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AN EXPERT DIAGNOSIS OF BRAIN HEMORRHAGE USING ARTIFICIAL NEURAL NETWORKS

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ABSTRACT

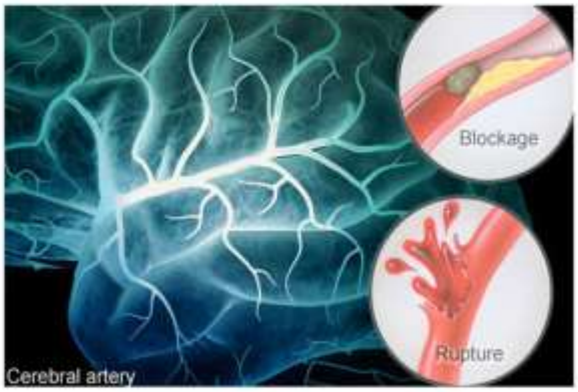
The fundamental motivation behind this study is to identify the brain hemorrhage and to give accurate treatment so that a human life can be saved due to brain hemorrhage. Brain hemorrhage is a type of stroke which is caused by an artery in the brain bursting and causing bleeding in the surrounded tissues. Diagnosing brain hemorrhage, which is mainly through the examination of a CT scan, enables the accurate prediction of disease. This project investigates the diagnosing brain hemorrhage more accurately 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.

KEYWORDS: - Artificial Neural Networks [ANN], Medical Image Processing, Brain Hemorrhage Diagnosis, Computerized Tomography [CT], Magnetic Resonance Imaging [MRI]

INTRODUCTION

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. Brain hemorrhage is also termed cerebral hemorrhages, intracranial hemorrhages or intracerebral hemorrhages by their types. Now a days, Brain hemorrhages are the third cause of death in the world after cancer and heart diseases.

There are several risk factors and causes of brain hemorrhages. The most common include, Head trauma Injury is the most common cause of bleeding in the brain for those younger than age 50. High blood pressure, this chronic condition can, over a long period of time, weaken blood vessel walls. Untreated high blood pressure is a major preventable cause of brain hemorrhages. Aneurysm, this is a weakening in a blood vessel wall that swells. It can burst and bleed into the brain, leading to a stroke. Blood vessel abnormalities, Weaknesses in the blood vessels in and around the brain may be present at birth and diagnosed only if symptoms develop. Amyloid angiopathy, this is an abnormality of the blood vessel walls that sometimes occurs with aging and high blood pressure. It may cause many small, unnoticed bleeds before causing a large one.



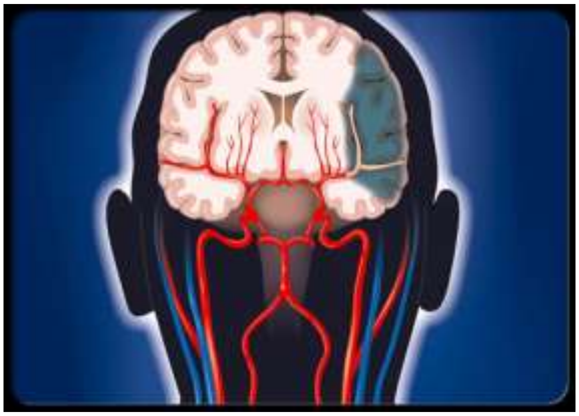
There are four types of hemorrhage, named according to where the bleeding occurs.

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

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 is

1) Computed Tomography [CT Scan] and
2) Magnetic Resonance Imaging [MRI]



