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Parkinsons Disease Detection using Radial Basis Function Neural Network

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Abstract: Parkinson's Disease diagnosis is very crucial for effective management and treatment of the disease . Therefore there is a need of a system that will assist the doctors and the medical representatives in the diagnosis of the disease enabling timely and effective treatment of the disease.
In this research work, T1-weighted MRI images from Parkinson's Progression Markers Initiative database are used from which features are extracted using Gray Level Co-Occurrence Matrix (GLCM). The features obtained are then given as input to Radial Basis Function Neural Network (RBFNN) classifier which classifies patients into Parkinson's Disease (PD) and Non-PD patients where in the accuracy of about 97 % is obtained, hence making it a very reliable system.
Keywords: MRI, Gray Level Co-occurrence Matrix, Radial Basis Function Neural Network, PD, Non-PD

I. INTRODUCTION

Parkinson's disease is a progressive nervous system disorder that affects the quality of life of millions of people worldwide by basically affecting the movement of these people. It is caused by a loss of nerve cells in parts of the brain called the substantia nigra, which leads to reduction in a chemical called dopamine in the brain. Symptoms generally develop slowly over years. The progression of symptoms is often a bit different from one person to another due to diversity of the disease. The cause of Parkinson's disease is largely unknown and although there is no cure, treatment options vary and include medications and surgery. Therefore it is important to detect Parkinson's disease so as to enable timely and proper treatment. In this paper, substantia nigra region of an MRI image is cropped and GLCM feature extraction method is applied on the MRI image. The features extracted are then used to train a neural network so as to develop a system that will help in the diagnosis of Parkinson's disease.

II. PROJECT METHODOLOGY

The following algorithm is used in this paper.
Preprocessing, Feature extraction and Classification are all done using MATLAB R2017a software.

1) *Step 1:* MRI images are collected from an online PPMI database .
2) *Step 2:* Preprocessing stage
a) Median filter is used on the image so as to remove any noise.
b) Then image is then cropped twice to generate the ROI (Region of Interest) image.
c) Next the cropped image is enhanced by using Histogram equalization technique .
3) *Step 3:* Feature extraction- GLCM features are extracted from the image. The extracted features are then automatically stored in excel sheet.
4) *Step 4:* Classification- Classification into non PD and PD patients or detection is performed using RBFNN classifier.

The figure 1 below depicts the block diagram of the project.

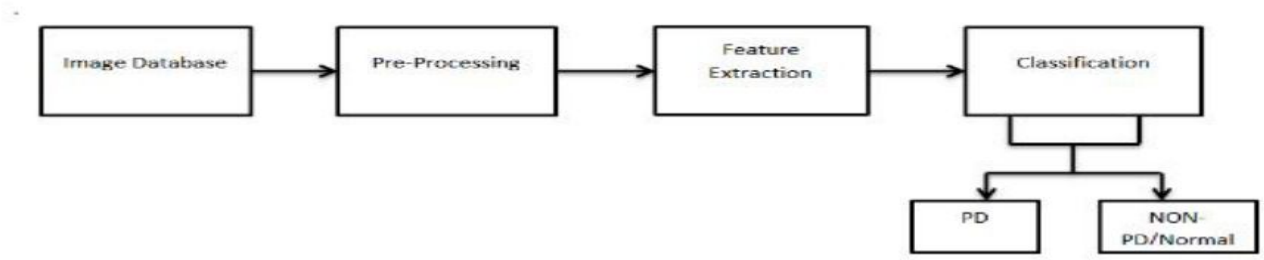

Fig 1: Block Diagram

III.DETAILED DESCRIPTION

This section gives a detailed explanation of the project work carried out.

A. Image Database Description

The image data-set for this paper is collected from an online PPMI database. A total of 240 T1-weighted MRI images of the brain are downloaded from PPMI, out of which 80 are PD subjects and 160 are NON-PD subjects.

B. Pre-Processing

1) *Median Filter:* Median filter is a spatial domain filter. The median filter is the most commonly used non-linear filter and it is widely used in digital image processing as it removes any noise present in the image while preserving its edges.
2) *Region of Interest Cropping:* ROI are samples within a data set that is identified for a particular purpose. In this paper the MRI image is cropped twice to obtain the substantia nigra region of the brain.
3) *Histogram Equalization:* Histogram Equalization technique is a technique that is used to adjust the image intensities so as to enhance image. It accomplishes image enhancement by effectively spreading out most frequent intensity values, i.e. stretching out the intensity range of the image. This method usually increases the global contrast of images and this method is useful in images with background and foregrounds that are both bright or both dark. This method of histogram equalization technique allows areas of lower contrast to gain a higher contrast. So in this paper histogram equalization technique is used to improve the contrast of the cropped image.

C. Feature Extraction

GLCM is a tabulation of how often different combinations of pixel brightness values occur in an image. In this paper 7 GLCM features are extracted from the processed images. The features extracted are contrast, correlation, homogeneity, entropy, mean and standard deviation.

The detailed explanation of these features are given below.

