Soft Computing based approach to diagnose Parkinson Disease Patient along-with Gender and Age

A project report submitted in partial fulfillment of the requirements for B.Tech. Project

B.Tech.

by

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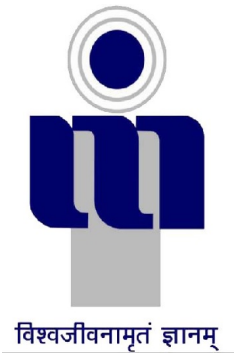

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CANDIDATES DECLARATION

We thus confirm that the work, which is being exhibited in the report, entitled **Soft Computing based approach to diagnose Parkinson Disease Patient along-with Gender and Age** , in halfway fulfillment of the prerequisite for the Degree of **Bachelor of Technology** and submitted to the institution is an authentic record of our own work carried out during the period *May 2015* to *September 2015* under the supervision of **Dr. Ritu Tiwari**. We have additionally refered to the reference about the text(s)/figure(s)/table(s) from where they have been taken.

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Date: Signatures of the Research Supervisors

ABSTRACT

In this report Parkinson Disease which involves malfunctioning and death of vital nerve cells in brain is discussed. Algorithms are proposed here which can predict a person's age, his/her gender and Parkinson health status. Gender and Age are part of Biometric for human recognition. These algorithms are based on Artificial Neural Network Algorithms . The approach is based on Human Gait Features, the various ways human can move. In this report mainly walking is considered as gait, that is a gait which keeps at least one foot in contact with the ground at all times. Gait of 162 subjects (97 patients and 73 healthy) from the datasets collected from PhysioNet is considered here and classification is done using proposed algorithms and results are compared to check the efficiency of proposed algorithms.

Keywords: Artificial Neural Network (ANN), Gait, Parkinson disease, classification, Gender, Age.

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(Himanshu Meena) (Kusum Dhalia) (Pooja Bhimte)

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ABBREVIATIONS

ANN	Artificial Neural Network
VGRF	Vertical Ground Reaction Force
MSE	Mean Squared Error
%E	Percentage Error
RBF	Radial Basis Function

NOTATIONS

G	Gaussian Radial Basis Function
ω	Gaussian Radial Basis Function
w_i	weight

CHAPTER 1

INTRODUCTION AND LITERATURE SURVEY

This chapter includes details of artificial neural network , gait features, our objective , platform used to implement the project and literature review related to work done in this field.

1.1 INTRODUCTION

In this section we briefly describe our project in which human age classification, gender classification and Parkinson disease recognition is implemented by artificial neural network.

1.1.1 Artificial Neural Network

Artificial Neural Networks (ANN) is an interconnection of artificial neurons which are electronic models of natural neurons.Neurons are assembled into layers. The main layer which interacts with nature to get data is known as the input layer. The last layer that interfaces with the yield to exhibit the prepared information is known as the output layer. Layers between the information and the yield layer that don't have any cooperation with the environment are known as hidden layers.
These neurons basically consist of inputs (like synapses), which are multiplied by weights (strength of the respective signals), and then computed by a mathematical function which determines the initiation of the neuron. Another function (which may be the identity) calculates the output of the artificial neuron (according to a threshold). ANNs combine artificial neurons with a specific end goal to process data. The computations depend upon the weight, as information lies in weights. [Shukla et al. (2010)]

1.1.1.1 Related Definitions

(i) **Supervised Learning:** Supervised learning is the machine learning assignment of deducing a capacity from marked training information. The training information comprise of both input as well as targets.

(ii) **Epoch:** These are basically iterations. In ANN, once the system process the input, the whole process is processed iteratively again and again in order to make the system more efficient and accurate.

(iii) **Learning Rate:** It is defined as the rate at which the system learns. There are a number of training parameters which control the extent of weight and the extent of learning of the Training algorithm.

