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A Survey on Computer Aided Techniques for Diagnosing Alzheimer Disease

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***Abstract*—Medical image processing is a fast growing and highly challenging field. Medical imaging Techniques are widely made use of in order to analyse the inner portions of the human body for the medical diagnosis. The Brain disorder such as Alzheimer is considered as a serious life threatening disease. The paper is basically a discussion and a comparative study on the computer aided techniques applied to the brain MRI images for diagnosing Alzheimer disease. The techniques like Principal-component-analysis PCA +SVM, Voxel-as-feature VAF +SVM, Non -negative - matrix factorization NMF+SVM and Probabilistic Neural Network-Radial Basis Function are discussed, and their performance, accuracy, specificity and sensitivity measures is evaluated.**

Keywords—Alzheimer Disease; Classification; Clustering; Computer Aided Diagnosis; Feature Extraction; Feature Selection; Probabilistic Neural Networks; Radial Basis Function; Region of Interest; Support Vector Machine

I. INTRODUCTION

The Content based image retrieval plays a significant role especially in the medical field, because thousands of images are produced by the hospitals everyday labelling them and classifying abnormalities by human intervention is a time consuming and difficult task and may not even be accurate. Alzheimer is a kind of dementia causing issues related to the memory, thinking capability and the behaviour of the person. [1] Alzheimer's is an intensifying disease, where the symptoms slowly worsen over a number of years and become severe enough causing difficulty in handling the daily tasks. Initially the memory loss is mild, but in the later stages the patient loses the ability to carry on a conversation and it becomes difficult for them to respond to the environment. Alzheimer is a leading cause of death ranked sixth in the list. The early diagnosis of such abnormalities can help temporarily slow down its worsening and thus improve the quality of life for those suffering from Alzheimer. Accurate result can be yielded only with the help of automated computer aided techniques. The computer aided tools have a very important role in making reliable and dependable decisions regarding such abnormalities apart from making such reliable decisions it also helps in providing a valid comparison among the brain images.

The further treatment planning depends on the accuracy with which the abnormality is detected; and the false detection may also cause wrong diagnosis leading to serious problem. The CAD tools consist of various stages for the final classification results from the initial input image database. [5] Feature selection and extraction are the most important processes done in the CAD tool, which is then followed by the process called classification. The different feature extraction approaches like Non-negative- matrix -factorization (NMF), Principle component analysis (PCA), and Voxel-as-feature (VAF) is applied to the SPECT image database, so as to extract meaningful and relevant information regarding the input source data as a result of this the features are reduced to its minimum. [5] The extracted features are then classification by the means of the classifier named support vector machine SVM. [6] This CAD tool using the supervised SPECT image for diagnosing Alzheimer's is considered to be of great value in reducing the bias involved in visually interpreting the SPECT images by the experts, and thus improving the efficiency of abnormality detection at its primary stage itself. [5]

The paper is planned as follows. In section 2 the related works and the methods are placed. Section 3 gives the results and discussions regarding the features like accuracy sensitivity and specificity of the varying techniques for the diagnosis of

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brain abnormalities. And with the section 4 the paper is concluded.

II. LITERATURE SURVEY

A. Feature extraction

In image processing, from the primary set of measured data, the relevant and informative features are extracted. [2] This process of feature extraction is also called dimensionality reduction. These reduced features are likely to contain only the features that are relevant for the further processing, and thus reduce the overall effort involved in handling the initial data input. A comparison among the (NMF) Non negative matrix factorization method, (PCA) principal Component analysis approach and the Voxel-as-feature (VAF) approach for feature extraction is discussed and these reduced features are then classified using the Support Vector Machine.[2]

B. Image Classification

The numerical properties of the image features are analysed and then this data is organised into categories and this process of categorizing data is called image classification.[3] Classification algorithms in general utilize two phases of processing such as i) Training ii) Testing. In the training phase, the feature properties of the image are isolated and, using these isolated properties a unique description of each classification category is defined, which is called the training class. [7] And these feature class partitions are used to classify the image features into the specific classes.

C. Support Vector Machine

The (SVMs) are relatively a steering classification technique that has their base in Statistical Learning Theory and apart from SVMs being highly robust and accurate in classification they are also quite effective even while using a small training sample and thus they are of high importance. By nature SVMs are binary classifiers, and so they can be chosen to handle the multiple classification tasks. The idea of Support Vector Machines is to use non linear mapping techniques to map the input data to the corresponding high dimensional feature space. The model describes the decision boundaries. [4] A decision plane marks the boundary between the collections of objects having dissimilar class properties. Support Vector Machine (SVM) is chiefly a classifier that classifies the data based on the hyper planes by separating them into the different class labels. [5] SVM also supports the task such as regression.

D. Non-negative Matrix Factorization

In the paper proposed by Padilla .P, Non-negative Matrix-Factorization (NMF) is used for extracting desired features of the query image. [5] The estimate of residual sum of squares RSS between the target matrix and its NMF is given in equation 1. It evaluates how well the NMF model reconstructs the original data.

$$\mathrm{RSS} = \sum_{ij} (\mathrm{Vij} - \mathrm{Vij}')^2 \tag{1}$$

$$1 - \frac{\mathrm{RSS}}{\sum \mathrm{ij}\ \mathrm{Vij}}^2 \tag{2}$$

NMF produces a sparse depiction of the data and this method gives accuracy up to 94% with highly specific and sensitive values.