1) *Contrast:* It is a measure of intensity or gray level variations between the reference pixel and its neighbour. Large contrast reflects large intensity differences in GLCM

$$\text{Contrast}=\sum_{i=o}^{N-1} i \sum_{j=0}^{N-1}(i-j)^2 P(i,j)$$

2) *Correlation:* Correlation feature shows the linear dependencies of gray level values in the co-occurrence matrix.

$$\text{Correlation} = \sum_{i=o}^{N-1} i \sum_{j=0}^{N-1} P(i,j) \frac{(i-\mu_x)(i-\mu_y)}{\sigma_x \sigma_y}$$

3) *Energy:* It is derived from the Angular Second Moment (ASM). The ASM measures the local uniformity of the gray level. When pixels are very similar, the ASM value will be large.

$$\text{ASM}=\sum_{i=o}^{N-1} i \sum_{j=0}^{N-1} P(i,j)^2$$

4) *Homogeneity:* It measures how close the distribution of elements in the GLCM is to the diagonal of GLCM. As homogeneity increases the contrast typically decreases.

$$\text{Homogeneity} = \sum_{i,j=o}^{N-1} P(i-j) \frac{1}{1+(i-j)^2}$$

5) *Entropy:* It is the randomness or the degree of disorder present in the image. The value of entropy is the largest when all elements of the co-occurrence matrix are the same and small when all elements are unequal.

$$\text{Entropy} = -\sum_{i=o}^{N-1} \sum_{j=0}^{N-1} P(i,j)\ lnP\ (i,j)$$

6) Moment 1 is the mean which is the average of pixel values in an image and it is represented as

$$m_1 = \sum_{i=o}^{N-1} \sum_{j=0}^{N-1} (i-j)\, P\,(i,j)$$

7) Moment 2 is the standard deviation that can be denoted as

$$m_2 = \sum_{i=o}^{N-1} \sum_{j=0}^{N-1} (i-j)^2 P\,(i,j)$$

Where

$P(i,j)$ = Element i, j of the normalized symmetrical GLCM.
N = Number of gray levels in the image.
μ = is the GLCM mean.
σ^2 = is the variance of intensities of all reference pixels in the relationship that is contributed to the GLCM.
All the GLCM features extracted are only used for the purpose of training the radial basis function neural network and on training the neural network we obtain the threshold values and on the basis of these values classification is done.

D. Radial Basis Function Neural Network (RBFNN) Classifier
Radial basis function neural network is an artificial neural network that uses radial basis function as activation functions.
The output of the network is a linear combination of radial basis functions of the inputs and neuron parameters. The RBFNN is composed of the input, hidden and output layer.
Figure 2 shows the net file that is obtained on training the classifier.

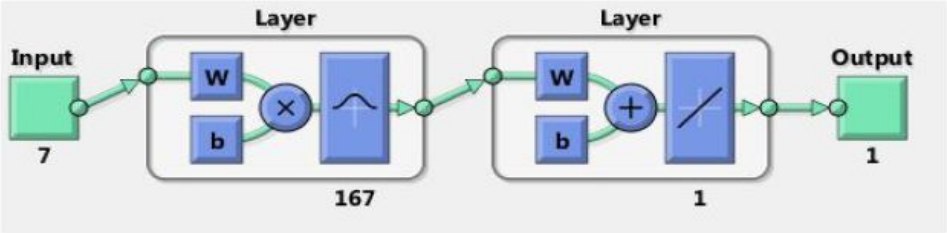

Fig 2 : Net file of RBFNN classifier

Training of RBFNN classifier is done by making use of stored extracted features.
The generated net file of the RBFNN classifier is used in this project work for detection of PD and Non-PD subjects. As shown in the figure the RBFNN classifier net file consists of one input layer and one hidden layer and one output layer.
As can be seen in the figure the hidden layer of RBFNN consists of 167 hidden neurons.
Figure 3 depicts the confusion matrix of RBFNN classifier obtained during the training phase.

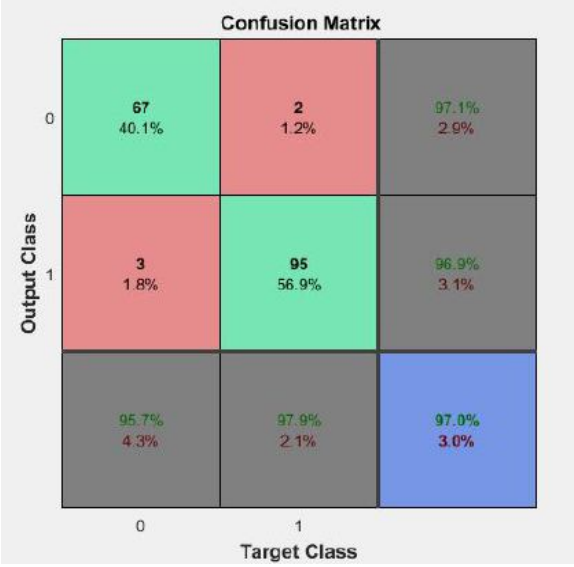

Fig 3 : RBFNN classifier confusion matrix

From the confusion matrix it is seen that Class 0 represents Non-PD subjects and class 1 represents PD subjects. In training phase a total of 167 subjects are used out of which 70 are NON-PD subjects and 97 are PD subjects. On training the RBFNN classifier it is seen that 67 Non-PD subjects and 95 PD subjects are correctly classified and 3 Non-PD and 2 PD subjects are wrongly classified. The RBFNN classifier used for training generates an accuracy of about 97% with an error rate of about 3 %.

