A survey on methods for detecting brain tumor from MRI images

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Abstract: *Brain tumor detection from MRI images is a challenging process due to high diversity in the tumor pixels of different peoples. Automatic detection has got wide spread acclaim because the manual detection by experts is time consuming and prone to error in judjement.Due to its high mortality rate, detection of tumor automatically is a new emerging technique in bio medical imaging. Here we present a review of few methods from simple thresholding to advanced deep learning methods for segmentation of tumor from MRI data. The segmentation of tumor methods is classified to image segmentation using gray level processing, machine learning and deep learning. We compare the result of various method in an attempt to find the best methods available. As medical imaging methods have improving day by day we hope this review will help to understand emerging trends in brain tumor detection.*

Keywords— Brain tumor, MRI data, Machine learning, Deep Learning

I. INTRODUCTION

Brain tumor is found to be two types Low Grade Gliomas (LGG) and High Grade Gliomas (HGG). In this HGG is very serious if not treated will reduce the life time of an affected person considerably.Based on the type and location of tumor the symptoms may vary. Losing weight, fever, fatigue are some of the symptoms of tumor.

The majority of research in developed countries shows that the number of people having brain tumors was killed due to the fact of inaccurate detection. Among cancer brain tumor is the most rapidly developing cancer and therefore its correct and early identification will be a challenge. Brain tumor is a major type of cancer. The cause of brain tumor is abnormal growth of cells in the brain. The growth and death of cells in brain is balanced. If that balance alters brain tumor occurs. These tumors may be broadly classified into two namely malignant (cancerous) or benign (non-cancerous). Glioma is a common and malignant tumor, which may lead to short life span in their highest grade. Based on the type and location of tumor the symptoms may vary.

Gliomas are cancerous tumors which can be further classified in to High Grade Gliomas (HGG) and Low Grade Gliomas (LGG) [1], [2]. In these HGG is deadly compared to LGG. HGG can reduce the life span of a person to less than a year even if it is detected [3]. The early detection of cancer will certainly improve the life of an oncology patient, which is a major step of treatment. There are a lot of techniques to detect cancer but most of them detect the cancer in advanced stage, so the chance of recovery of the patient will be less. Due to overlapped structure of cancer cells the early detection of tumor detection is challenging. If the affected persons is in an advanced stage Doctor's suggest surgery, chemotherapy or Radiotherapy as treatments to cure the disease.

By using MRI (Magnetic Resonance Imaging) early detection of tumor is possible. But the large amount of MRI data to be processed is an overhead. Thus manual detection will be challenging. Image processing is used to segment the tumor parts in MRI images accurately. For early detection of tumor we use biopsy, Experts opinion etc. human prediction of tumor is less accurate and the existing biopsy test may take one or two weeks to produce the result. So automatic detection of tumor using image processing techniques are getting popularity.

The major benefit of using image processing technique is the time for detection will comparatively much lesser than manual detection. The location of the tumor can be detected by using image processing on MRI data. But the noise produced in the MRI data lead to false identification of tumors [4]. So to reduce the noise present in MRI data novel methods have to be used. Anisotropic Filters is a good example for noise removal. But here we took Total Variation (TV) as a method which is better than anisotropic filtering [5]. For detecting and classifying the features in a MRI data many techniques are used like SVM (Support Vector Machine), k-NN (k- Nearest Neighbour) [6], NN (Neural Networks) [7], Deep Learning Based CNN (Convolutional Neural Network) [8], [9] etc. Before applying classification techniques, pre-processing techniques should be applied.

II. LITERATURE SURVEY

P. Natarajan, N. Krishnan [10] suggests a simple thresholding based tumor identification. First the image is preprocessed to remove noise. Median filtering is employed for noise reduction and edge sharpening is also employed. Simple thresholding is used to segment the image. Morphological operations are also done to fine tune the result. Tumor is identified using image subtraction method. The method fails due to the illuminance invariance present in the MRI data.

Sahoo, Laxmipriya, et al. [11] use Support Vector Machine (SVM) for tumor classification. SVM is used either as a classifier or it is used for regression. In classification it creates a hyper plane to separate the features obtained from an image. Fig. 1. Show the SVM hyperplane for classification. SVM is also be used for regression. SVM algorithm analyze and recognize the special patterns present in the data. When the data is given the hyperplane is used to separate the features in to two thus it work as binary classifier [12].

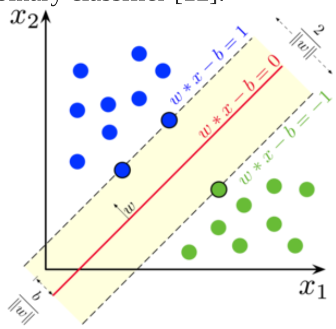

Fig.1.A typical Linear SVM classifier

The major disadvantages of SVM are the optimal features are not easily identifiable when there is nonlinearly separable data is present and the method is likely to give poor performance, if the number of features is much less than the number of samples.

