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SVM-KNN and Pixel Gradient based Segmentation Technique for Brain MRI Tumor Images Classification

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Abstract: The research paper proposes a novel and robust segmentation technique for the classification of Brain MRI Tumor Images. It is a completely automatic technique for the segmentation of tumor in a tumor pretentious brain MRI image with its classification from a normal image. In this technique, method is able to detect brain tumor utilizing the pixel intensities differences among the tumor and its neighbouring tissues. Here, it also uses the associated tumor's pixels labelling which can efficiently segments the brain tumor from the image. After that, SVM-kNN is exploited for the classification of brain MRI image from the normal one. For the feature vector's computation, GLCM technique is utilized. From the results, it can be observed that with only less number of feature vectors, in terms of speed and computational power used, the method is much better. As accuracy of nearly 98% is computed using the proposed method which is very good in comparison to the other methods used.

Keywords: GLCM, MRI, Solidity and Thresholding, SVM-kNN.

I. INTRODUCTION

In the world, Brain tumor [2] [12] is a foremost cause of death. It is caused by an evolution of some anomalous tissues inside the brain. Tumor is of two kinds: one is malignant tumor and the other is benign tumor. If the Malignant tumor is not detected at an early stage it can cause to death as it is cancerous in nature and has the ability to grow inside the brain. Hence, it is more precarious than the benign tumor. For such diagnosis, Magnetic Resonance Imaging (MRI) is used. MRI technique is utilized to detect the tumor in the brain by the Radiologists. They can observe a brain MRI image to accomplish whether it is a normal or cancerous image. In this field, there may be numerous images which need to be scrutinized. Therefore, it leads to decrease in the accuracy and increase in time consumption for the diagnosis. Hence, automatic classification method exploiting the computer technology is desirable so that an increase the accuracy can be achieved with minimum time consumption. The proposed method in this research paper has the following steps: (a) Image pre-processing, (b) segmentation, (c) feature extraction, and (d) classification. Image pre-processing is done to eliminate unwanted noise elements from the image so that it becomes apt for further processing. It is required for the perfect segmentation of tumor from the image. Segmentation is stated as the way in which only the preferred amount of part of the image is retained and the unwanted parts (i.e. noise) is eliminated. Here, it is done to extract the area of tumor in the image so that the classification may become easier and accurate. In the feature extraction stage, processing of some calculated parameters is made from the segmented images which are used as input to the classifiers for the classification. At this step, further reduction in the information of the image to a minimum level is occurred. For efficient classification, features which are extracted should be significant and beneficial. Now, at the classification step, classifiers are utilized to differentiate a normal image from a diseased image which are having tumor exploiting some of the classification algorithms. There can be so many such algorithms which have been already utilized for the classification purposes. These are as follows: Support Vector Machine (SVM) [1] [3], k-Nearest Neighbours (kNN) [4], Artificial Neural Network (ANN) [5], Probabilistic Neural Network (PNN) [6] etc. Each and every classifier has some benefits as well as shortcomings. k-NN [4] has the limitation of its high computational cost. It is also difficult in the kNN for choosing a proper value of 'K' parameter. Even though k-NN is very efficient in classifying something but its performance is degraded by its limitations. PNN [6] also has a problem of its very slow speed. ANN [5] also performs better than the above mentioned classifiers with the high dimension of feature vectors, but it also has a problem of high computational cost. As feature vector is small in our method, SVM-kNN will perform the best amongst all of the other classifiers.

The Research Paper is systematized as follows. Section II describes about the proposed method with block diagram. Section III tells about the experimental work used in the proposed method. The tumor classification and experimental results are shown in section IV followed by conclusion in section V.

II. PROPOSED METHOD

The block diagram shown in the Fig.1 represents the classification of brain MRI image of a normal person and a person having brain tumor. This proposed method

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contains the following sections: Pre-processing (RGB to grayscale conversion, resizing and filtering), segmentation, feature extraction, training and testing.

