of Objects.
  - Area of the Number Of Objects
- Figure next shows the areas extracted from the CT Image as well as number of regions in it for ICH and SDH.



Design of SDH Hemorrhage

Design of ICH Hemorrhage

Extracted Features of Hemorrhage

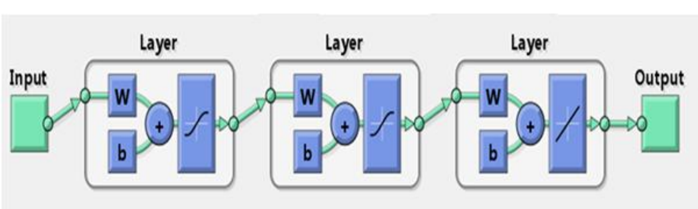
6.10 Extract Features for ANN

- No. of Objects
- Area of Object
- Energy
- Entropy
- Standard Deviation
- Covariance
- Hemorrhage Percentage
- Background Area

6.11 Train and Test the System

- In the first training, set of input images will be taken from a given location to extract input features and the known output will be found by naming the images from the type of the 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.
- Number of hidden neurons, percentage of the training, test and validation images will be defined before the training after a successful testing.
- Since the neural network starts with random initial weights, the results will differ slightly every time it is run.
- The random seed is set to avoid this randomness using rand method.
- 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 then be used to train the tested images as well.

7. Design of the Neural Network



8. Performance Results

8.1 Results of Different Hidden Layers ANN using various Test Images

No .of Neurons	True Output	False Output	True %	False %
5	8	4	66.67 %	33.33 %
10	8	4	66.67 %	33.33 %
20	9	3	75.00 %	25.00 %
25	9	3	75.00 %	25.00 %

8.2 Results of Different Hidden Layers ANN using various Validating Images

No .of Neurons	True Output	False Output	True %	False %
5	7	8	46.67 %	53.33 %
10	7	8	46.67 %	53.33 %
20	6	9	40.00 %	60.00 %
25`	12	3	80.00 %	20.00 %

8.3 Evaluation Results

Parameters	Numbers of Hidden Layer Neurons			
	5	15	20	25
True Positive (TP)	10	11	11	16
False Positive (FP)	4	5	1	2
True Negative(TN)	5	4	4	6
False Negative (FN)	3	5	5	2
Sensitivity (SE)	76.92 %	68.75 %	68.75 %	88.89 %
Specificity (SP)	33.33 %	26.67 %	26.67 %	27.27 %
Accuracy (AC)	68.18 %	60.00 %	71.43 %	84.62 %
Mathew's Corr. Coeff. (MCC)	49.90	43.83	43.95	95.97

9. Conclusion

- Automatic detection of hemorrhage is a very complex task.

- The segmentation and the quantification of region are based on the watershed algorithm based segmentation procedure.
- After making the use of watershed algorithm it was found that boundaries of each region are continuous, but problem of over segmentation was faced as well as the process was little bit time consuming.
- For resolving the over-segmentation problem in the watershed algorithm, an approach based on the concept of marker is used.
- A marker is a connected component belonging to an image.
- The use of feed-forward network using with back propagation has reduced the error at the output and which enable to detect the hemorrhage effectively.
- Different neural networks were created with various number of hidden layer neurons.
- Out of which output of network with 25 hidden neurons was found very satisfactory because in the process of testing the percentage of true detection was 80 % and while validating it was found to be 75 %.
- As well as the other parameters like Sensitivity, Specificity, Accuracy & MCC we can conclude that the system with 25 hidden neurons is giving better accuracy (84.62%), better sensitivity (88.89%) and MCC gives the quality of classification which is 95.97 in case of system with 25 hidden layer neurons.
- Specificity i.e. proportion of negatives which are correctly identified is highest in system with 5 neurons (33.33 %) and in 25 neuron system it is moderate (27.27 %). from above we can conclude that the system with 25 neurons is better among all.
- The proposed system could be taken in to the next level by implementing identification for EDH and SAH.

10. REFERENCES

[1] Mohr et al. Hemorrhagic Stroke The Dana Guide. The Dana Foundation. 2007 March. Available: http://www.dana.org/news/brainhealth/detail.aspx?id=9824 . [Accessed 10 November 12].

[2] U. Balasooriya and M. U. S. Perera, “Intelligent Brain Hemorrhage Diagnosis Using Artificial Neural Networks”, IEEE Business, Engineering and Industrial Applications Colloquium (BEIAC), 2012.

[3] Ran Li, “Medical Image Segmentation Based on Watershed Transformation and Rough Sets”, 4 th International Conference on Bioinformatics and Biomedical Engineering (ICBBE), ISSN=2151-7614, ICBBE-5518119,1-5,ICBBE-2010

[4] P. Rahardjo, “The Implementation of Feed forward Back propagation Algorithm for Digit Handwritten Recognition in a Xilinx Spartan-3”, Journal EECCIS, Volume - 4, Issue No. 2, December 2012.

[5] S. Loncaric and Z. Majcenica, “Multiresolution Simulated Annealing for Brain Image Analysis”, Medical Imaging 1999: Image Processing, 3661, p1139-1146, 1997.

[6] Liu et al., “Hemorrhage Slices Detection in Brain CT Images. In Pattern Recognition”, ICPR 2008. 19th International Conference on, Tampa, FL, IEEE. 1-4, 2009.

[7] Z. Majcenic and S. Loncaric, “Quantitative intracerebral brain hemorrhage analysis”, 1997.

[8] R. Maini and Dr. H. Aggarwal, “Study and Comparison of Various Image Edge Detection Techniques”, International Journal of Image Processing, Volume-3, Issue-1.

[9] L. Rastislav and K. N. Plataniotis, “Color Image Processing: Methods and Applications”, CRC Press, ISBN 10:0-8493-9774-X

[10] A. Khare and M. Saxena and S. Tiwari, “Edge Detection Method for Image Segmentation A Survey of Soft Computing Approaches”, International Journal of Soft Computing and Engineering (IJSCE) ISSN: 2231-2307, Volume-1, Issue-4, 174-178, 2011.

[11] M. Kaur and G. Jindal, “Medical Image Segmentation using Marker Controlled Watershed Transformation”, International Journal of Computer Science and Technology, ISSN: 0976-8491 (On line) ISSN: 2229-4333 (Print), Volume-2, Issue-4, 548-551, d011.

[12] B. Krose and P. van der smagt, “An introduction to Neural Networks”, English Edition, November 1996.

[13] Matlab. [2009], Matlab Help

[14] S. Wadhwani, A. Wadhawani and M. Saraswat, “Classification of Breast Cancer Detection Using Artificial Neural Network”, Current Research in Engineering, Science and Technology(CREST) Journals, ISSN 2320-706X, Vol 3, Issue 03, pg. 85-91, May 2013.