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Research paper

Anfis to Detect Brain Tumor Using MRI

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Abstract

Processing of Magnetic Resonance Imaging(MRI) is one of the widely known best techniques to diagnose brain tumor since it gives better results than ultrasound or X-Ray images. The main objective is to diagnose the presence and extraction of brain tumor using MRI images. Image preprocessing includes contrast stretching, noise filtering and Adaptive Histogram Equalization(AHE). AHE gives a graphical representation of digital image without enhancing above the desired level. The next stage involves transferring the redundant information in input image to reduced set of features is called feature selection and is done by color, shape or texture of an image. Image is segmented using incorporation of Artificial Neural Networks(ANN) and Fuzzy logic called Adaptive Neuro-Fuzzy Inference System(ANFIS) wherein we get the desired output to differentiate tumor affected and normal image with its severity level. Since we deal with uncertainty much more, fuzzy logic serves as a vibrant tool in representing human knowledge as IF-THEN rules. MATLAB has been implemented in detection and extraction of tumor at an early stage.

Keywords: *Brain tumour, magnetic reasonance imaging(MRI), image preprocessing, adaptive histogram equalisation(AHE), adaptive neural network(ANN), fuzzy logic.*

1. Introduction

The upper part of central nervous system is an important organ which consists of nerves and tissues like glial cells(supporting cells) and meninges. Brain tumor could be spoken as the rapid irregular cell growth, which normally emerges from blood vessels or brain nerves. Alternatively, brain tumor is also defined as deformity in structure and behaviour of brain. The tumor is classified only after biopsy of the tumor cells. The Types could be broadly listed as three. They are benign tumor, premalignant tumor and malignant tumor. A tumor which gradually rises over time to affect brain tissues severely comes under the type Benign. A type of tumor caused by carcinogenic substances like gamma rays and which could be recovered by treatment comes under Pre-malignant. A complex type of tumor where fatal occurs is Malignant tumor. Brain tumor can occur at any age. The highest rate of fatal deaths of cancer is caused by brain tumor. Significant danger exposures like gamma rays radiation and other factors like hierarchical passing could be a cause for brain tumor. The longevity of the patient affected by the tumor will increase by a considerable amount, only when detected at the right age.

The Magnetic Resonance Imaging(MRI) is the technique of imaging deeply used for studying about the brain and MRI images that widely help to detect tumors in brain tissues. Alternate techniques used for the same process are (Computed Tomography)-CT and X-Ray. The latter is a radiation type, which when passed through the body, harder parts like bone may block it to appear white on the film surface. The former uses ionization, but MRI blends a more vibrant magnet with radioactive waves and hence it is used.

The recent survey from Central Brain Tumor Registry of the United States(CBTRUS) tells us that there are nearly 80,000 cases of malignant and benign diagnosed in the year 2016 throughout the world. The near estimation reports that 30% of the overall population in the world is suffering from brain tumor. This paper deals with identifying and discarding the third type of fatal tumor type to prolong the healthy lifestyle of patients. The Adaptive Neuro Fuzzy Inference System(ANFIS) advent a mix of neural networks and fuzzy logic implementation to eradicate the uncertainty issue which is being highly dealt in this work. This is used to throw away the ill-defined ambiguity content of segmenting geometrically or grey level of pixels in an image. The complete methodology of tumor detection is developed and simulated using MATLAB.

2. Literature Survey

Mr.Lalit, et.al have attempted to detect brain tumor using the best advantages of both Artificial Neural Networks and Fuzzy Logic. The image is obtained from MRI and textural features are extracted using Principal Component Analysis(PCA). The work deals with feature extraction and detection using neuro-fuzzy classifier wherein it is used for classification of different brain MRI samples[1].

