An Improved Detection of Tumors and Edemas in Brain using Enhanced Learning Process Algorithm

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ABSTRACT

In medical image processing brain tumor segmentation plays the major task. It is very important to identify the brain tumors edemas in the early stages. The other name for brain swelling is cerebral edema. It's very serious issues and this may causes death because it develops the fluid in the brain. This will amplify the pressure within the skull and this is also referred as intracranial pressure (ICP). Various manual automated processing techniques are using to detect the tumors and edemas in the brain. Still there is a lack of accurate results and more time to detect the exact place of the tumor or edema. In this paper, an Improved Detection of Tumors and Edemas in Brain using Enhanced Learning Process Algorithm (ELPA) is introduced. To amplify the performance of this ELPA, adopted the edge detection approach to find the edges of the affected area. Results show the performance of the ELPA and other manual and automated processes.

Keywords

ICP, ELPA, Machine Learning (ML), brain segmentation, tumor, edema.

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Introduction

Brain tumors are increases more complications based on the age. This will grow the abnormal and uncontrolled cells that are developed in the brain. This is more dangerous to the person if it is not detected in early stages. Brain tumors are divided into few types such as Meningioma, Glioma, and Pituitary tumors are more common than the others. Analyzing the medical images can provide the training for the medical professionals to know the status of diseases and finding the clinical challenges to increase the quality of the healthcare. From all the other medical image analysis, detection of brain tumor segmentation concerned a lot of observation. Machine Learning (ML) is most widely used to find the abnormal patterns that are applied to any medical images. ML algorithm computes the various features that are more complicated or finding the abnormality. For the brain tumor diseases, the ML algorithms with image processing techniques gives more accuracy to detect exact locations of the tumor or edema effected regions in the selected image.

Sometimes brain tumor causes the cancerous or noncancerous which are based on growing the abnormal cells in the brain. Among all the cells in the brain glial cells, gliomas are the most general brain tumor [1]. The algorithm mainly focus on brain MRI scan images detection which is adopted the noise removal filters in selected image and detecting the affected area, finding the lesions in given brain image.

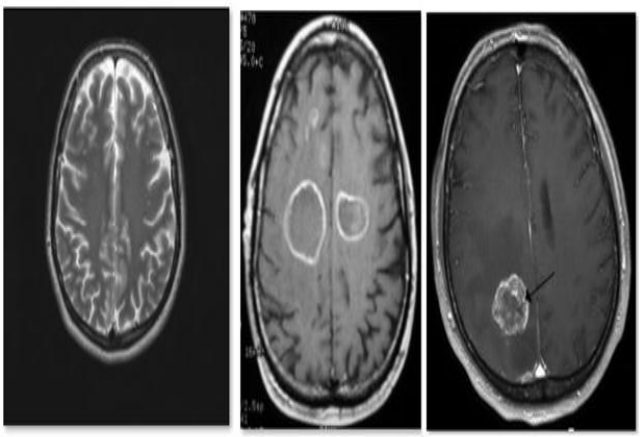

Figure: 1 (A) Normal Image, (B) Edema Effected Image, (C) Tumor Effected Image

ML contains set of methods that improves the performance of the detecting the abnormalities in the brain. Figure 1 (a),(b),(c) explains about about the various types of images that are having normal image, tumor image and edema image. The proposed algorithm is the combination of sharpening, noise filter, feature extraction and edge detection. The improved results are shown in this work by implementing the proposed algorithm.