A general artificial neural network can be represented as follows:

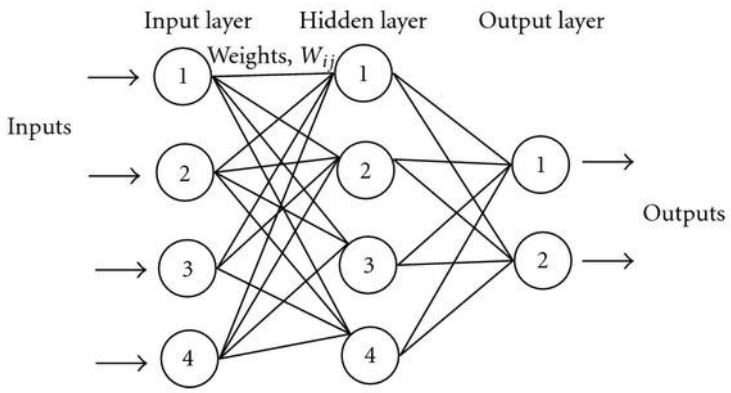

Figure 1.1: Artificial Neural Network. [asiaforest.org (2008)]

1.1.1.2 Neural Network Classification

Classification is a decision making process in which an object needs to be allocated a predefined class or group on the basis of characteristics that it holds. Neural Networks are important as well as a fast technique for classification . The previous research works in ANN classification shows that neural networks are a better alternative to various traditional classification methods. Neural networks are able to calculate the rear probabilities , which helps in setting up the classification rule and executing statistical analysis. The advantage of using neural network for classification can be understood by following points:

1. Neural networks are data- dependent, self-adjusting approaches in which they are able to adjust themselves to the data without any description of function for the model.

2. ANN are global operational approximators because they approximate functions with random accuracy.

3. Neural networks are non-linear prototype, and they are flexible in modeling real world complex relationship.

1.1.2 Gait Features

Human gait is basically locomotion through the movement of human limbs. Scientifically, it can be defined as bipedal, biphasic forward propulsion of center of gravity of the human body, which consists of alternate sinuous movements of different parts of the body so that there is minimal expenditure of energy.

1.1.2.1 Definitions

(i) **Gait Analysis:**It is the systematic study of motion of any object, which is done by measuring body movements using devices and techniques, body mechanics and muscular activity. Gait Analysis is a process in which gait features are identified, quantified in measurable parameters, measured through different techniques and interpreted for the desired result.

(ii) **Ground Reaction Force:** The reaction force supplied by the ground, in reaction to the force applied by the body on the ground is called ground reaction force. It has three components:

- Vertical component
- anterior-posterior
- medial-lateral

The highest magnitude component is Vertical component, which is called Vertical Ground Reaction Force (VGRF).It is mainly generated by the vertical acceleration of the body. VGRF is measured using force plates or sensors. [Jenkins and Ellis (2007)]

1.1.2.2 Data-set

The data-set has been taken from PhysioNet.org. PhysioNet is resource of bio-medical researches. It contains large collections of recorded physiologic signals. The data-set contains measures of gait from 93 patients suffering from Parkinson Disease and 73 healthy controls. It includes VGRF records of subjects, as they walked at their usual

pace for 2 minutes on a level ground. VGRF is measured using the 8 sensors underneath each foot. Sampling rate is 100 samples/sec. It also consists of the demographic information of the subjects. [physionet.org (2007)]

1.2 MATLAB

We have used the MATLAB to implement and execute our project. MATLAB is a numerical computing environment and fourth-generation programming language developed by MathWorks. We have used Neural Network Toolbox (nntool) and Neural Network pattern-recognition Toolbox (nprtool) in our project. Neural Network Toolbox simulates and analyzes the networks.

The toolbox lets us model different neural network architectures and implement them in quite simple way.

Key Features

- GUIs for building, training and testing the given data-set in artificial neural networks.
- Support for a number of classification, clustering and pattern recognition algorithms
- Provides a window, which allows you to import, produce, utilize, and export neural networks and data.

Version - MATLAB (R2013a)

1.3 LITERATURE REVIEW

The extensive literature survey has been done for the project. Starting from the basics of neural network, gait features, VGRF has been the main topic of study. In Zhang (2000), the advancements in the field of neural network classification has been summarized. It also takes in account the convention computational method and the issues with it are defined. A relationship between neural network and conventional classifier has been established in order to compare the both.

