Performance Comparison of FMRI Image Analysis Techniques

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Abstract— Functional magnetic resonance imaging (FMRI) is a neuroimaging process that utilizes MRI technique for measuring brain activity by the detection of associated blow flow change. Numerous methods for FMRI image analysis has been continuously evolving day by day. The techniques such as state vector machines (SVM) and linear neural networks are very common for the analysis of FMRI images. However, continuous efforts are being placed to improve the accuracy levels. So in this paper a new method for the classification of MRI images is proposed to meet the requirement. Convolution neural network (CNN) is a technique which is currently being used in the field of image processing. In this thesis work CNN along with k-means clustering, feature extraction and nuclei segmentation are implemented for the efficient detection of activated image features from a given set of MRI database. A set of 40 MRI images is collected and segmented by the technique known as nuclei segmentation. The noise is removed by cropping the non-brain portion from the images. Further, Feature extraction and k-mean clustering algorithm is implemented in order to extract features and partition them into the clusters. Finally, the classification is done by the methods including SVM, linear neural network and convolution neural network. The results are obtained in terms of accuracies and are compared with each other.

Key words: FMRI, CNN, SVM, Neuroimaging, Feature extraction, Accuracy

I. INTRODUCTION

Brain mapping is a branch of neuron science which is based on mapping of certain biological properties or quantities onto spatial representations which results in maps. Also it is the analysis of brain functions with the help of imaging techniques. Brain mapping includes all sort of neuroimaging. In fact it can be considered as advanced form of neuroimaging which produces brain images when results are provided by certain data processing techniques such as maps which projects behavior onto brain regions(for ex:FMRI). A connectogram is a map which describes cortical regions around a circle which are lobe organized. Different neurological measurements such as cortical curvature or thickness are represented by concentric circles within the ring. White matter fibers which are represented by lines in the center of circles depict the connections between cortical regions which are weighted by fractional anisotropy and strength of connections [1].

Now a day's brain mapping techniques are widespread in the field of neuroscience and they rely on evolution on various image acquisition, analysis, and representation and visualization techniques. Functional and structural neuroimaging are considered as an important aspect of brain mapping. With the advancement in the research technology and use of neuroimaging tools, FMRI emerges as a very prominent tool for analysis of human brain. FMRI can give high quality visualization of activity location in the brain resulting from any stimulation. It therefore allows the study of how the healthy brain functions, how it is affected by various diseases and how it recovers after any damage.

II. METHODOLOGY

A. Image Acquisition and Segmentation:

A set of 40 MRI images was collected from the website openfmri.org. The images correspond to the activation and non-activation group when a subject was allowed to listen to an audio track. The obtained images were then segmented into brain and non-brain regions. Here the process of image segmentation is done by the help of nuclei segmentation. In nuclei segmentation, active contours are used to place a boundary across the brain region. The contours so placed across the brain regions are then contracted in such a way that whenever it reaches across the boundary there becomes a mismatch in the gray level values and the contraction stops there and hence the boundary is obtained across the required brain region[2][3]. After the process of image segmentation noise is removed from the image just by cropping the rest of the non brain region.

Fig. 1: Image before segmentation

Fig. 2: Image after nuclei segmentation

B. Feature Extraction:

GLDM and GLCM are used for the purpose of feature extraction. Both of them provide certain features. The probability density function is obtained from gray level difference method and other features including contrast, correlation, difference variance, entropy, sum average, sum variance and geometric features are obtained from the other one.[4,5] The features are obtained in a 2-dimensional co-ordinate plane. Till now labels are not assigned to the features therefore for label assigning clustering is done in the next step.

C. Clustering:

After the process of feature extraction, the labels are assigned to the set of features in two dimensional space. The k- means clustering technique is implemented for the same purpose [6, 7]. In the current thesis work, two set of results are obtained. First by clustering the feature set into two clusters and second by clustering it into three clusters [8]. Former represents the two clusters as activation group and non-activation group. Latter represents the three clusters in non activation, partially activation and full activation groups.

D. Classification:

The final step of the work is the classification of the above clustered features. For the classification of features convolution neural network is used as a classifier. The clusters in the two dimensional space are separated from each other by the help of the CNN classifier. Results obtained by CNN classifier are compared with state vector machine (SVM) classifiers[9] and linear neural network[10]. The results are obtained in terms of accuracy, precision and recall value of the classifiers.