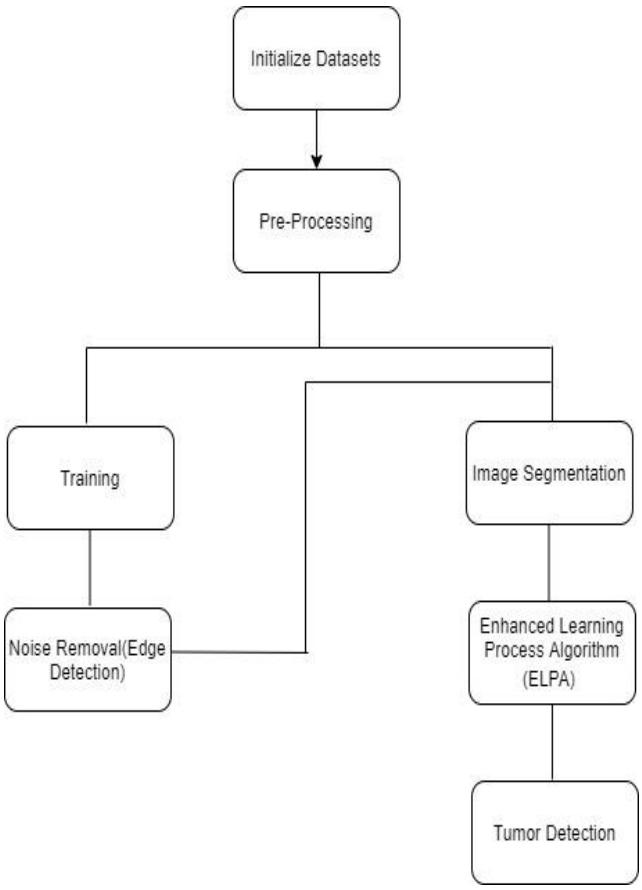

Figure 2: Proposed Methodology Architecture

Literature Survey

For the finding of brain tumor various complicated issues are identified in brain tumor segmentation. The intend of the brain segmentation is to label every pixel into a distinctive brain tissue group. This prediction of the segmentation is that the brain image is not having whichever tumor tissue or additional irregularities [2], [3]. In brain, the white matter lesion segmentation is one of the techniques that segment the white matter area from the usual tissue. Necrotic and cores are the sub-regions of the white matter lesion, the goal of this segmentation achieved based on the binary classification methods. The aim of the tumor detection is to identify the abnormal tumors or lesion cells with give the reports of the every cell. As the detection of the tumor identified this returns the bounding box and the label is classified as [4], [5], [6]. Some of the research works that returns the single label segmentation mask. The author mainly focuses on detecting the glioma tumor segmentation and sub-region voxel (or pixel) intensity segmentation. The author Liu et al. [7] in 2014 written a survey on brain tumor segmentation based on MRI images. One more interesting aspect is this survey doesn't contain any deep learning methods.

The author [8] proposed the hybrid method to identify the brain tumor using Support Vector Machine (SVM) and Fuzzy C-Means Clustering (FCM). The dataset used in this system is real time dataset which consists of 120 patient images which are MRI images. All the selected MRI images are converted to two-dimensional matrices for image enhancement. After the successful implementation of the Fuzzy C-Means, skull striped by Double Thresholding, Erosion, and Region Filling methods. The accuracy is increased up to 91.66%.

The author [9] developed a new method which combines the Curvelet and Gray Level Co-occurrence Method (GLCM) features using Support Vector Machine (SVM) classifier to detect brain tumors on MRI images. For this method, the pre-processing is mandatory to get the abnormal effected area within the brain MRI image. For the training the vectors such as spatial and frequency field depending on statistical parameters and various texture parameters are stored in the MRI images as feature vectors. These vectors are used to train the SVM Classifier.

Table 1: performances of various existing systems

Reference	Method	Preprocessing	Segmentation	Classifier	Database	Accuracy (%)
[8]	Mid-range Stretch	Skull stripping	Fuzzy C-Means	SVM	120 images from WWW	91.66 %
[9]	-	Skull stripping	Watershed Algorithm	SVM, GLCM	Brainweb and IBSR dataset	90%
[10]	Smoothing by Gaussian filter	-	-	LVQ based PNN	64 images	100%
[11]	Gabor and Fast Fourier Algorithm	-	MCWA	-	Breast X-ray mammograms	Enhanced visibility of image to identify more information