According to Kale et al. (2004), a view based method to identify human using their gait features has been proposed. Two different image features were considered: The first one was the outer contour of the binarized silhouette of the person while walking and second one was the entire binary silhouette. Based on the studies in referenced paper ,they employed two approaches to obtain observation vector from the image features. In the first approach(indirect approach),by generating the frame to exemplar (FED) distance ,the high dimensional image was transformed to a lower dimensional image .It is concluded that for effective gait recognition, the gait details in the FED vector sequences is received in hidden Markov model(HMM). In the second approach which was direct approach, they processed with features directly and trained an HMM. The

estimation of HMM parameters was based on the distance between the exemplars and the image features. It was concluded that the statistical behaviour of HMM provides complete robustness to recognition.

In a research by Shukla et al. (2012) biometrics were used as an advanced way for person identification. Biometrics consider measurable physiological features of a person. Here, gender identification using human gait in images has been investigated. The features (center of mass and height of person) were used and then computer-vision based gender recognition was performed on the basis of discussed features and standard deviation and Feed Forward Back Propagation algorithm. MSEREG was used as performance function. With experiments results it was demonstrated that the recognition performances were observed by using different number of neurons and layers.It was observed that replacing performance function with SSE provides performance increment.
In Lee and Mase (2001),a method is proposed walking behavior of pedestrian which is completely based upon gait. The gait feature here examined is acceleration of the subject. It recognizes whether the person is walking on level ground, up or down.

In Bakar et al. (2010), Multilayer Perceptron algorithms have been used to detect whether a person is suffering from Parkinson disease or not taking ANOVA as a feature selection. In Ramani and Sivagami (2011), author has used a number of classification and machine learning tools for Parkinson Disease recognition and has compared them.

In Horng et al. (2001), Age- group classification has been performed using image processing and backpropagation ANN.

In Kurban and Beşdok (2009), RBF networks has been compared for classification. Its performance has been evaluated as it is quite efficient in signal processing and time-series analysis. Kala et al. (2009), proposes a faster neural network algorithm, which trains the neural network faster than the pre-existing algorithms.

1.4 OBJECTIVE

The main objective is to propose the efficient neural network algorithms for Parkinson Disease, Gender and Age classification. We use Vertical ground reaction force (VGRF) as gait feature to classify the given data. We train and test the data-set using different neural network classification algorithms in Matlab. Finally, we compare these algorithms on different parameters and performance measures.

CHAPTER 2

DESIGN DETAILS AND IMPLEMENTATION

To recognize the pattern and classify the given data-set, we need artificial neural network architecture. To understand the concept of neural network classification we have considered the algorithms, which are discussed below.

2.1 Classification Algorithms

2.1.1 Scaled Conjugate Gradient Back-propagation:

Basically it is a multi-layer feed-forward network in which error is propagated backwards i.e. from output layer to hidden layers and then to input layer.
This algorithm is an iterative algorithm in which MSE and %E are minimized. In Scaled Conjugate Gradient (SCG) algorithm the quadratic approximation of the error E in a neighborhood of a point w is denoted by:

$E_{qw}(y) = E(w) + E`(w)Ty + 1/2\ yT\ E`(w)y$

The linear system defined by Moller determines the critical points for $E_{qw}(y)$ as follows:

$E`_{qw}(y) = E`` (w)y + E` (w)=0$

SCG is a member to the class of Conjugate Gradient Methods, which show linear convergence on most problems.It is faster than other second order ANN algorithms because it uses a step-size scaling mechanism, such that for each learning iteration line-search is not required. And also we get better results than other training techniques and neural networks tested as standard back-propagation. [Orozco and García (2003)]

2.1.2 Radial Basis Function:

Radial Basis Function is an ANN architecture in which radial function is used as activation function. It is time efficient than backpropagation if data is large. [Wikipedia (2015)]

In RBF, vector of real numbers are supplied as input, which in case produce scalar function of input as an output. In pattern recognition the unit corresponds to a subclass. The hidden node consists of a basis function which depends upon center and width. Center is any point with same dimension as input vector. Then Euclidean distance is calculated for each unit *i* in input. This distance is given as parameter in basis function to produce output of the hidden node. This basis function is generally Gaussian function for classification. [Orr et al. (1996)]