E. Principle Component Analysis

It a statistical technique of high importance that is used for finding patterns in a high dimensional data. Principal component analysis is a mathematical way of transforming correlated variables into the corresponding uncorrelated variables, which is also called principal components. Y_i is a linear combination of original variables (x_i)

$$Y_i = a_{i1}x_1 + a_{i2}x_2 + \ldots a_{ip}x_p \; ; \; i=1..p \tag{3}$$

The new variables Y_i is derived in the decreasing order of importance and they are called principal components. The principal component analysis is performed either on the symmetric Covariance or the symmetric Correlation matrix.

$$C = \mathrm{Var}(X) \tag{4}$$

Here C is the covariance matrix of x_i The multi-dimensional data is accumulated together in a Table-Of-Real data matrix and is then normalized in case the units of measurement or the variances of the variables are different. In order to perform the analysis apply the PCA to the Real data and then from the newly obtained PCA objects a screen plot of Eigen values is sketched to individually study their importance.

F. Voxel-as-Feature

The feature selection is comparatively less efficient in classifying because though ROI is defined the number of voxels accumulated from the entire brain is usually very large.

A higher ratio of number of voxel features to the count of samples leads to over fitting. The presence of uninformative voxels in the training set reduces the generalization capability of the classifier. So while performing the feature selection the irrelevant features are removed and this reduces the dimensions in the workspace where the classifier operates.

Thus eliminating the danger of over fitting .Six different voxel selection approaches were adopted in order to decide which voxels are to be considered by the SVM classifiers. Voxel selection has a very crucial impact over the accuracy of SVM classifiers. [8] Taking into Consideration the accuracy in classification and time-consumption, linear SVM with a more number of voxel features and the RBF SVM with a small number of voxel features have a better accuracy and they cost shorter time. [8]

G. Probabilistic Neural Network-RBF

This method increases the classification accuracy in the functional brain images. The multi level wavelet method extracts and classify the features. Then morphological filtering technique segments the interested areas which are then compared with respect to the neighbouring pixel positions. [7] PNN has its base in Bayesian classification and it involves computing the probability density function. PNN is composed of three layers such as input hidden and the output. The input layer is responsible for calculating the distance between the input vector set and the training set that shows how closely they are related.[8] The hidden layer gives a summation of all the contributions for each class of input.[11] Output of this function depends on the Euclidean distance between Xi and Xj

$$K(Yi, Yj) = \exp(- \| Yi - Yj \|^2 / 2\beta^2) \quad (5)$$

Here $\gamma = - 1 / 2 \beta^2$ and β is a free parameter. On substituting it gives the following equation. In equation 5 the output depends on the Euclidean distance between data points Yi and Yj.

$$K(Yi, Yj) = \exp(-\gamma \| Yi - Yj \|2), \gamma > 0 \quad (6)$$

Radial basis function network is widely used because of its high training speed. As in case of PNN the RBF architecture also consist of three operational layers. [10] [12] each node in the input layer has a component of the feature vector. The second layer employs the non- linear transformation on the input set and the count of neurons related to the hidden neurons in the output layer equals the count of training classes. [9] The nature of the network is predicted by the count of hidden neurons and the activation function at the output layer. This method that combine PNN and RBF networks gives an accuracy of 98% sensitivity of 100% and specificity of 75% for the functional brain images.

TABLE1. FEATURE ANALYSIS OF TECHNIQUES NMF, PCA, VAF and PNN-RBF

FEATURES	ACCURACY	SPECIFICITY	SENSITIVITY
NMF	94%	93%	96%
PCA	93%	88%	96%
VAF	58%	<50%	<50%
PNN-RBF	98%	75%	100%

III. RESULTS AND DISCUSSIONS

Voxel-as-Feature when applied to a sample the count of relevant voxels within the region under consideration can be up to a thousand. And the ratio of the number of voxel features to the count of samples results in over fitting and also limits the generalization capacity of the classifier. This method is not reliable because it has a very low degree of accuracy and the sensitivity, specificity values are less than 50%.The combination of PNN-RBF methods increases the accuracy in brain image classification. [11] This method gives an accuracy of 98%, sensitivity of 100%, specificity of 75 % for the functional brain images. This approach is an efficient and effective to diagnose the brain disorders at an early stage. As compared to PCA and VAF the NMF method gives a higher accuracy, sensitivity and specificity ranges. It has an accuracy of about 94% while the other two methods PCA and VAF have 93% and 58% respectively. On comparing NMF and the PNN RBF method NMF has a greater specificity but

as the PNN RBF technique provides more accuracy and sensitivity and so this method is mostly preferred.

IV. CONCLUSION

This paper presented a comparison with respect to the various techniques adopted in dimensionality reduction and the classification of the brain images and also discussed the accuracy Specificity and the sensitivity range of each technique in terms of percentage. The Probabilistic Neural Network-RBF is proposed as it increases the classification accuracy of the brain images. The Probabilistic-Neural-Network-RBF is proposed as it increases the classification accuracy. Then the morphological filtering technique segments the brain images by comparing the area of interest with the neighbourhood pixels. This method gives an accuracy of 98%, sensitivity of 100%, specificity of 75 % for the functional brain images. This technique is an efficient method to diagnosis the brain disorders in an early stage.

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