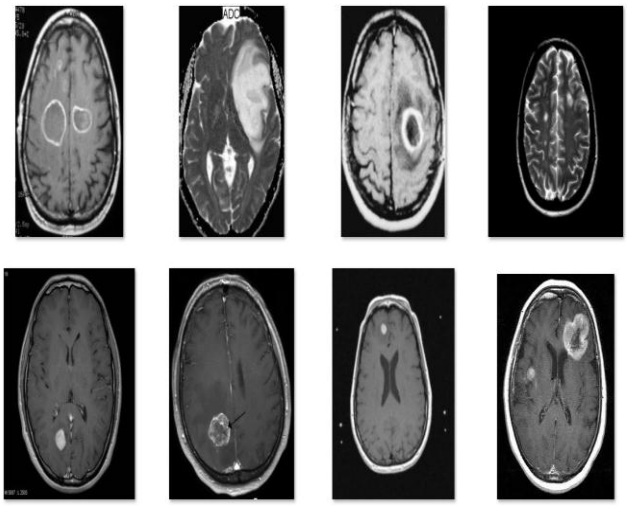

Figure 3: brain dataset from UCI repository

Brain mr images

The brain MRI Images are downloaded from kaggle dataset repository (brain tumor dataset) and edema-detection. As shown in the figure 3 this dataset consists of 110 images 65 are male and 45 are female and among this 54 are tumor affected images, 26 are normal images and 30 are edema affected images.

Preprocessing

In this stage, two stages are considered such as skull stripping and median noise removing filter.

Skull Stripping:

In brain image processing, skull stripping is most important task. The brain anatomy and intensity of brain is based on stripping. To get the better results this will merges various operations such as adaptive threshold and morphological operations, to provide better results. This is the dynamic technique that will automatically extract the features of the brain. Jaccard Similarity Coefficient (JSC) is used to calculate the likeness between the skulls exposed image and the ground-truth image and is defined as the dimension of the be related area of the two images divided by the size of the union of the two images.

$$J(A,B) = \frac{|A \cap B|}{|A \cup B\}} - - - (1)$$

Noise Filtering-Median Filter

Median filter is the nonlinear filter, this is purely mathematical analysis and mostly complex. This is used to remove the noise in the input image.

$$\sigma_{med}^2 = \frac{1}{4n\, f^2(\overline{n})} \approx \frac{\sigma_i^2}{n + \frac{\pi}{2} - 1} \cdot \frac{\pi}{2} - - - (2)$$

The input power is represented asσ_i^2, n is the median filtering mask size, f(¯n) is the method of the density for noise.

Feature Extraction

Mean (M). The mean of an image is calculated by means of adding all the pixel values of an image divided by the sum number of pixels in an image.

$$M = \left(\frac{1}{mxn}\right) \sum_{a=0}^{m-1} \sum_{b=0}^{n-1} f(a,b) - - - (3)$$

Edge Detection

It is image processing method, which finds the edges of the images. This is used to detect the discontinuities in brightness. In this work, to progress the performance of the proposed appraoch the proposed edge detection technique is adopted.Prewitt operator is used for detecting edges horizontally and vertically.The antonym for the sharpening is blurring. In sharpening the edge content is increased and in blurring the edge content is reduced. To improve the content of the edges, firstly find the edges of the image.