R.J. Deshmukh and R.S. Khule have proposed with artificial image classification of tumor since manual classification gives ambiguous results. MRI scan image of brain of patients are taken as input to train the neural network with database images. With

the adopted fuzzy rules in the knowledge base, test the MRI scan images and finally detect the presence of tumor[2].
R. Karuppathal and V. Palanisamy research includes detection of tumor in brain followed with various stages of image processing like preprocessing, feature extraction and segmentation. The work mainly focuses to classify the segmented tumor using using Fuzzy-K Nearest Neighbour Method and to name the tumor as normal or benign or malignant [3].
Er.Anjna and Er.Rajandeep kaur says that ANFIS for Brain Tumor Detection played vital roles with the implementation of simple mechanism for detection of range, area of tumor in brain MRI. The classification of brain tumor is done with the help of ANFIS and then compares the results with Fuzzy C-means and K-NN (K-Nearest Neighbour). A complete feature set and fuzzy rules are selected to categorize an abnormal image to find out corresponding tumor type[4].

3. Architecture Diagram

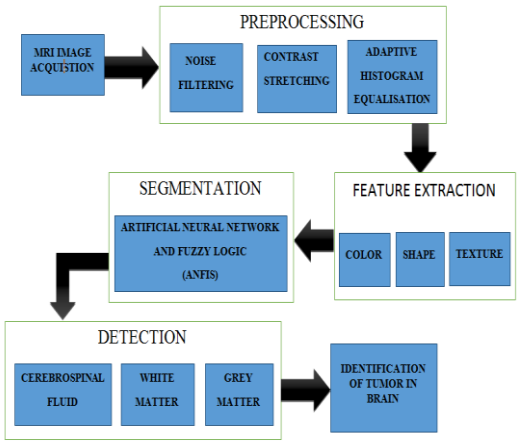

Fig. 1: Architecture diagram to detect brain tumor

4. Proposed Methodology

The design implemented for identifying brain tumor with MRI images is slotted into five stages and the middle stage deals with incorporation of the most significant hybrid process called ANFIS. The uplifted process involves programming of MRI tumor involved images for the earliest recognition and classification of it to treat it better.

MRI Image Acquisition

The input images fed for the process has been organised from databases of some open source where it is feasible to access images with malignant and benign tumors. MRI image has been chosen for processing because it provides a clear cut concept and accurate results when compared to CT or X-Ray images.
The radiology field has been supported with a profound technique of imaging in medical approach called Magnetic Resonance Imaging(MRI) which could capture anatomy pictures of normal and abnormal tissues. Since MRI comes under radiology field, components used for scanning of detected parts involves usage of strong magnetic field, and radio waves for generation of images. The wide known practical methodology of Nuclear Magnetic Resonance(NMR) is the Magnetic Resonance Imaging(MRI). MRI is still chosen as a better choice than CT even while the phases of technology has gone to an unimaginable manner just because the risks of X-rays can now be well managed. As already stated above, MRI was truly named as Nuclear Magnetic Resonance Imaging(NMRI) since it is an application of the same. In distant and analytics MRI, atoms of number one atomic number are passed to detect tumor using radio frequency signals. The presence of hydrogen atoms is most common among the body of human beings and other living organisms, in water and fat. Due to this fact, MRI scans route the presence of water and fat to detect tumor between tissues on the liberal properties of the hydrogen atoms.

Image Preprocessing

Noise filtering

The methodology to remove noise from a signal, basically from an image is said to be Noise Filtering. A form of noise which causes narrow sharp and immediate obstacles on images is called Salt and Pepper noise which could also be known as impulse noise. It could be sparsely populated black and white pixels. Past analog and present digital devices have characters that make them liable to external noise. Ultimately, a vibrant noise reduction technique used for all components is morphological filter or otherwise called median filter which is basically a non-linear filter. It could be a blend of reducing both salt and pepper noise or either of it on the cart. This serves as the very first step of tumor detection process called pre-processing step to get accurate results in the further process. It is a digital image processing technique to be used on digital images as it could retain the edges in the noise removal process. It works by passing through the signal one by one, which replaces one entry by the median of adjacent entries and this pattern could be widely known as “window”. The few previous order entries and few successive order entries would be best suitable for 1D signals and 2D signals would go with complex “box” or “cross” patterns. The median is the middle value of all the present entries in the window when it has an odd number of entries after sorting it in numerical order. When the sorted result is in even, then there is an extra possible median left out.