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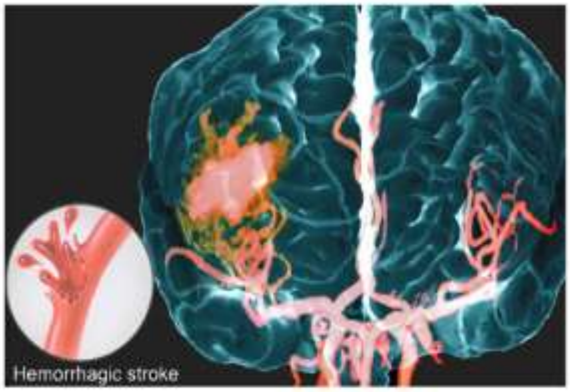
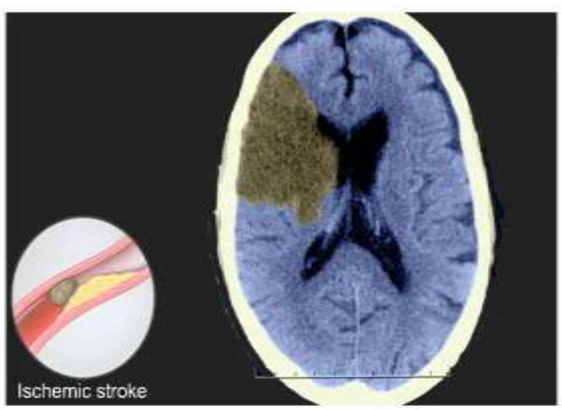


Comparing both CT and MRI images, MRI is the most frequently used method for brain imaging and related research. At the same time bones can be well segmented in CT data using simple thresholding techniques because of the contrast between the bones and the surrounded tissues. In contrast, soft tissues 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.

