An Intelligent Computing Based Approach for Parkinson Disease Detection

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Abstract—**In this work various machine learning techniques such as support vector machine (SVM), nearest neighbor (k-NN), artificial neural network (ANN) has been used for detection of Parkinson disease. Input features are collected from the handwriting of various normal and Parkinson persons. The inputs and their corresponding targets are given to machine learning based methods. A comparative study of SVM, k-NN and ANN has been carried out. Accuracy of the proposed method is found to be 100% for all the tested data. Hence machine learning based methods can be put to use in real time scenario.**

Keywords— Machine Learning; ANN; SVM; k-NN; Parkinson's Disease.

I. INTRODUCTION

Parkinson's disease (PD) is a disorder in which motor reflexes of central nervous system are lost. Studies stated that Parkinson's disease occurs mostly in people over 50 years of age. PD ultimately causes loss of motor function symptoms which include tremor, impaired balance, etc. Different methods have been given for detection of Parkinson's disease. Some of the methods are discussed in the section below.

In [1], it was mentioned that voice recording with central tendency and dispersion metrics is useful. Considering that PD affects the handwriting motor abilities of patients, handwriting samples of PD patients are collected and analyzed. PD is predicted using machine learning and it was found that sustained vowels carry PD-discriminative information [2]. It is shown that handwriting samples collected with a computerized system can be used to build PD tele-monitoring systems. An automated method of tremor assessment has also been proposed which is based on feature extraction from accelerometer mounted on different parts of the body which can successfully quantify tremor severity [3]. Due to its regular assessment a tool has also been designed to monitor its symptoms [4]. In this the patients were asked to use the tool for four days and the data collected was capable to distinguish whether their medication is at its best or not.

In this work various machine learning based methods are used to distinguish between Parkinson's and normal person from handwriting recordings. The paper is organized as follows. Section II describes various machine learning based methods used, section III discusses the proposed methodology, results are discussed in section IV and Section V contains the conclusion of the work.

II. MACHINE LEARNING TECHNIQUESN USED

Machine learning has been used in various fields of engineering. Various machine learning techniques that have been used are SVM, k-NN, ANN etc.

A. Support Vector Machine

SVM is a supervised learning technique used for pattern recognition and classification. It creates various support vectors separated by hyper-plane. Based on a given labelled training data, the new input data are categorised. SVM based method first finds the hyper-plane to separate various classes. Margin is the term given to twice this distance. Therefore, the goal is to find an hyper-plane which maximizes the margin. The hyper plane of the SVM network is shown in Fig.1. The notation used to define the hyper-plane is shown in (1):

$$f(x) = \beta_0 + \beta^T x \qquad - (1)$$

Where β = weight vector.

β_0 = bias.

X = training examples closest to the hyper-plane which are also called support vectors.

B. Nearest Neighbor Algorithm

In k-NN algorithm the output of any unknown sample is predicted based on the number of nearest neighbor. In this algorithm, first the known cases are stored and new cases are classified based on a similarity using various distance. The samples are classified based on similarity with neighbours. Various types of distance measure used are Euclidean, Manhattan, Minkowski etc. A simple k-NN classifier is shown in Fig.2.