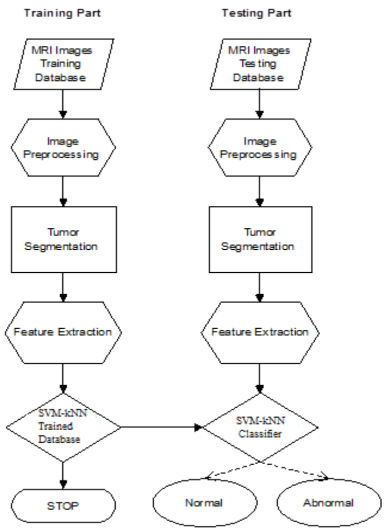
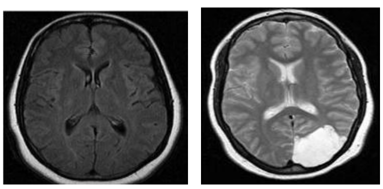


Fig.1. Block Diagram

Firstly, system is trained using the training dataset of brain MRI images for the training of classifier. After that dataset which needs to be tested is provided to the trained classifier which classifies it into two categories i.e. normal and abnormal (having brain tumor in this case) based on the training.

A. MRI Image

The Magnetic Resonance Imaging (MRI) is exploited for medical diagnosis of various diseases. It is considered as one of the best tools used in hospitals and clinics [7]. Advantages of having MRI images are: (a) It can provide very high contrast among the tissues, (b) It also checks on the body to exposure from ionizing radiations. MRI images of normal and abnormal brains, respectively, are shown in the Fig.2. It is clearly observable from the figure that the tissues which are affected by the tumor are having higher intensity as compared to the normal tissues.



(a) (b)

Fig.2. Brain MRI (a) Normal and (b) Abnormal

The images taken at the time of MRI are in the form of RGB images. Hence, before providing it to the model, images are being, firstly, converted to the gray scale image. It is also resized to a size of 500x500.

B. Pre-processing of image

At this stage, median filter is utilized for filtering the image and this is known as pre-processing of the image. Pre-processing is required because the image gets distorted due to the addition of noise at the time of acquisition and hence, the contrast of the image is also becomes low. This results in lowering of efficiency in the further steps of the analysis. Therefore, Filtering is desirable so that the noise can be removed and image contrast level can also be enhanced. In the Fig.3, Filtered image is shown.

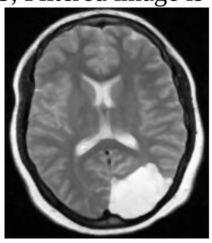
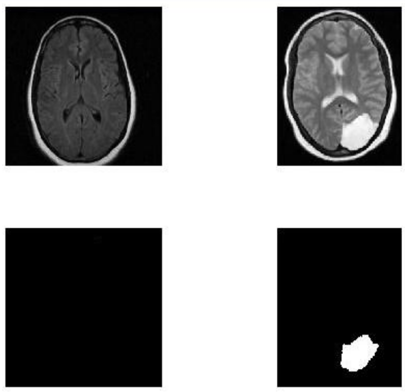


Fig.3. Filtered image

There are various filtering techniques present but here, median filtering is used because using median filter is advantageous in a way that it can eliminate the noise and preserve the edges which is helpful in improving the contrast of the image. Increase in tumor segmentation accuracy can also be done by this step.

C. Segmentation

Tumor detection is an essential task in the field of biomedical imaging. It is so because brain tumor is a severe disease and can cause death if it is not properly diagnosed. When any MRI image of the brain is taken, it is generally observed that the place where the tumor is present have higher intensity level compared to the neighbouring tissues intensity level. In this research, intensity values and solidity of the tumor is exploited to identify the tumor from its neighbouring tissues using the segmentation technique. Thresholding is the first step of segmentation. In this, the intensity values greater than the predefined threshold value is selected and using this, the values which are lower than the threshold values are ignored. The threshold values for the research are chosen by hit and trial method and 164 is the value taken during this research for the threshold. Even after thresholding, image still comprises unwanted regions along with the tumor region. For the removal of these unwanted regions, solidity and area [8] of the segmented regions are computed. For this, 0.2 value is selected for the solidity and only those regions which are having solidity values greater than 0.2 are to be considered as tumor intensity values. The second criteria of identification is the area where the maximum area of the region is considered as the tumor based region.