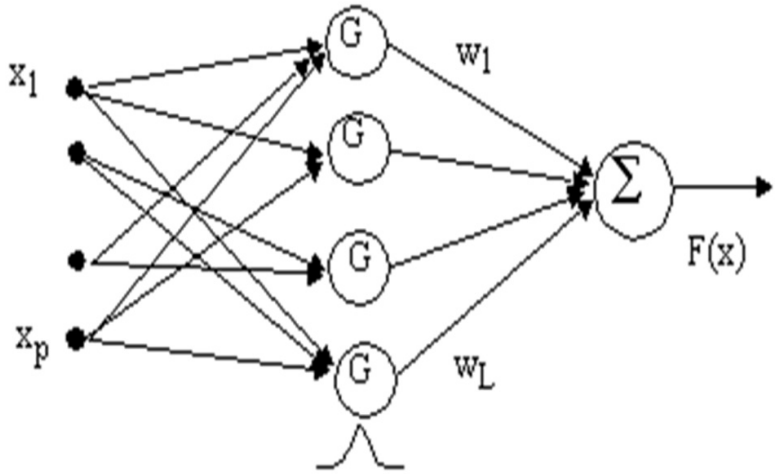

Figure 2.1: Radial Basis Function Neural Network.[Bors (2001)]

2.1.3 Layer Recurrent:

These are utilized for information in which a sequence depends upon the earlier one. Mathematical formulation of layer recurrent neural network:-
Recurrent neural networks learn from sequences. A sequence is defined as a list of (x_i,y_i) pairs, where x_i is the input at time i and y_i is the desired output. There are collections of sequence in the data-set.

- Input vector x_i (data)
- Output vector y_i (data)
- Predicted output vector y_i (computed through forward propagation)

- Hidden state h_i

When looking only at a single timestep, the recurrent network looks like a simple one-hidden-layer feed forward network. In this network x_i denotes input layer, y_i, denotes for output layer and h_{i-1} refers to the previous hidden layer, which is also an input. Then, there is a hidden layer between input and output layer. The thing which is different in this architecture is that it has two input layers; both of the input layers are connected to the hidden layer as a single layer.

Thus, there are three separate matrices of weights:

- Input-to-hidden weights W_{hx}
- Hidden-to-hidden weights W_{hh}
- Hidden-to-output weights W_{yh}

Hence, the forward propagation of network can be represented as follows:
$h_i = \sigma\ (W_{hh}\ .h_{i-1} + W_{hx}\ x_i + b_h)$

Main point is that, these equations are the same as the equations for a single hidden layer feed forward network, with the understanding that the input layer is broken into two pieces xi and h_{i-1}. [Gibiansky (2014)]

2.2 IMPLEMENTATION/EXECUTION OF THE PROJECT

The Project has been implemented using **nprtool** and **nntool** in MATLAB. These command in MATLAB open GUI window, which takes training data and target as input.

2.2.1 Scaled Conjugate Gradient Back-propagation:

This algorithm has been implemented using nprtool in MATLAB. It solves the classification problem with 2-layer feed forward network with sigmoid transfer function in hidden layers. Data is randomly divided into three parts for training, validation and testing. No of neurons for hidden layer are set and network is trained. Performance measures are mainly MSE and %E. After training, results can be visualized using confusion matrix.