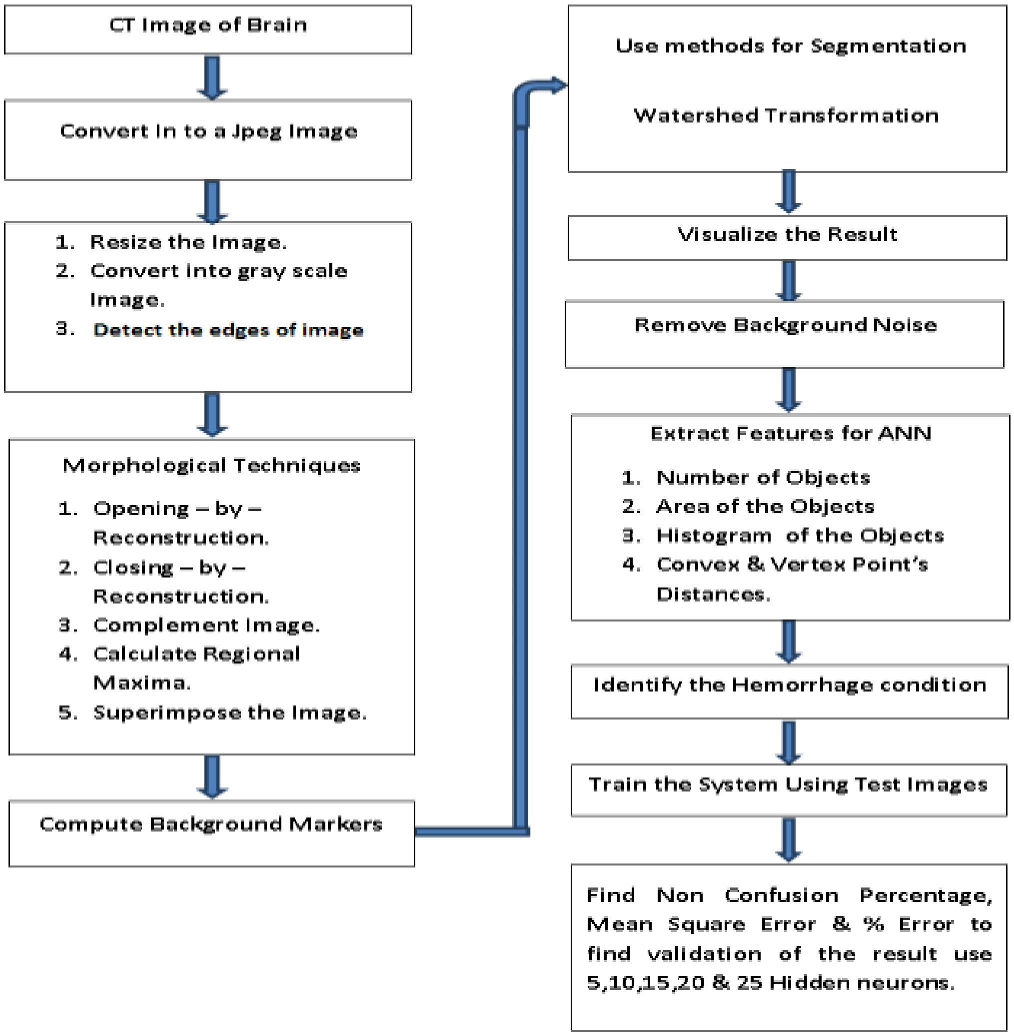


CURRENT METHODS

If any kind of stroke is suspected, immediate evaluation is needed. Examination may reveal evidence of brain injury with weakness, slurred speech, and or loss of sensations. Generally, a radiology examination is necessary, such as a computed tomography (CT) scan or magnetic resonance imaging (MRI) scan. The CT or MRI can highlight various features and location of brain bleeding. If bleeding inside of or around the brain is noted, further testing may be ordered to try to determine the cause of the bleeding. This additional testing can help to determine if abnormal blood vessels are present as well as the next step in either diagnosis or treatment. In certain situations, a spinal tap (lumbar puncture)) may be required to confirm evidence of bleeding or rule out other brain problems.Patients with bleeding inside of the brain must be monitored very closely. Early treatment includes stabilizing blood pressure and breathing. A breathing assist machine (ventilator) can be required to ensure that enough oxygen is supplied to the brain and other organs. Intravenous access is needed so that fluids and medications can be given to the patient, especially if the person is unconscious. Sometimes specialized monitoring of heart rhythms, blood oxygen levels, or pressure inside of the skull is needed. After a person has been stabilized, then a determination of how to address the bleeding is made. This stabilization and decision-making process takes place very rapidly. The decision to perform surgery is based on the size and location of the hemorrhage. Not everyone with an intracranial hemorrhage needs to have surgery.Various medications may be used to help decrease swelling around the area of the hemorrhage, to keep blood pressure at an optimal level, and to prevent seizure. If a patient is awake, pain medication may be needed.Any patients who have experienced a brain hemorrhage do survive. However, survival rates are decreased when the bleeding occurs in certain areas of the brain or if the initial bleed was very large.If a patient survives the initial event of an intracranial hemorrhage, recovery may take many months. Over time and with extensive rehabilitation efforts, including physical, occupational, and speech therapy, patients can regain function. However, some can be left with persistent weakness or sensory problems. Other patients may have residual seizures,headaches, or memory problems.Infants less than 32 weeks gestational age are at higher risk of developing intracranial bleeding, due to the immaturity of the blood vessels. A significant percentage of premature infants may develop some amount of intracranial hemorrhage. This can lead to hydrocephalus, or an enlargement of the fluid-filled spaces of the brain, and can be very serious. If delivery cannot be delayed, certain medications can be given to the mother in an effort to help prevent this condition. 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.

PROPOSED METHOD

Proposed Method Flowchart



Proposed Method Design

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.

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- 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.

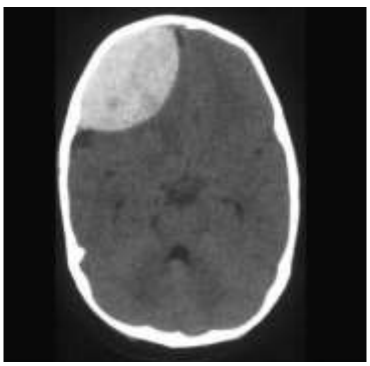
1) Image is pre-processed by performing the following steps:

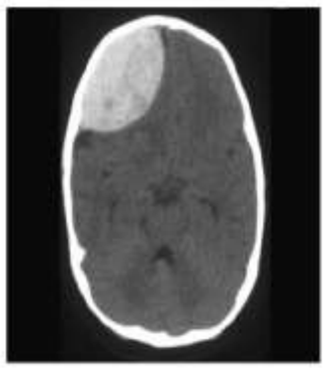
- Resizing the image is done so it fits on the system user interface.
- Convert in to grey-scale image to make it contrast.
- Detect edges of the image

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.