Arriaga-Gomez and Miguel F et al [13] k-NN is one of the major distance-based algorithms; where given k as a positive integer and a sample feature vector (sample template), the k training features with the smallest distance to the sample is selected. The sample is identified as the most repeated among the selected k feature vector.

Ramteke R. J. and Y. Khachane Monali et al [14] proposed automatic classification for medical images. Abnormality detection in medical images are performed to classify whether tumor is detected or not.The major advantages of k-NN are simpler to implement and understand. The result will not be accurate always as it determines its class assignment by either getting a majority vote for them or averaging the class numbers of nearest k points.

S. Pereira, A. Pinto, V. Alves and C. A. Silva et. al [15] use Convolutional Neural Networks(CNN) to produce some great results. Convolving an image with kernels to obtain lower level to higher level features are the main application of CNN. In paper [8] single layered CNN is used so that the features used for classification is less when compared to deep networks.

Deep learning methods [16] use highly complex algorithm to extract the features automatically from the data provided. So importance is given to developing the architecture of the network rather than finding special features in the data. So here we propose Machine learning based SVM for classification and Total Variation (TV) filtering for Noise removal.

III. System Model

Noise in MRI images is due to the malfunction of the equipment and the environment in which it is placed. The MRI equipment noise is caused by field strength, RF pulse, RF coil, Voxel Volume and receiver bandwidth. The most common noise which affect an MRI image is Gaussian or salt and pepper. Both of these noise reduce the tumor detection performance of SVM classifier. Several de noising techniques are available. The most common methods are median filtering, histogram equalization and anisotropic filtering. But for de noising and enhance MRI data we propose Total Variation (TV) filtering. Methods like median filtering or linear smoothing reduce the effect of noise but affect import details such as edges. But TV filtering is based on the fact that images affected by sharp or spurious noise will have high variation. So the absolute gradient of the image will be high on these regions. In order to reduce the affect noise the gradient is to be minimized. This reduces the noise but also keep edge information than ordinary noise removal algorithms.

The total Variation de noising is expresses as

$$y = x + n; \qquad y, x, n \in R^n \qquad (1)$$

Where x is the original image and y is the image corrupted by noise n. To estimate x from y is by minimizing the objective function

$$E(x) = \min_{x} \|y - x\|_2^2 + \lambda \|\nabla x\| \qquad (2)$$

Where λ is called the regularization parameter which controls the smoothing operation performed on the image and ∇ is the gradient operator.

The entire process in the proposed method is shown in Fig.2.

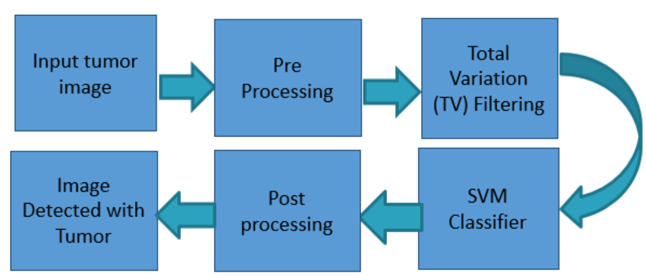

Fig.2.block diagram of proposed method

Tumor image:

The tumor image database is obtained from *https://figshare.com/articles/brain_tumor_dataset/1512427*.

The database contain 789 tumor images of 4 different categories. The images are in ordinary PNG format and can be easily processed.

Pre-processing:

Medical data is difficult to obtain. Also the data obtained will be taken by MRI machine using different conditions. So illumination variation is inherent. Pre-processing of the images reduce the illumination variation. Here normalization of the image is performed. The pre-processing operation is shown below

$$I(x, y) = \frac{I(x,y) - \mu(x,y)}{\sigma(x,y)} \quad (3)$$

Where μ is the mean value of the image and σ is the variance. The process convert the image to zero mean and unit variance.

Total Variation:

Total Variation filtering is performed on the normalized image using equation2. It is based on the principle that images having spurious noise have high total variation. So the gradient of the image is high. Reducing the gradient also minimize the total variation hence noise.

The process is iterative. We done 100 iterations per image. Noises like Gaussian and salt and pepper are successfully reduced. Here λ is the regularization parameter controlling the amount of de noising, smaller value implies more aggressive de noising and hence smoothed results. Some examples on tumor images have shown below.Fig.3. is the noisy MRI image.