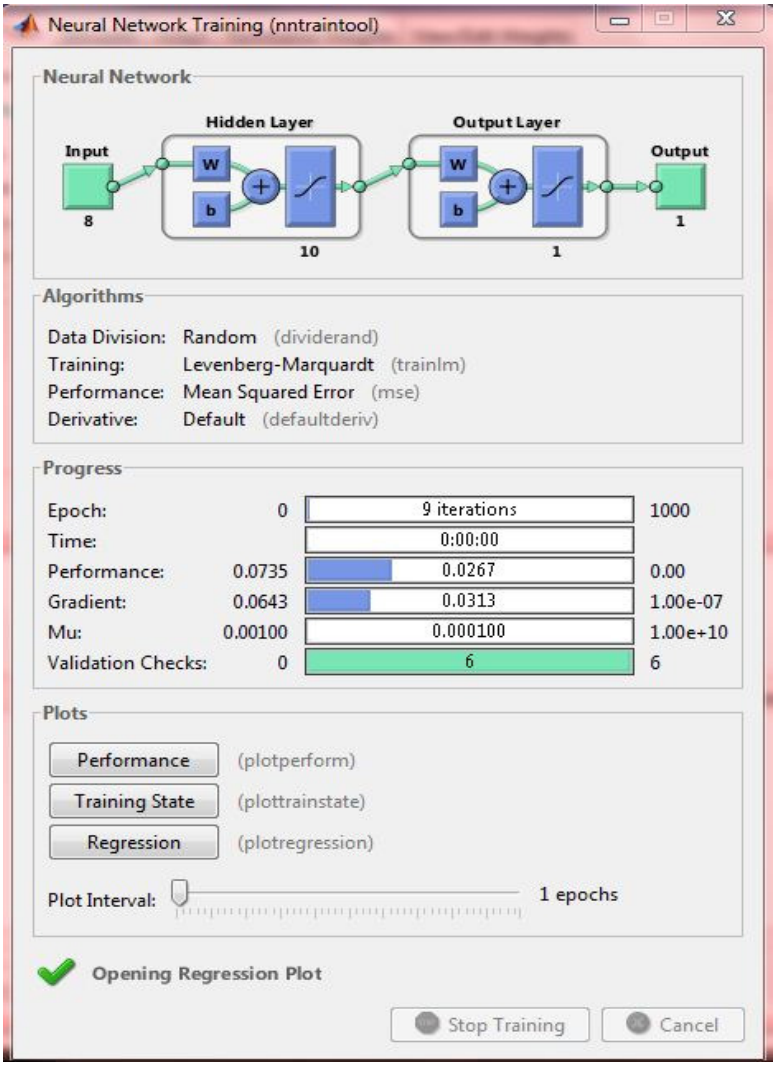

Figure 2.2: Neural Network Pattern Recognition Tool.

2.2.2 Radial Basis Function

This algorithm is implemented using nntool in MATLAB. This GUI provides a no. of algorithms to be opted. Input and Target data are imported to Network data manager from MATLAB workspace. Radial Basis Function is chosen as Network type and provide the corresponding required parameters. For Radial Basis Function(Exact Fit) goal and spread are filled and a RBF neural is created. The RBF network is trained as soon as it is created. RBF training statistics are visible at command-space in MATLAB.

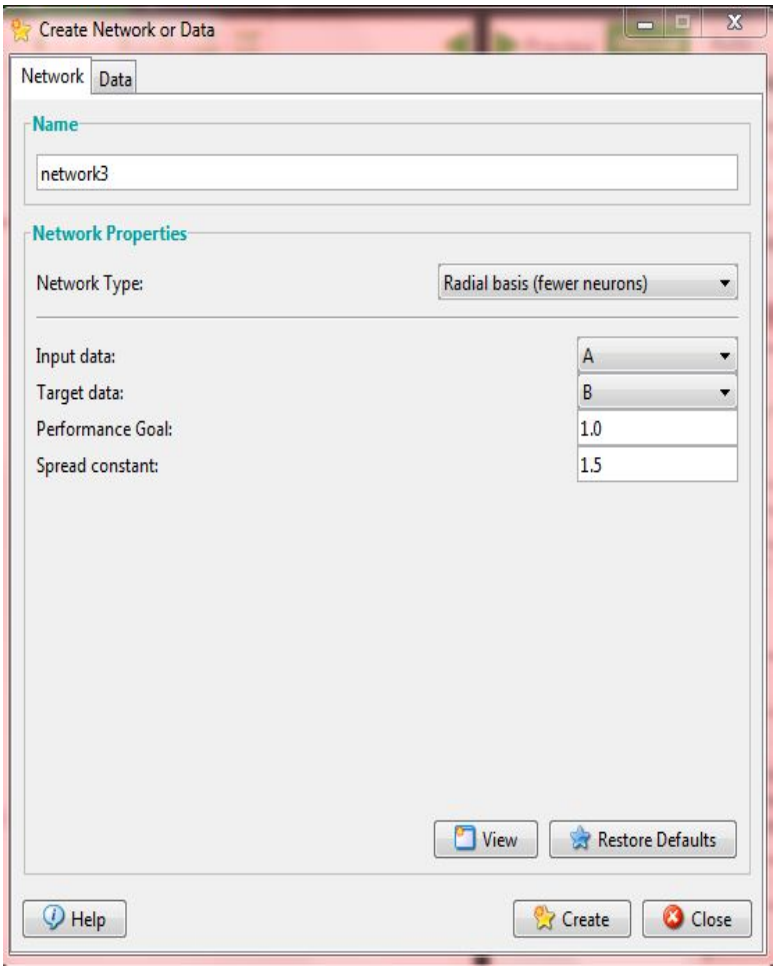

Figure 2.3: Neural Network ToolBox- RBF training.