III. RESULT AND DISCUSSION

A. Results of Two Cluster Classification:

Accuracy is defined as the ability of a classifier to detect a true positive feature into true positive or a true negative feature into true negative. Precision tells about how many return documents are correct similarly recall determines how many positives do the model returns [11].

True Positive	False Positive
False Negative	True Negative

Table 1: Four possible outcomes

$$\text{Accuracy} = \frac{Tp+Tn}{Tp+Tn+Fp+Fn} \quad (1.1)$$

$$\text{Precision} = \frac{Tp}{Tp+Fp} \quad (1.2)$$

$$\text{Recall} = \frac{Tp}{Tp+Fn} \quad (1.3)$$

The results of the work are calculated for two clusters and three clusters. A comparison is done between obtained values of accuracy, precision and recall for different classifiers. Table 1.2 describes the accuracy, precision and recall values of the corresponding classifier for classification of two clusters. It is clearly shown that in case of two cluster classification, performance of CNN is best among all the classifiers.

Classifier	Accuracy (%)	Precision (%)	Recall (%)
Quadratic svm	63.33	63.84	64.025
Polynomial svm	63.33	65.28	64.93
RBF svm	70	69.445	69.005
Multilayer svm	33.3	33.97	34.84
Linear neural network	57.14	58.93	58.75
Convolution neural network	96.667	96.97	96.667

Table 2: Classification of two clusters

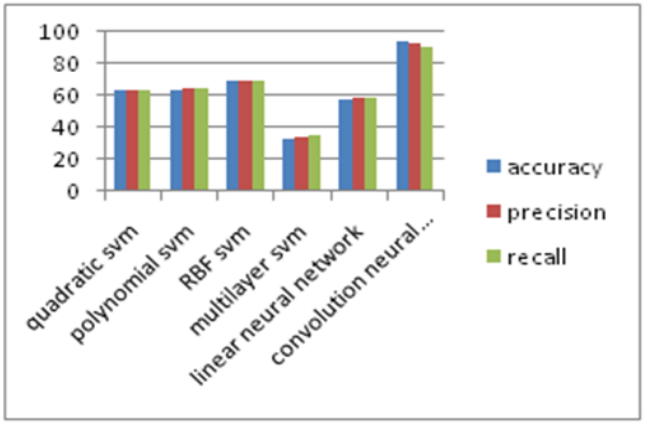

Fig. 3: Two cluster comparison between classifiers

B. Results of Three Cluster Classification:

Quadratic SVM, polynomial SVM, and multilayer SVM are not applicable in case of three cluster problem therefore accuracy, precision and recall values are obtained for RBF SVM, linear neural network and convolution neural network. This is shown in table 1.3. Here also in case of three cluster classification CNN performance is better than the other two classifiers.

Classifier	Accuracy (%)	Precision (%)	Recall (%)
RBF svm	86.67	86.97	76.97
Linear neural network	85.6	85.26	83.26
Convolution neural network	93.57	92.53	91.00

Table 1.3: Classification of three clusters

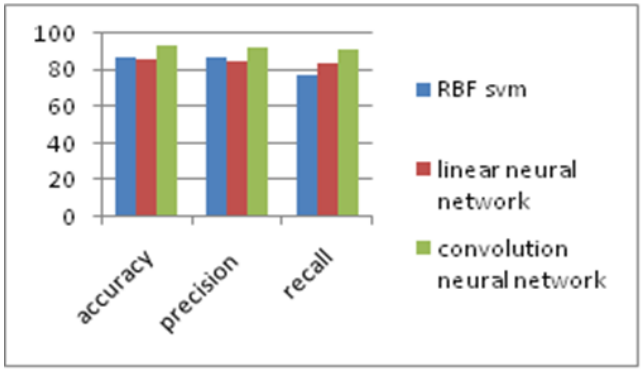

Fig. 4: Three cluster comparison between classifiers

IV. CONCLUSION

In this study, the main motive of the proposed method is to determine the accuracy level of the image classification. For this purpose images were collected and segmented by the nuclei segmentation. Features were extracted by gray level difference method and gray level co-occurrence matrix which was then further clustered by K-means algorithm. In the final step of the work, classification was done by using convolution neural network. The results of proposed method showed that an accuracy of 93.57% and 96.67% was achieved

for two clusters and three clusters respectively. Results were also carried out by the already used traditional methods. A comparison is done between the accuracy of all the techniques and it can be clearly seen that the proposed method has got some significant advantage over the others.

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