IV. PREDICTION

After training the RBFNN classifier, the trained and saved net file is used for prediction or detection of Parkinson's disease. The total number of NON-PD subjects and PD subjects are 80 are 160 respectively.

During training stage different threshold values are obtained and the threshold value that gives a higher accuracy of prediction is chosen as the defining characteristic threshold value for detection and the defining characteristic threshold value for detection or prediction of disease is 0.05. Where all PD subjects have a threshold value greater than 0.05 and Non-PD subjects have a value less than 0.05.

V. CONCLUSION

In this paper, a RBFNN classifier was used for the purpose of classifying the patients into PD and Non-PD subjects.

An accuracy of 97% was achieved on using RBFNN as a classifier. Hence this system proved to improve the disease detection rate.

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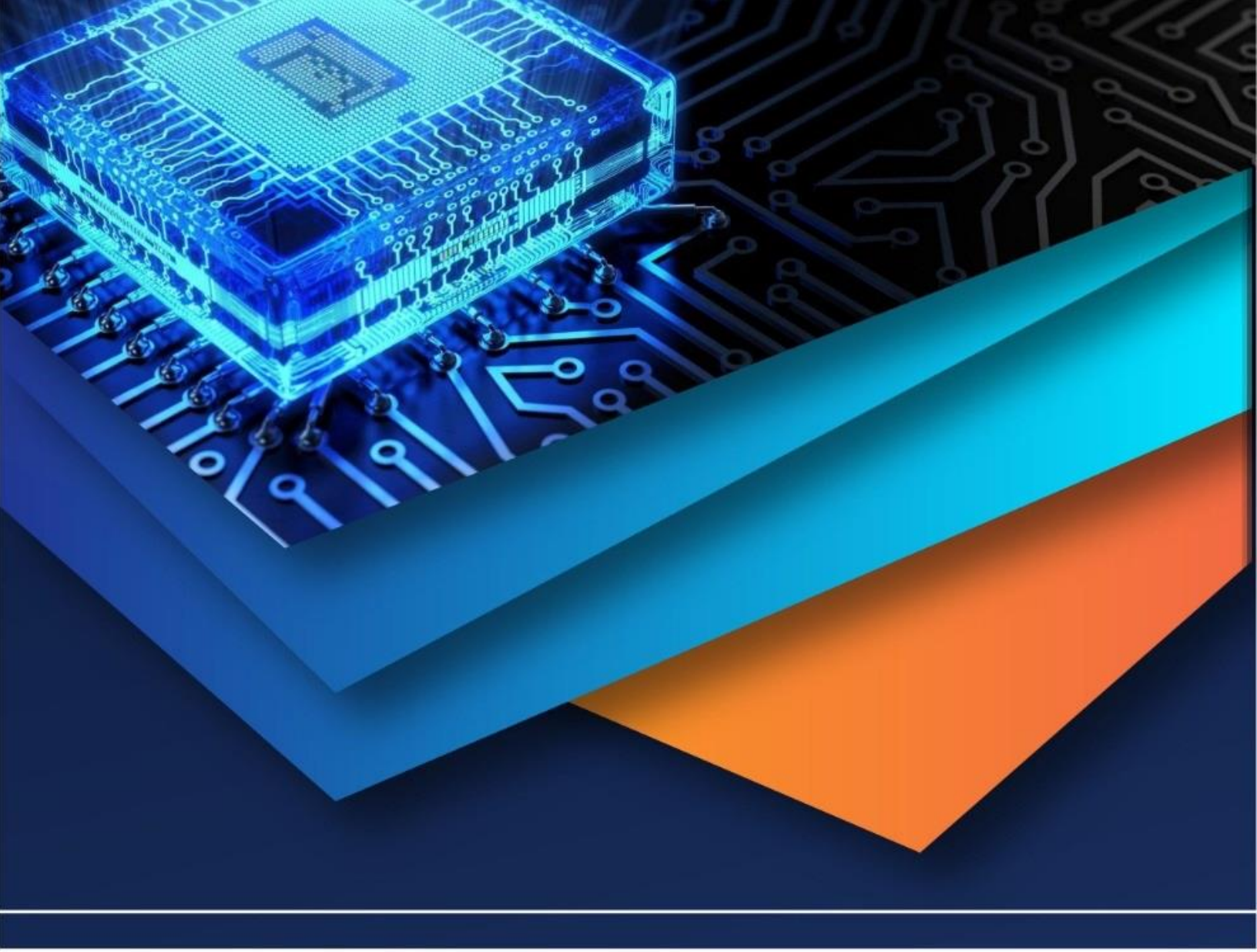

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