Amalgamation of NNE and Jaya Algorithm to Extract the Abnormal Part in MRI Images

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Abstract: Among the available detection techniques for the identification of abnormality present in the brain, MRI is a best technique. This paper presents a method to distinguish the abnormal brain images from the normal ones in the database available. The procedure involves preprocessing, feature extraction and classification. Ensemble based classification is done using neural network and Jaya Algorithm helps in optimizing the threshold value used for classification.

Keywords: Magnetic Resonance Imaging (MRI); Feature Extraction; Ensemble; Neural Network; Jaya Algorithm.

Introduction

The diseases related to brain have been the reason of the number of deaths. According to American Society of Clinical Oncology (ANCO), in August 2015, about 22,850 people of US will be reported to have primary tumor of the either brain or spinal cord from which, approximately 15,320 will die in the coming year. Approximately, 4,300 youngsters will be reported of having a brain or CNS tumor the following year [1]. Brain Tumor results from the abnormal and uncontrolled division of the brain cells. Commonly, the cells in the body decease with age and are replaced with the new cells. But, with cancer and other tumors, this normal cycle is disturbed resulting in the rise of tumor cells in the body. The abnormal cells, when created in the brain, it is called brain tumor. Tumors directly or indirectly damage the healthy brain cells by clustering around the healthy tissues of the brain [2-3]. Brain gets damaged with tumor because of rising pressure in the brain, shifting it towards the skull, and penetrating them into the healthy brain tissues. Brain tumor is further divided into primary and metastatic tumors. Primary tumors arise in the brain itself whereas metastatic tumors emerge in other organs of body and then, spread to the brain via blood cells or adjacent tissues [4].

The various techniques used for detection of abnormalities in brain incorporate Magnetic Resonance Imaging (MRI), Magnetic Resonance Spectroscopy (MRS), Computed Tomography (CT), Positron Emission Tomography (PET) and Electroencephalogram (EEG).MRI is the standard imaging practice used by doctors todetect brain abnormalities by taking the pictures from diverse planes and creating three-dimensional image of brain.It observes the signals emitted by the healthy as well as tumor affected tissues present in the brain and process it accordingly to give the results. Magnetic resonance Spectroscopy (MRS) estimates the levels of metabolites which are different in tumor affected tissues is than that of the normal tissue. It helps in identifying the activity patterns that helps in treatment after diagnosis of any abnormality. The types of metabolites that are commonly considered for diagnosis with an MRS are choline, lactate, and N-Acetyl- Aspartate (NAA) etc. Computed Tomography (CT) makes use of advanced technology along with x-ray. CT possesses the ability to show amalgamation of soft tissues, blood vessels along with bones. CT images can detect some types of tumors, as well as aid in detecting the inflammation and bleeding. The contrast agent used with a CT scan is Iodine. Positron Emission Tomography (PET)is an additional test performed to obtain more information. It provides an image of the brain's functioning, which is done by computing the rate at which glucose is absorbed by the tissues which is administered to the body of patient. The information obtained about activity of brain is measured by PET scan which is used to create live image with computer. EEG records the electrical brain activity with the use of electrodes that are placed on the head as well as connected to computer. It is used for diagnosis of unconsciousness, dementia, epilepsy etc. [5]

The later part of the paper involves: Preprocessing and segmentation (discussed in Section 2), Feature Extraction (presented in Section 3), Classification (elaborated in Section 4). Paper is then summarized in last section.

Preprocessing

Preprocessing aids to improve the image quality. First of all, MRI images taken from the database are resized to a specified size. If images are colored, then the gray scale conversion is done. Enhancement of quality of image is done by noise removal at the same stage. The noise can be removed using median filter, high pass filter etc. Image segmentation used for the image analysis,is the process in which partition of digital image into numerous regions [6]. MRI images are divided into the

multiple segments so as to obtain the details about the each part of the brain and to extract the lesions, Region of Interest (ROI) [7]. Among the various segmentation techniques, adaptive thresholding and canny edge detection has been used.
The adaptive thresholding techniques [8] applied to the image obtained after preprocessing of MRI image taken from MIDAS [9] given in Figure 1. Here, Figure 2 shows the preprocessed MRI image. In this, a parameter θ is defined for the brightness threshold, which can be specified by the user. It is used for the conversion of the grayscale images into the binary images. The adaptive thresholding technique when applied to MRI image gives the binary image as shown in Figure 3.