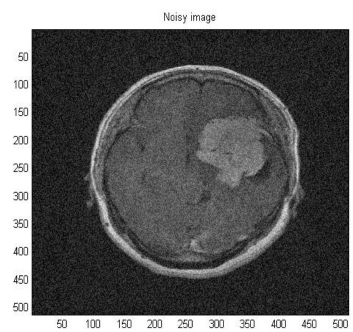

Fig.3.Noisy image

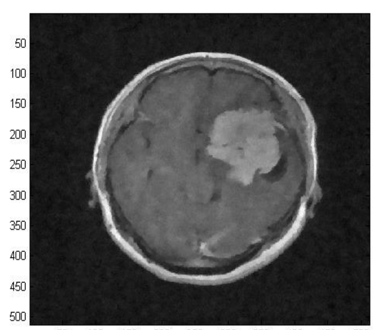

Fig.4. Total Variation de noising with λ=.01

Fig.4.clearly shows a smaller value of λ=.01 with 100 iterations reduces the Gaussian noise considerably.

SVM Classifier:

Machine learning is an application of artificial intelligence which learns from the observed data rather programed for finding a result. Machine learning make use of patterns in the data for learning and classification. Machine learning can be classified into supervised learning and unsupervised learning. In supervised learning a previously learned data and their labels are used for future events prediction. But in unsupervised learning there is no previous data or labels. Unsupervised learning is mainly used for regression analysis.

SVM comes under supervised learning models. Here we used a binary svm classifier which make use of pixel intensity for classification. A threshold value is used for labelling the pixels either as tumor pixels or non tumor pixels. The data set contains 789 tumor images and training of svm classifier is performed on 600 images. To get more images data augmentation can also be performed.

The learned model is applied on the remaining images and got good results. Along with total variation de noising SVM performs better than common methods like median filtering and machine learning. The training is done with 5 fold cross validation for better accuracy. Some of the results obtained are shown below.

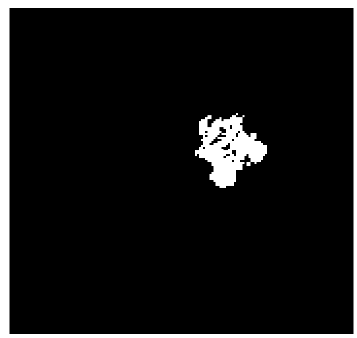

Fig.5.Tumor Area detected using TV de noising

And SVM classifier

Fig.6.Tumor Area detected in the presence of noise

And SVM classifier

The above results in Fig.6. Shows the need for removing the noise present in the MRI data before going for tumor detection. Fig.6. leads to inaccurate results in the presence of noise. Fig.5. Shows better tumor segmentation with TV de noising. Some morphological operations are performed if required after the classification. Fig.7 shows the classifier result for TV de noising

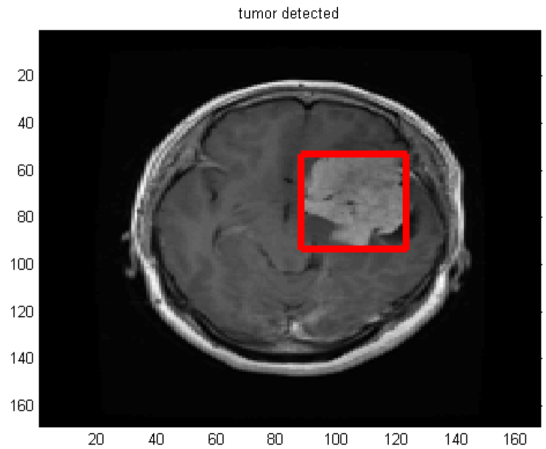

Fig.7.SVM classification

IV. EXPERIMENTAL SETUP, RESULTS AND DISCUSSION

The proposed method is validated on a publically available database. The dataset contains around 3000 tumor images along with the ground truth data. The proposed method is validated on the first dataset contains 766 images with tumor. *Evaluation:* The evaluation metrics used here are

$$Sensitivity = \frac{TP}{TP + FN}$$

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

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

Table 1 shows the Average value of Evaluation parameters for 769 images.600 images are used for training the classifier and 169 images are used for testing. The result obtained are compared with SVM classifier. Tabel1.Comparison of with de noising and without de noising.

Tabel1. Comparison of SVM with de noising and without de noising along with median filtering, Anisotropic filtering

Method	Sensitivity	Specificity	Accuracy
SVM with Noise	0.85	0.75	0.75
SVM+TV-proposed	0.90	0.98	0.92
SVM+ Median Filter	0.75	0.78	0.78
SVM+ Anisotropic	0.90	0.95	.90

V.CONCLUSION

The factors causing MRI noise is mainly due to the hardware. So it can't be avoided. Noisy data can lead to false tumor detection and leads to inaccurate results. The only method is to reduce the noise before going for tumor classification. Since SVM is a pixel based binary classifier each pixel is important. The proposed method outperform the commonly available noise reduction methods like median filtering, anisotropic diffusion. The obtained results clearly shows the advantage of the proposed method.

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