C. Artificial Neural Network

ANN is basically consist of input, weight, bias, transfer functions, outputs etc. In this work ANN used is a back-propagation neural network. It is a multilayer feed forward neural network [5]. A feed forward neural network is shown in Fig.3. The back-propagation algorithm is a generalization of least mean square algorithm. The sensitivities are back-propagated through the network from last layer to first layer. The back-propagation neural network is used in this work to determine the epileptic and non-epileptic signals.
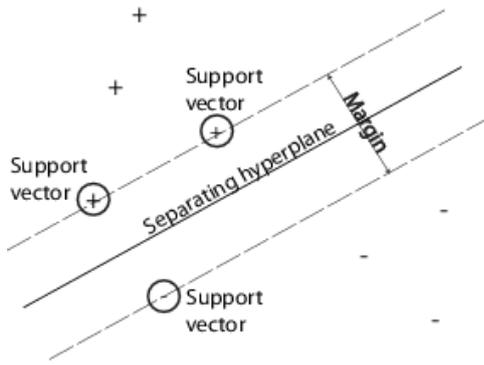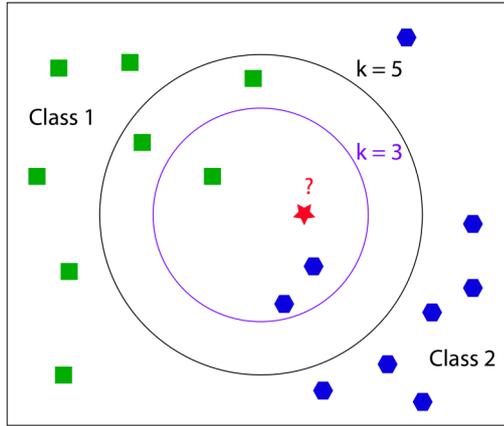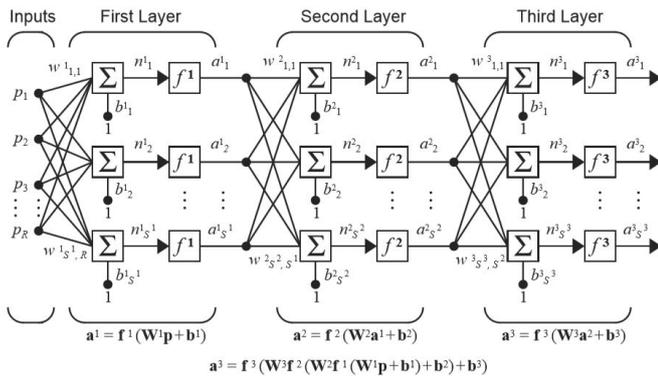
Fig.1. SVM Classifier.

Fig. 2. k-NN Classifier.

$$\mathbf{a}^1 = \mathbf{f}^1(\mathbf{W}^1\mathbf{p}+\mathbf{b}^1) \qquad \mathbf{a}^2 = \mathbf{f}^2(\mathbf{W}^2\mathbf{a}^1+\mathbf{b}^2) \qquad \mathbf{a}^3 = \mathbf{f}^3(\mathbf{W}^3\mathbf{a}^2+\mathbf{b}^3)$$

$$\mathbf{a}^3 = \mathbf{f}^3(\mathbf{W}^3\mathbf{f}^2(\mathbf{W}^2\mathbf{f}^1(\mathbf{W}^1\mathbf{p}+\mathbf{b}^1)+\mathbf{b}^2)+\mathbf{b}^3)$$

Fig.3. Three layer feed forward neural network.

III. PROPOSED METHOD

The proposed machine learning based method is described below in the following subsections. The flowchart of the proposed method is shown in Fig.4.

A. Dataset

The data set is taken from UCI machine learning database [6]. The handwriting database consists of 62 Parkinson's and 15 healthy individuals' data. In handwriting there are three types recordings, static spiral test (SST), dynamic spiral test (DST) and stability test on certain point (STCP). It determines the patient's hand stability or hand tremor level which will be helpful for classification.
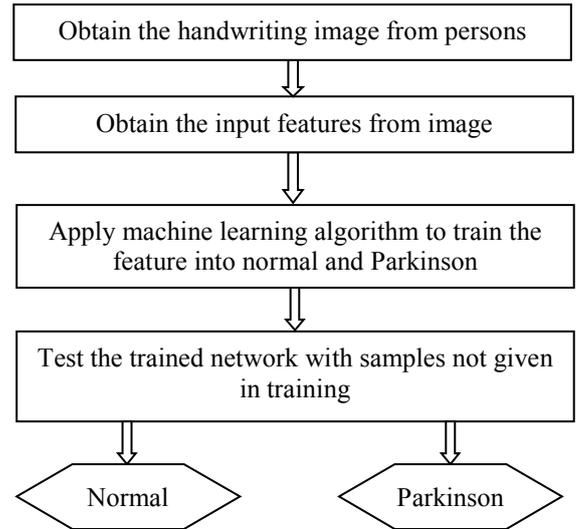

Fig.4. Flowchart of the proposed method.

B. Proposed Machine Learning Method

In this work various machine learning based methods such as SVM, k-NN, ANN has been used to predict normal and Parkinson's person using handwriting patterns. In SVM based method the input and targets are designed first. The normal person is selected as target '0' and the Parkinson's patients are targeted as '1'. The SVM based method is designed with radial basis function kernel. The accuracy obtained in SVM is 37.5%.

ANN is also used in this work. Back-propagation neural network is chosen as ANN for the problem. After various trial optimal neural network is obtained. The final neural network is a 3 layered network with tan-sig transfer function with 20 neurons in hidden layer.