Contrast stretching

This operation tends to re-arranging of input values over a scattered range in an output image which could be used to enhance the contrast in the displayed image. Possibly stretching and histogram equalization are the two stretch methods available for operation. The former method aims in improving the image contrast by stretching the range of values to a desired set and hence it is called normalization. This confines to a method of one-one linear mapping of input to output values by applying a linear scaling function. Here, both the input and output images are gray level. Ultimately, the desired output of enhancing an image is less harsh.

Adaptive histogram equalization

The image histogram depicts the rate of recurrence of grey levels in the image. This method applies a non-linear mapping technique to re-allocate the intensity values of pixels in the input image and this would then reflect the traits of having a better uniformity of intensity levels in output image. This digital image processing technique greatly varies in working with the ordinary histogram equalization with the fact that, adaptive employs histograms of large in number with each one corresponding to separate and different parts of an image which could be further used to reallocate the lightness value. In addition to this, AHE is much employed of the reason that the image is not histogrammed beyond the desired level thereby producing an accurate output image. Since the working nature is not much varied, the rank value of image produced in normal histogram equalization is proportional to the rank value produced in AHE allowing to compare pixel in center to that of neighbourhood pixels. The output peak of histogram is strong where the pixels are homogenous in nature and this leads to amplification of noise in that area.

Feature Extraction

Feature extraction takes predominant and notable features within an image for tumor detection and recovery at its earliest. The local features of the image are utilized to distinguish the different images. These features are categorized on various key component of image data like color, shape, texture and others which can be used in image matching, pattern recognition and retrieval. This much involved segregation technique extracts feature by keeping as much information as possible from large set of data of image. This could then be categorized as the high and low-level feature extraction. Low-level are small details of the image like point, line, edge corner. It can be automatically extracted from the image without having knowledge of shape. High level feature is built on top of low level features to detect objects and larger shapes in the image. After categorizing the process and extracting the important features for recognition, the segregated output would be the input for training the database which hold the textual property in it. This recognizing property of patterns and feature extraction goes by taking a set of data at the first place and develop further accordingly to overcome the difficulty of eradicating redundant data and producing informative values. This methodology uses a feature vector as it reduces the input features to a confined set if it is redundant in nature or large for processing. This could also be called as dimensionality reduction. Feature selection is the determination of a subset of the basic initial features which are supposed to hold a more valuable information with the output produced by using the reduced set of data. In complex data analysis, larger number of variables are involved which consumes more amount and power to produce a weak set of training samples. To heal this situation, default sets which are already built by experts could be used for complex type analysis.

Image Segmentation

After the feature has been extracted out, segmenting the image into several parts plays a major role from where the objects could be identified. To segment an image, we use highly qualified techniques namely Artificial Neural Networks(ANN) and Fuzzy logic which is together called Adaptive Neuro-Fuzzy Inference System(ANFIS).

ANFIS Architecture

The ANFIS structure mainly deals with 6 inputs and only one output. These 6 inputs reveal the various texture features got from all the individual images. The FIS (Fuzzy Inference System) consists of training sets which is normally the base for all fuzzy rules. The input is a gaussian membership function and the desired output would be a simple linear combined membership function of 49 rules. There are two categories into which the dataset is divided namely the test and training data. The latter has all the four tumor types, and these can be classified into white matter, gray matter and others. The former mentioned is a process which is used for matching with the extracted features. The combination of FIS and fuzzy logic is a basic classifier making use of fuzzy logic and reasoning rules based upon the theory of fuzzy. This multivalued logic reasoning ranges between 0 and 1. Adaptive Neural Network(ANN) is a logical structure of network with a quite large number of nodes which are said to be interconnected with the directed and weighted links. The second part of ANFIS which is the Fuzzy Inference System is a mix of triplet functions namely fuzzy set theory, fuzzy IF-THEN rules and Fuzzy Reasoning. The first factor in the triplet function contains too many logical levels between 0 and 1. The second factor in the triplet function takes the IF-Then rules: if x is A then y is said to be B where A and B are linguistic values, X and Y are fuzzy sets. The third factor of the triplet function is the Fuzzy Reasoning which is used to derive a conclusion from the fuzzy rules and facts. The basic fuzzy inference system is capable of taking either fuzzy input or crisp input, but it always produces fuzzy sets as outputs. But in our case, we need crisp output and therefore de-fuzzification is done. In this process we extract the desired value that can best represent the fuzzy set.