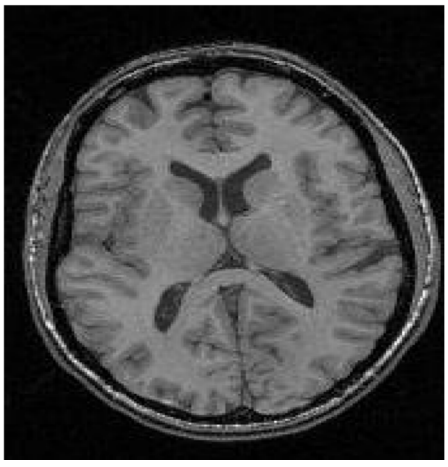

Figure 1. Original MRI image [9]

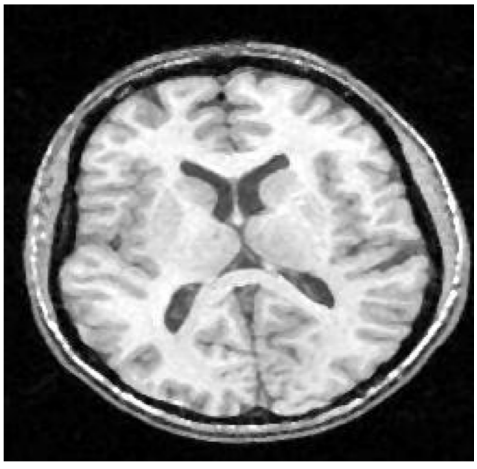

Figure 2. MRI image after preprocessing

Feature Extraction

Feature extraction involves extracting the features of the images. It is used for minimizing the complexity as well as processing time for the analysis of the required images. The Gray Level Co-occurence Matrix as well as texture features are used for feature extraction in this method, which are explained in Table 1.

Table 1. Texture Features [10]

Sr. No.	Features	Definition
[1]	Mean	Average of entire image intensity.
[2]	Variance	Determines difference of intensity deviation from mean value.
[3]	Skewness	Exhibits symmetry over the image.
[4]	Kurtosis	Presents flatness of the histogram.
[5]	Entropy	States the uniformity of histogram from the image.
[6]	Contrast	Tells about intensity contrast amid a pixel and its neighbor over complete image.
[7]	Correlation	Determines the value by which a pixel is correlated with its neighbor pixels across the whole image.
[8]	Energy	Depicts sum of squared elements in GLCM

Classification

Artificial Neural Network (ANN), Bayesian classification, Support Vector Machine (SVM) etc are used for this purpose [11]. Classification is done using the ensemble classification based on the neural network and optimized using Jaya Algorithm. In this the back propagation algorithm is used as the base classifier using different methods [12]. Venkata Rao developed the Jaya algorithm [13] which is used for problems either constrained or unconstrained. The outcome obtained from the problem reaches the optimal solution, by preventing the worst solution. This algorithm makes use of objective function to extract the abnormal portion from MRI image.The objective function g(x) is to be minimized or maximized. There are n design variables and m participant solutions for each i iterations. Best participant obtains the optimal values of g(x) whereas the worst participant of g(x) are obtains the worst values. The equation used in this algorithm is:

$P'_{e,f,d}=P_{e,f,d}+ r1,e,d(P_{e,best,d}-| P_{e,f,d}|)- r2,e,d(P_{e,worst,d}-| P_{e,f,d}|)$ (1) where $P_{e,f,d}$is value of e^{th} variable for f^{th}participant in d^{th} iteration. $P'_{e,f,d}$ is updated value of $P_{e,f,d}$. $P_{e,best,d}$ is value of e variable for best participant whereas $P_{e,worst,d}$ is value of e variable for worst participant. $r_{1,e,d}$and $r_{2,e,d}$ are random numbers that exist between 0 and 1 for e variable in d iteration. The second term in equation 1 shows the likelihood of solution to move nearer to optimal solution whereas third term shows the likelihood of solution to prevent worst solution. Updated value is accepted only if the solution is superior to the previous one. The classification is done on the basis of features extracted from the segmented images. Simple averaging method is used for the combination of results from different classifier. The whole data is divided into the training and testing data. The data which is classified as training data is then used for training the neural network. Rest of the data is used for the testing purpose. The training and testing dataset involves both normal as well as abnormal MRI images. The threshold value used for classification in neural network ensemble is optimized using Jaya Algorithm. Then optimized threshold value is used for classification into normal and abnormal.

Results

The NNE when implemented on MATLAB R2010a, yielded convincing outcome. Out of 60 MRI images, obtained from the internet (BRATS-2012, MIDAS etc.), 40 are used for training while 20 are used for testing. The available database has 30 normal brain MRI image and 30 abnormal MRI image.

Table 2. Recognition Rate of Neural Network Ensemble

Parameters	Normal Brain	Abnormal Brain
Detection as Normal Brain	70%	30%
Detection as Abnormal Brain	0%	100%

Conclusion

The proposed system helps in easy diagnosis of normal and abnormal brain. The total accuracy achieved with the system is 85%. Further, the PET scans can also be used for the detection and classification purpose.

References

[1] Brain Tumor Statistics, “http://www.cancer.net/cancer-types/brain-tumor/statistics”
[2] N. N. Gopal and M. Karnan, “Diagnose Brain Tumor Through MRI Using Image Processing Clustering Algorithms Such As Fuzzy C Means Along With Intelligent Optimization Techniques”, IEEE International Conference on Computational Intelligence and Computing Research, 2010, pp.1-4.
[3] M. Karnan and K. Selvanayaki, “Improved Implementation of Brain MR Image Segmentation Using Meta Heuristic Algorithms”, IEEE International Conference on Computational Intelligence and Computing Research, 2010, pp.1-4.
[4] P. Sapra, R. Singh and S. Khurana, “Brain Tumor Detection using Neural Network”, International Journal of Science and Modern Engineering, vol. 1, 2013, , pp. 83-88.
[5] The essential guide to Brain Tumors, “ http://blog.braintumor.org”
[6] E. A. Maksoud, M. Elmogy and R. A. Awadi, “Brain Tumor Segmentation based on a Hybrid Clustering Technique”, Egyptian Informatics Journal, vol. 16, Feb. 2015, pp. 71-81.
[7] D. A. Dahab, S. S. A. Ghoniemy and G. M. Selim, “Automated Brain Tumor Detection and Identification using Image Processing and Probablistic Neural Network Techniques”, International Journal of Image Processing and Visual Communication, vol. 1, Oct. 2012, pp. 1-8.
[8] E. F. Badran, E. G. Mahmoud and N. Hamdy, “An Algorithm for Detecting Brain Tumor in MRI Images”, IEEE International Conference on Computer Engineering And Systems, 2010, pp. 368-373.
[9] MIDAS, “ http://insight-journal.org/midas/community/view/21”
[10] Q. Ain, M. A. Jaffar and T. Choi, “Fuzzy anisotropic diffusion based segmentation and texture based ensemble classification of brain tumor”, Applied Soft Computing, vol. 21, Aug. 2014, pp. 330-340.
[11] Parveen and A. Singh, “Detection of Brain Tumor in MRI Images, using Combination of Fuzzy C-Means and SVM”, IEEE 2nd International Conference on Signal Processing and Integrated Networks (SPIN), 2015, pp. 98-102.
[12] S. Yang and A. Browne, “Neural network ensembles: combining multiple models for enhanced performance using a multistage approach”, Expert Systems,vol. 21, 2004, , pp. 279-288.
[13] R. Rao,”Jaya: A simple and new optimization algorithm for solving constrained and unconstrained optimization problems”, International Journal of Industrial Engineering Computations, vol. 7, 2016, pp. 19-34.