2.2.2.1 Layer Recurrent Network

As described in RBF, Layer Recurrent Network are also created and trained in nntool. This algorithm minimizes MSE and %E of the data.The parameters for this network are no. of neurons in the hidden layer. Since, there are two parts of a hidden layer,both have same no. of neurons. Outputs are exported from Network Manager into system and stored.

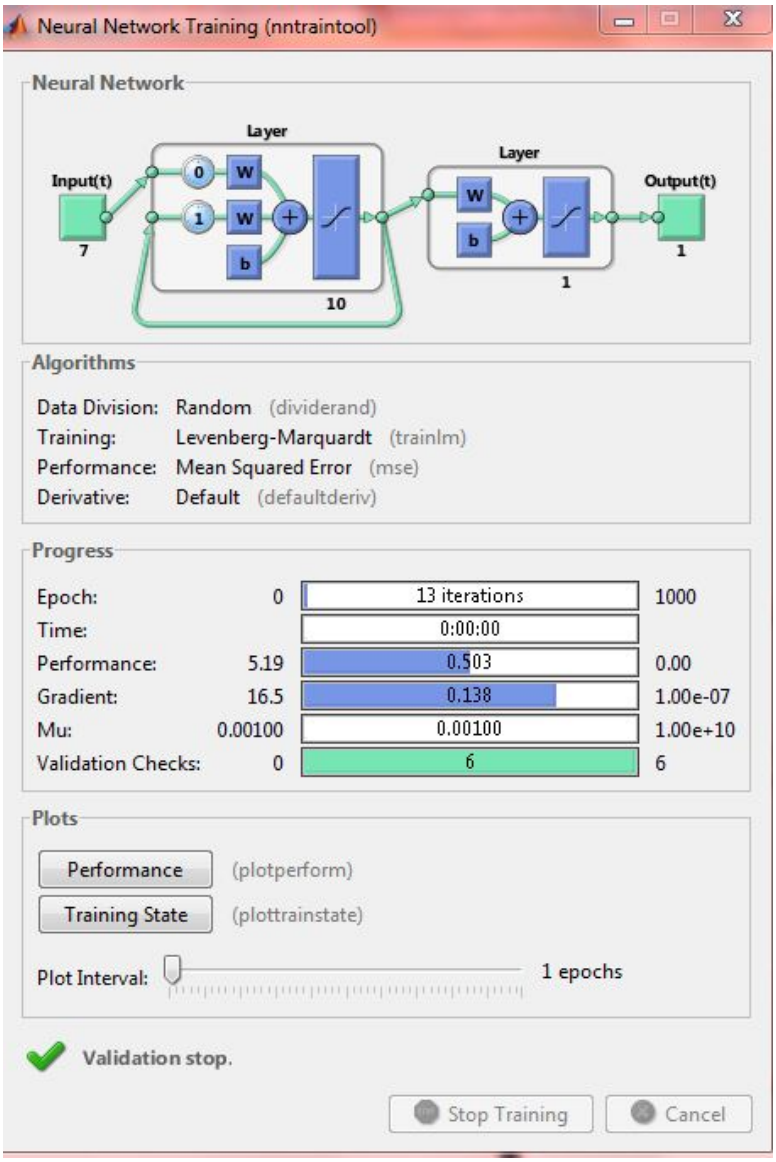

Figure 2.4: Neural Network ToolBox- Layer Recurrent Network training.

CHAPTER 3

RESULTS AND DISCUSSION

3.1 RESULTS

Following results are the observations of training Scaled Conjugate Gradient Backpropagation, RBF and layer recurrent neural network for different parameters. Performance function used for all these is MSE i.e. main objective is to minimize the mean squared error for each network and given data.

3.1.1 Gender Recognition

For Gender Recognition, two classes has been assumed: male and female. In the dataset, male class was represented by '0' and female class was represented using '1'. The dataset has been trained using three mentioned neural networks. The results are as follows:

3.1.1.1 Scaled Conjugate Gradient Backpropagation

As the table shows that, MSE and %E both are minimum if no of neurons are set 30 in scaled conjugate gradient backpropagation neural network.