Detection

The tumor is detected from the extracted features namely cerebrospinal fluid, white matter, grey matter and it is compared with the original image. The obtained matter is finally compared with the original image and rate of presence of tumor is detected in the persons for early detection and recovery.

5. Implementation

Basic GUI Implementation

Fig. 2: GUI implementation

This is the basic GUI Implementation in MATLAB in which the image is loaded and can perform filtering, Adaptive Histogram Equalization, Feature extraction by clicking on the respective buttons on the page.

Image Loading

The image is being loaded in the page to perform the filtering and the following process. After loading the image, the image is initially preprocessed by noise filtration, contrast stretching, Adaptive Histogram Equalization. After preprocessing the Feature Extraction process is performed following which the segmentation technique is performed. After segmenting the image is analyzed based on the ANFIS which ADAPTIVE NEURO-FUZZY INFERENCE SYSTEM is. Finally, after analyzing the image based on ANFIS, detection is done based on the image whether the tumor is present in the brain or not.

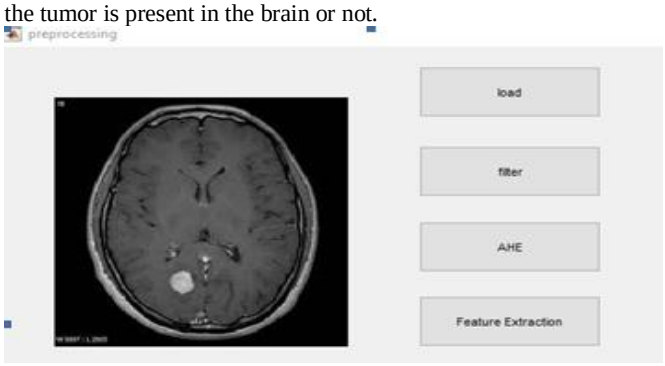

Fig. 3: Image loading

Image Preprocessing

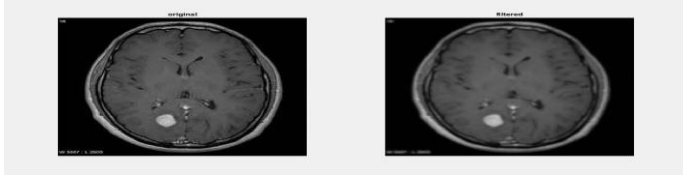

Fig. 4: Image preprocessing

After loading the image, it is preprocessed based on the noise filtration and contrast stretching. The original image is being filtered and form a new filtered image based upon which the other following processes can be performed.

Adaptive Histogram Equalization

Original image

The original image is being loaded to check for adaptive histogram equalization.

Fig. 5: AHE implementation

Histogram of original image

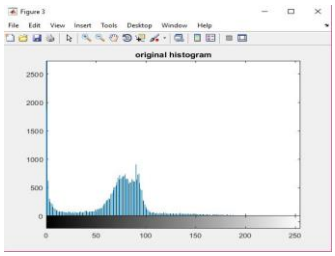

Fig. 6: Histogram of original image

The original image which is being loaded will has the above type of histogram.

Edited image

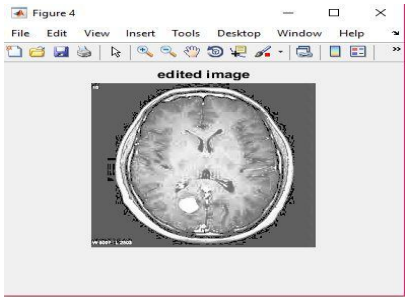

Fig. 7: Image after AHE

After performing Adaptive histogram equalization, the image will get modified as denoted in the above picture and it is the preprocessing stage that helps in the detection of tumor in the brain.