(a) (b)

Fig.4. (a) Normal Brain MRI with its segmented image and
(b) Abnormal Brain MRI with its segmented image

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After utilizing these properties, the brain MRI image is segmented to identify the tumor as the foreground image and neighboring tissues as background image. Fig.4 shows the segmentation results. In this, the two images are shown such that (a) represents the segmented image containing the tumor and (b) represents the segmentation of a normal MRI image. The segmented results are also represented as there counterpart images.

D. Feature extraction

After the segmentation, features extraction is a very vital role in the image processing or computer vision for pattern recognition and classification. A raw segmented image is not the ideal one to be given to the classifier directly for the classification purpose because it contains some unwanted data which only increases the computational time and cost of the analysis. Hence, some of the significant and important data points are extracted from the segmented image using the feature extraction process. These features extraction process contains many types of features such as intensity based features [12], texture based features [13] and shape based features [14]. Numerous features are computed from a segmented image which forms a feature vector. Now this feature vector is given as input to the classifier for efficient classification of normal and abnormal MRI image. In this research, we are using Grey Level co-occurrence matrix (GLCM) [9] technique for computing 5 texture features which constitutes a feature vector of 5x1 dimension for each image. Features calculated using GLCM are given as follows:

CORRELATION: Correlation is computed into what is known as the correlation coefficient, which ranges between -1 and +1.

$$Correlation = \sum_{j,i=0}^{N-1} G_{ji} \frac{(j-\mu)(i-\mu)}{\sigma^2} \quad (1)$$

CONTRAST: Contrast is defined as the separation between the darkest and brightest area.

$$Contrast = \sum_{j,i=0}^{N-1} G_{ji}(j-i)^2 \quad (2)$$

ENTROPY: Entropy is a measure of the uncertainty in a random variable.

$$Entropy = \sum_{j,i=0}^{N-1} -\ln(G_{ji})G_{ji} \quad (3)$$

HOMOGENEITY: Homogeneity is defined as the quality or state of being homogeneous.

$$Homogeneity = \sum_{j,i=0}^{N-1} \frac{G_{ji}}{1+(j-i)^2} \quad (4)$$

ENERGY: It provides the sum of squared elements in the GLCM .Also known as the uniformity or the angular second moment.

$$Energy = \sum_{j,i=0}^{N-1} G_{ji}^2 \quad (5)$$

Where G_{ji} is the Grey Level Co-occurrence matrix (GLCM).

E. Classification using SVM-kNN

Classification a process of classifying the data into their respective classes and this can be done in two parts: training and testing. During training, classifier is trained using the known data. And, after that unknown data is taken and given to that trained classifier for classification for testing. The efficiency of classification mainly depends upon the training. During this research work, SVM-kNN is utilized for the classification purpose. Support vector machine (SVM) [1] is an algorithm of classification which is based on the supervised learning model. And, SVM-kNN is a hybrid model of the two separate classifiers namely Support Vector Machine and k-Nearest Neighbour classifiers. According to the nearest neighbour approach, SVM utilizes only single representative point for each class as the support vector and hence, can be considered as a 1NN classifier [10]. However, in the hybrid of SVM and kNN, more than one support vector points are chosen from the sample points. Say these are k in number and hence, the class is decided for the tested samples.