In nearest neighbor algorithm the network is designed with various nearest neighbors. The final number of nearest neighbor chosen is 1. The distance used in this work is Euclidean distance. Table I shows the performance of the network for all the techniques. After the network is designed the performance of the method is evaluated which is described in the section below.

TABLE I. PERFORMANCE OF VARIOUS METHODS

Methods Used	Time	Network	Accuracy
SVM	20min	Radial basis function	37.50
ANN	24hour	Tan-sig	100
k-NN	5 sec	Euclidian distance	100

IV. RESULTS

The performance of the proposed machine learning based method for Parkinson's disease detection is evaluated. The performance of the method was evaluated in terms of %accuracy in detecting the Parkinson's disease.

A. *Performance with SVM*

The performance of the SVM network is analyzed in terms of time taken; mean square error and percentage accuracy. Confusion matrix obtained for SVM network is given on Table II. From all the results obtained it can be observed that the proposed method can detect the normal and Parkinson's disease using SVM but the accuracy can still be improved using other machine learning techniques.

TABLE II. CONFUSION MATRIX OF SVM FOR ONLY TEST SET

Predicted	Actual	
	Normal	Parkinson
Normal	12031	0
Parkinson	20186	79

B. *Performance with ANN*

The performance of the ANN based method is analyzed in terms of mean square error and percentage accuracy. The overall performance of the method is shown in Table III. From Table III it can be observed that Confusion matrix obtained for network is given on Fig.5. From all the results obtained it can be observed that the proposed ANN based method can detect the normal and Parkinson patients.

TABLE III. PERFORMANCE OF BACK-PROPAGATION NEURAL NETWORK

Network Architecture	Performance Goal	Accuracy (%)	Number of misclassified data
20-20-1	0.1	97.1	9430
20-20-1	0.01	99.8	795
20-20-1	0.001	100	83
20-20-1	0.0001	100	11

C. *Performance with k-NN*

The performance of the method with k-NN based method is also given. Table IV shows the confusion matrix of the k-NN based method. In this method there is no misclassified data unlike the k-NN based method.

TABLE IV. CONFUSION MATRIX OF K-NN FOR ALL DATA

Predicted	Actual	
	Normal	Parkinson
Normal	120310	0
Parkinson	0	202659

D. *Comparison of Machine Learning Techniques*

The performances of all the three methods are compared to obtain a suitable method. Table V shows the performance of all the methods. From table V it can be observed that SVM based method has less accuracy than ANN and k-NN. Although ANN and k-NN have 100% accuracy, ANN based method have some misclassified data. The time taken for ANN is also higher. Hence in comparison to other methods k-NN is better.
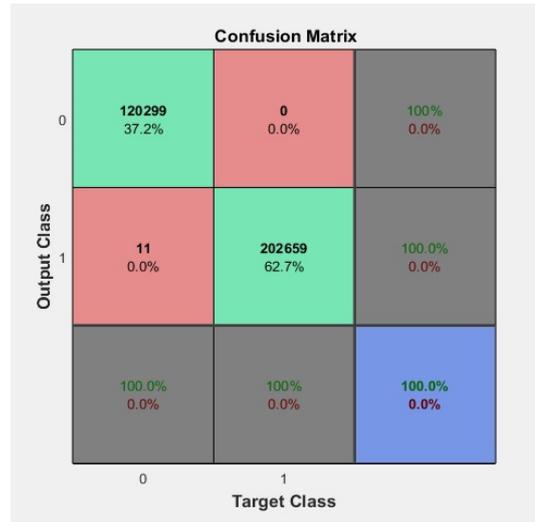

Fig. 5. Confusion Matrix of ANN for all data.

TABLE V. PERFORMANCE OF K-NN

Artificial Neural Network	SVM	K-nearest
No. of Layers:3 No. of Neurons:41 Transfer Function: Tan-sig Performance Goal: 0.0001 Accuracy:100% No. of misclassified data:11 Time:23h 26min	Classification function: rbf Accuracy:37.50% Time:20 min	Classification function: Euclidean distance Accuracy:100% Classified:100% Time:5 sec

V. CONCLUSION

In this work machine learning based methods such as ANN, SVM, k-NN has been used to detect normal and Parkinson condition. The performance of the ANN and k-NN based method is 100% accurate with all the tested cases. Although ANN and k-NN have same accuracy, ANN based method have some misclassified data. The time taken for ANN is also higher. Hence in comparison to other methods k-NN is better. The future work of the method can be to implement the method in hospitals and check the accuracy of the methods.

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