Histogram of edited image

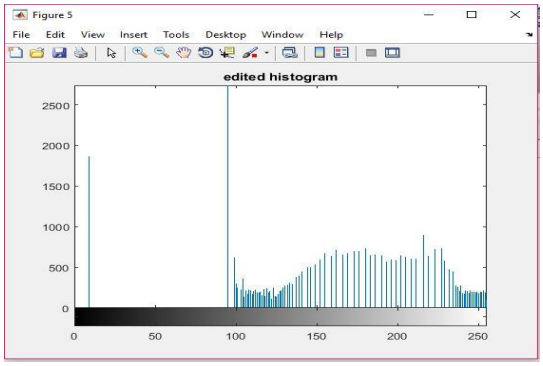

Fig. 8: Histogram of edited image

The image which is being preprocessed by using the Adaptive histogram equalization (AHE) will have the histogram Image as denoted in the above picture. After performing adaptive histogram equalization, the feature extraction is being performed.

Feature Extraction

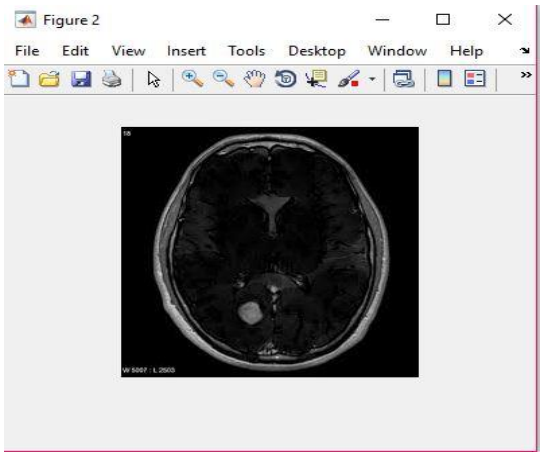

Fig. 9: Feature extraction

Performing feature extraction, the image can be distinguished from the original image as can be used for further detection of tumor. The features can be categorized based on color, shape, texture etc. Based the features the image can used for detection. The tumor is being highlighted from the original image by performing feature extraction.

ANFIS Implementation

FF NN training tool

Feed forward neural networks always process the signals in a one-way direction and have no inherent temporal dynamics. Hence it is referred to as static.

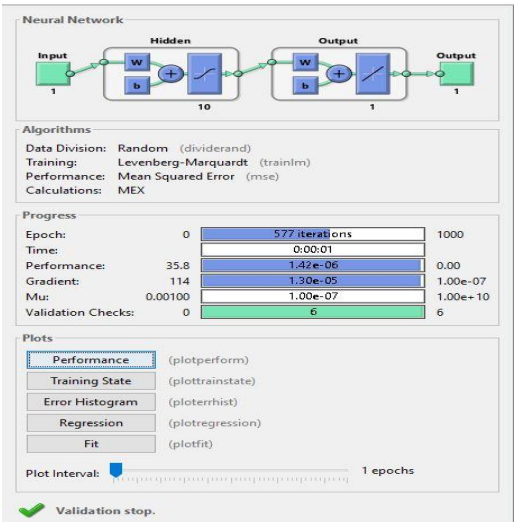

Fig. 10: FF NN training tool

Ideal feed forward neural network architecture

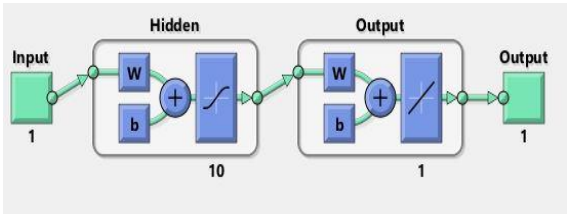

Fig. 11: FF NN architecture

Each network in the neural network consists of three layers of units: an input layer, a hidden layer, and an output layer. Input units were fed to hidden units through the weighted interconnections, and in turn hidden units were connected to output units via weighted interconnections

Training result for FF NN with 10 Nodes

Multilayer architecture in neural network consists of input layer hidden layer and output layer like the general feedforward neural network but in multilayer neural network there can be multi inputs.