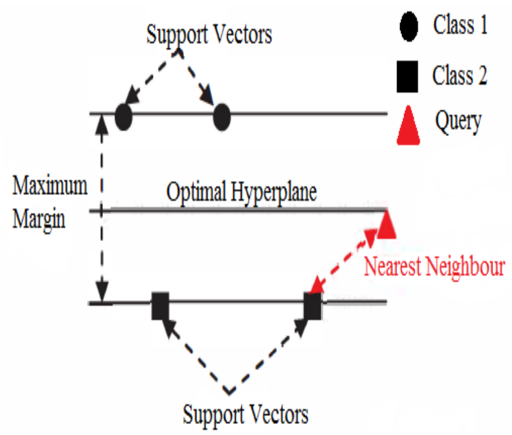

FIG.5. SVM-KNN CLASSIFICATION

It can be observed in the Fig.5 that SVM-kNN algorithm considers more than one support vectors as the representative points for any class. This is a much better classifier than the SVM because in SVM only sample point that is present nearest to the hyperplane represents the support vector. While in SVM-kNN, all the support vectors are considered as as representative points for the classes so that maximum of information of a class can be exploited in the classification process. During this analysis modeling, nearest neighbour (that is, support vector) is calculated as the query point utilizing the k-nearest neighbour algorithm. Performance of a classification algorithm can be measured by a specific table layout which is called the Confusion Matrix [10].

III. EXPERIMENTAL DISCUSSION

The proposed method, shown in the Fig.1, includes following stages: image pre-processing, segmentation, feature extraction and classification. At the image pre-processing stage, MRI images are first converted to grayscale from RGB and resized to a size of 500x500. Then median filter is utilized to remove noise from the image and to make segmentation accurate.

TABLE I
FEATURES EXTRACTED

GLCM FEATURES	NORMAL IMAGE	ABNORMAL IMAGE
Correlation	0.7867	0.9543
Contrast	1.7382 e-04	2.2134 e-04
Entropy	-2.4343 e06	-1.2361 e07
Homogeneity	0.9999	0.9999
Energy	0.99983	0.9922

During the segmentation stage, Tumor region is extracted from an abnormal brain MRI image leaving behind all other unwanted parts of the image. These stages make the classification process easier and faster as the unwanted portion is already removed. In the feature extraction stage, as the unwanted portion is already removed from the image, hence only 5 features are computed for the classification. As the number of features in the feature vector is small, the proposed method is fast and also takes less computational power in comparison to the other methods. During the classification process, training and testing is to be done. In training section, known data (i.e. 5 features*40 images) is given to the classifier for its training. After the completion of training, nor during the testing, 50 unknown images are given to this trained classifier for the classification. The classification is performed using SVM-kNN.

IV. RESULTS & DISCUSSION

In the proposed method, brain MRI images of 90 patients are utilized. From these 90 images, 40 images have been exploited to train the classifier and other 50 images are used for testing. Firstly, features are computed for the 40 training images which are given to the classifier (based on SVM-kNN). After the training, 50 unknown images have been selected and given to this trained classifier for classification into normal and abnormal (Tumor). In table II, confusion matrix is shown for the classification results of SVM-kNN. Accuracy is calculated based on the confusion matrix shown in Table II and it can be seen that accuracy is come out as 98%.

TABLE II
Confusion Matrix

	PREDICTED CLASS			
ACTUAL CLASS		Abnormal	Normal	Accuracy
	Abnormal	24/25	1/25	96%
	Normal	0/25	25/25	100%

TABLE III
Comparison of proposed method with other methods used.

REFRENCES	METHOD	ACCURACY
PROPOSED METHOD	Segmentation + SVM-kNN	98%
Sanchit Kumar, Sahil Dalal [1]	Segmentation + SVM	96%
Hari Babu Nandpuru et al [10]	Skull Masking + SVM	84%
Ketan Machhale et al [11]	Skull Masking + SVM-kNN	98%

Table III shows the comparison of the proposed method on the basis of the proposed technique and accuracy with the other methods. And our method i.e. SVM-kNN with segmentation gives much better results compared to the other methods with only fewer number of features used.

V. CONCLUSION

This research paper comprises of segmentation technique for the extraction of tumor region from the abnormal image. With that, its classification is also performed from the normal image using SVM-kNN. Results obtained from the proposed method shows very efficient results with an accuracy of classifying the brain MRI tumor images as 98%. This mehod is also advantageous in a way that it is fast in speed and exploits only small amount of computational power in comparison to the other methods.

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