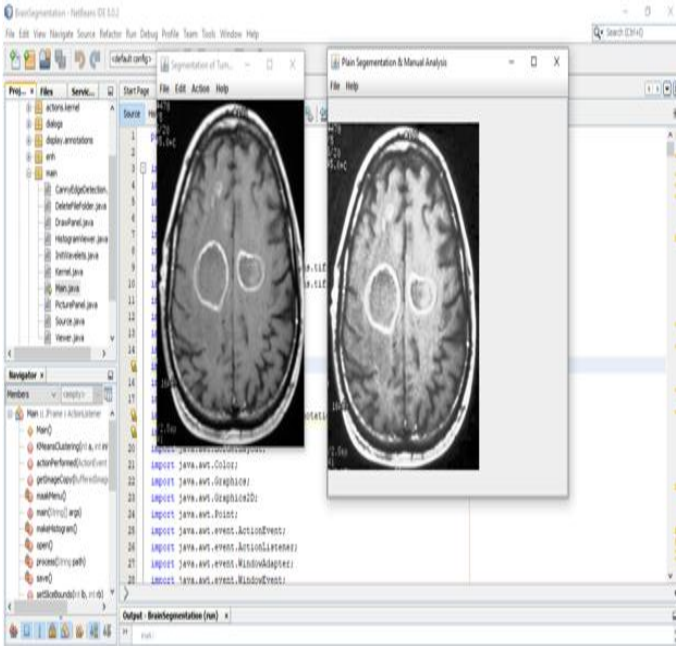

Figure 4 this is basic and manual image segmentation process

Proposed methodology

The proposed system is mainly focuses on detecting the affected area (i,e either tumor or edema) within the MRI scan image. Firstly this will segment the image into two parts affected and not affected area. All the dataset images are sent for training, after that pre-processing of each and every image for segmentation. These dataset images are grayscale images and the foreground of the images are located at the center. From the various angles the skull images are taken, hence the position and size of the tumors vary in different angles. Based on the size of the tumors the diagnosis of the tumor becomes harder. The direction of the

captured image can be known by the expert physician. In machine learning, the process is similar to the human learning process. This can be applicable for the deep neural networks.

Enhanced Learning Process Algorithm (ELPA)

Step 1: Input image
Step 2: Pre-processing
Step 3: Skull stripping using equation 2.
Step 3: Sharpening, Noise filter using equation 3
Step 4: edge detection.
Step 5: Results as shown in the figure 5 and 6.

Figure 5: This is the Semi-Automatic Segmentation

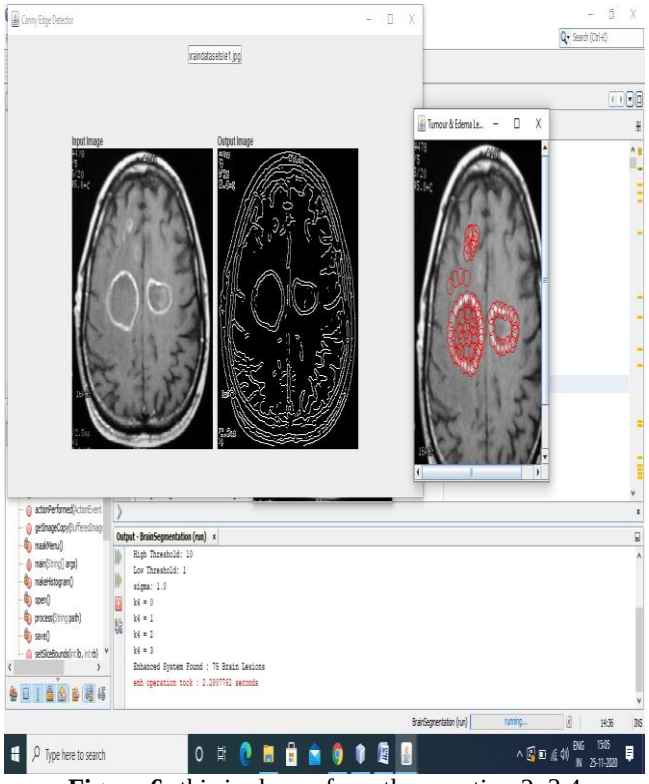

Figure 6: this is shown from the equation 2, 3 4

Performance metrics

The performance of the proposed methodology is calculating the various parameters such as False Positive Rate (FPR), False Negative Rate (FNR), Sensitivity, Specificity and Accuracy; General count values such as True Positive (TP), True Negative (TN), False Positive (FP) and False Negative (FN) are used by these measures.

False Positive Rate (FPR)

This will find the normal region of the image

$$FPR = \frac{FP}{FP + TN}$$

False Negative Rate (FNR)

This will find the abnormal region of the given brain image

$$FNR = \frac{FN}{FN + TN}$$

Sensitivity

This will find the sensitivity area of the input brain image is to be calculated.

$$Sesitivity = \frac{No.\,of\,TP}{No.\,of\,TP + No.\,of\,TN}$$

Specificity

This will find the specific abnormal area of the image.

$$Specificity = \frac{No.\,of\,TN}{No.\,of\,TN + No.\,of\,FP}$$

Accuracy:
This computes the overall accurateness of the input image

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN}$$

Experimental Results

The experiments are conducted by using JAVA and JDK 1.8 with net beans 8.0.2 as IDE. The hardware for the system to process these numbers of images are 8 GB RAM and 1 TB Hard drive with I3/I5 processor.