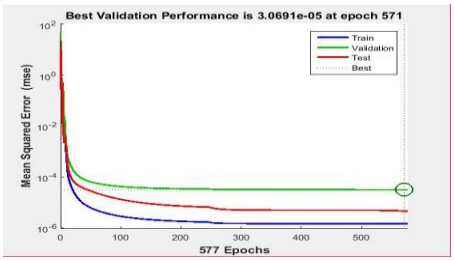

Fig. 12: Training results for FF NN

Training state for FF NN with 10 nodes

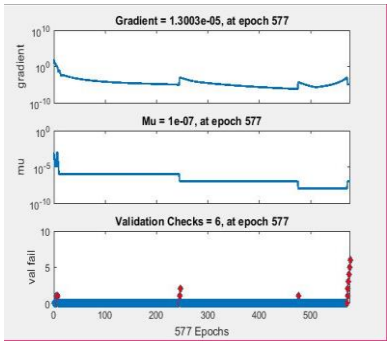

Fig. 13: States for FF NN

Best fit regression for NN with 10 nodes

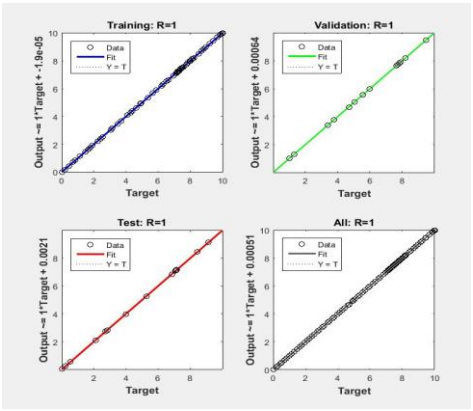

Fig. 14: Best fit regression

Training results for error histogram with 20 bins

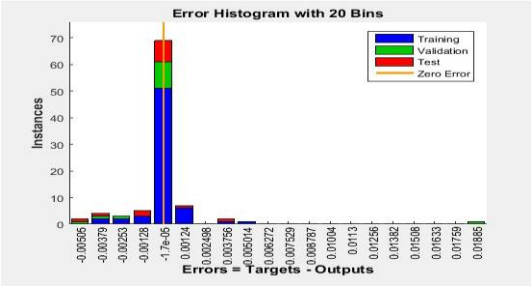

Fig. 15: Error histogram

Training result of function fit for output element 1 with 10 nodes

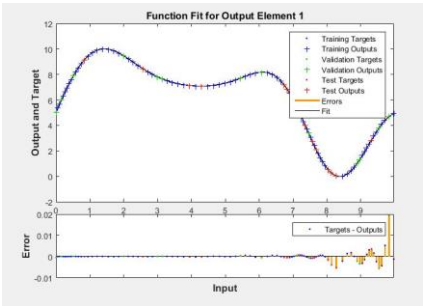

Fig. 16: Function fit

Fuzzy logic implementation

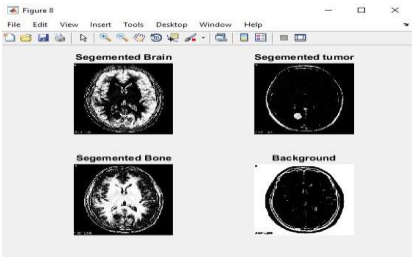

Fig. 17: Segmented image

Fuzzy logic is an approach to computing based on the "degree of truth" rather than usual "true or false". By implementing the featured image in fuzzy logic, a clear segmentation of the tumor is being identified as shown in the picture. Segmented image is very much important in the detection of tumor cells in the brain.[20][21]

6. Conclusion

In this paper we showed the ability of ANFIS and the ANN in detecting the tumor cells of the brain. The Brain tumor detection would be useful to doctors to predict analyze and detect tumor. This would prompt the doctors to systematically collect and analyze the images of the affected brain, and then provide necessary treatment and helps in the early detection of tumor to avoid the loss of lives. Fuzzy logic is nearest model to human model of conduction. Fuzzy sets with membership functions are easiest way to combine different conclusions and to represent in pictorial view than other available methods. Fuzzy logic includes fast conclusion, fast development, flexibility and also suitable for hybrid methods. Neural Network is closest to human brain anatomy cell. Neural networks can be used for all those applications where there seems some relationship between input features and output, that generally cannot be described by a mathematical relationship. Also, they are used where we are ready to accept a slight percent of error and the application results are not critical. Few applications based on Fuzzy Logic can be solved by ANN and thus are less useful. Both neural networks and fuzzy logic have merits and demerits so the merits of both these are amalgamated as Adaptive Neuro-Fuzzy Inference System (ANFIS).

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