Images for Preprocessing and Edge Detection is shown


Original RGB Image


Grey-Scale Image


Edge-Detected Image

3) 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

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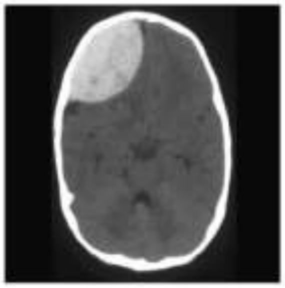
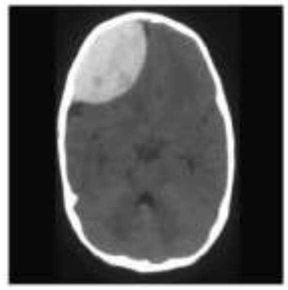
Images for Morphological Operations is shown

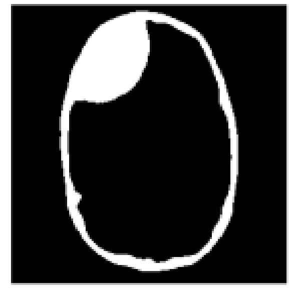


Reconstructed Image followed by Opening

Reconstructed Image followed by Closing



Negative of Reconstructed Image



Negative of Image after using Thresholding

4) Watershed Segmentation Algorithm

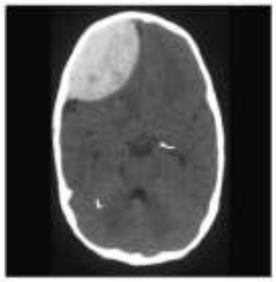
- The main goal of watershed segmentation algorithm is to find the "watershed line"in an image in order to separate the distinct regions.
- To imagine the pixel values of an image is a 3D topographic chart, where x and y denote the coordinate of plane, and z denotes the pixel value.
- The algorithm starts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

5) Markers & Watershed lines

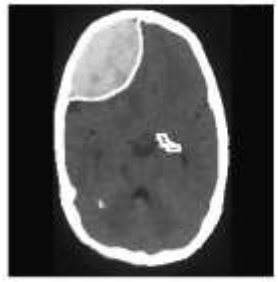
- For resolving the over-segmentation problem in the watershed algorithm, an approach based on the concept of marker is described in.
- A marker is a connected component belonging to an image.
- The markers include the internal markers, associated with objects of interest, and the external markers, associated 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.

Segmentation and Background marker

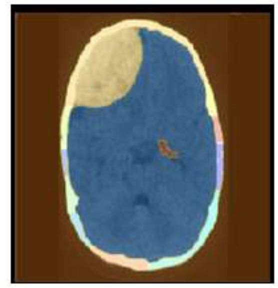
Region Maxima



Modified Region Maxima



Segmented Image Using Watershed Algorithm



Colour filled Segmented Image Using Watershed Algorithm

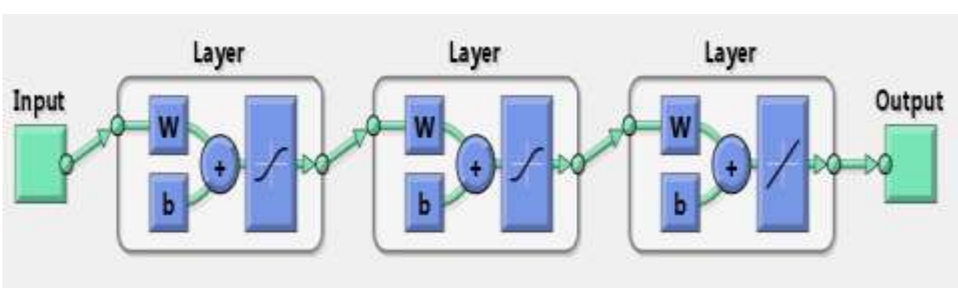
6) Extract Features for ANN

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

7) 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.

Design of the Neural Network



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.

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