Table 2 Performance of the proposed approach

	Sensitivity	Specificity	Accuracy
Manual Segmentation	89.78	87.67	89.02
DCNN-F-SVM Model	90.87	88.67	91.21
ELPA	92.32	93.12	94.56

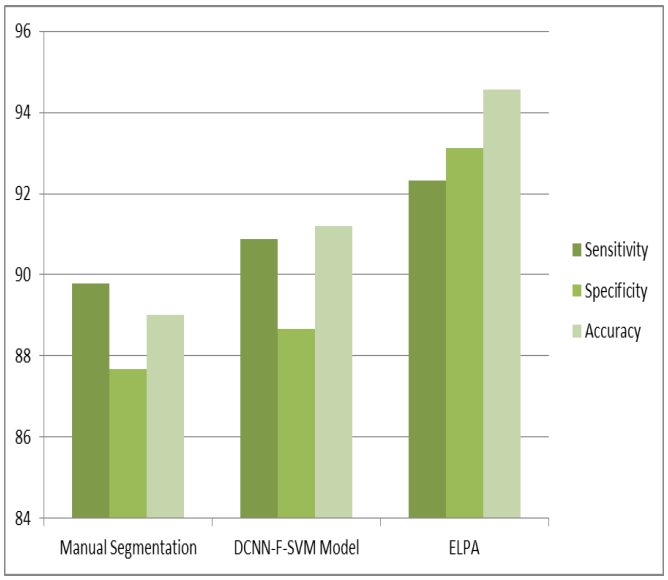

Figure 7: Performance of various existing and proposed methodology

Table 3 The average time taken for processing of every image

	Manual Segmentation	**DCNN-F-SVM Model**	**ELPA**
Average time taken for single image to detect Tumor	4.5312	3.2943	2.2807
Average time taken for single image to detect Edema	4.3974	3.0164	2.4088

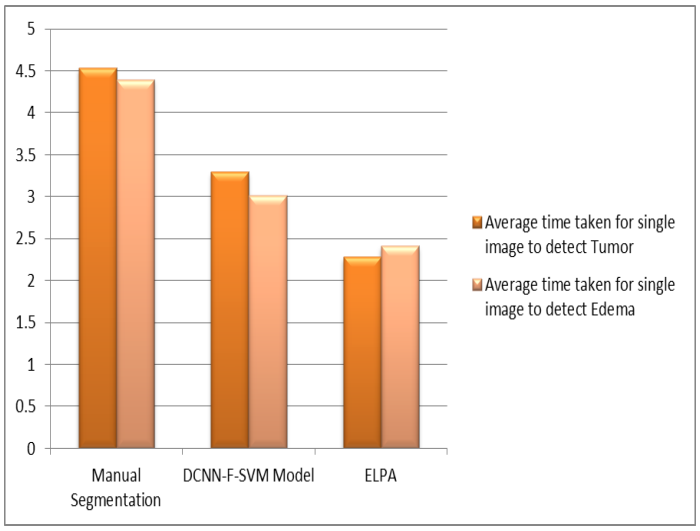

Figure 8: Performance based on the time taken to process the one image to detect the tumor and edema.

Conclusion

Diagnosis of the brain diseases such as tumors and edema needs high accuracy without any divergence. Any wrong analysis will cause the irreversible losses. In this paper, the proposed methodology Enhanced Learning Process Algorithm (ELPA) focuses on all the sides to solve the various issues and improves the performance in terms of results. Though the accurate detection of tumor becomes more complex the ELPA overcomes all the issues and performs well. ELPA is the combination of machine learning and images processing techniques. In future, the ELPA performs well, if ELPA is integrated with the deep learning algorithms the performance may improved.

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