No of neurons	Time taken	MSE	%error
10	6	2.7616e-1	44.55
20	10	4.981e-1	66.83
30	14	2.1901e-1	37.62
40	20	3.2232e-1	43.56

Table 3.1: Gender Recognition-traincg

3.1.1.2 Radial Basis Function

Resultant data shows that there is no significant change in MSE if both goal and spread are varied. Similarly MSE is lower than the backpropagation. Hence, we can say that RBF can be a good choice for gender recognition using VGRF.

goal	spread	No of neurons	MSE
1.0	1.5	2	0.238839
1.0	2.0	2	0.238839
1.5	1.5	2	0.238839
1.5	2.0	2	0.238839

Table 3.2: Gender Recognition-RBF

3.1.1.3 Layer Recurrent

It is visible that classification using Layer Recurrent Method, generates minimum MSE other than both RBF and backpropagation. Also, MSE is minimum if no of neurons in hidden layer is set to 20.

No of neurons	Iterations	MSE
10	14	0.00834
20	13	3.18e-5
30	14	0.00953
40	12	0.0158

Table 3.3: Gender Recognition-Layer Recurrent

3.1.2 Parkinson Disease Recognition

Parkinson Disease is a chronic and progressive movement disorder, which is caused due to damage of nerve cells.[pdf.org (2008)] In earlier stages its recognition is quite difficult because symptoms are very common with other diseases. Since, its effect starts from slowness in movement, therefore VGRF has been chosen as gait feature to detect whether a person is suffering from Parkinson disease or not. Healthy subjects in standard data-set are called ‘CO’ where as patients suffering from Parkinson disease are denoted by ‘PD’. For classification CO and PD has been replaced by ‘0’ and ‘1’,respectively. The results from different neural network classification are as follows:

3.1.2.1 Scaled Conjugate Gradient Backpropagation

It can be infered from the following table that MSE is minimum if no of neurons in hidden layer are equal to 40, but at the cost of execution time.

No of neurons	Time taken	MSE	%error
10	5	5.9414e-1	69.80
20	09	6.3206e-1	70.79
30	12	4.5747e-1	67.82
40	14	2.2215e-1	41.08

Table 3.4: Parkinson Disease Recognition-traincg

3.1.2.2 Radial Basis Function

Radial basis does not show much variation if its spread and goal are changed accordingly. It is faster than earlier network as well as MSE is also lesser than that. Hence, RBF can be considered for further implementation of Parkinson Disease recognition.

goal	spread	No of neurons	MSE
1.0	1.5	2	0.212331
1.0	2.0	2	0.212331
1.5	1.5	2	0.212331
1.5	2.0	2	0.212331

Table 3.5: Parkinson Disease Recognition-RBF

3.1.2.3 Layer Recurrent

Layer recurrent has been proved as faster and better network in this classification. MSE is minimum in case if hidden layer consists of 20 neurons. The statistics of this classification are:

No of neurons	Iterations	MSE
10	10	1.69e-09
20	10	1.10e-09
30	9	2.06e-09
40	9	3.00e-09
50	8	3.65e-09

Table 3.6: Parkinson Disease Recognition-Layer Recurrent

3.1.3 Age Recognition

The standard data-set also contains demographics of the subjects, i.e. age, weight, height etc. Since, Parkinson Disease affects after middle age, therefore subjects are above age of 30 years. Subjects are now assigned a particular age group. The groups are defined as per the following table. Hence, age recognition is basically multi-class classification where as both gender and Parkinson Disease recognition were binary classification. Therefore, here classification should be termed as age-group classification.

Age of subject	Age-group
30-40	1
40-50	2
50-60	3
60-70	4
70-80	5
80-90	6

Table 3.7: Age Groups

3.1.3.1 Scaled Conjugated Gradient Backpropagation

In this case, MSE is minimum if no of neurons in hidden layer are 40 whereas % error is minimum when no of neurons are 30.

No of neurons	Time taken	MSE	%error
10	02	0.496	50.35
20	09	0.529	42.45
30	12	4.01	17.98
40	17	0.283	43.70
50	12	4.13	62.43

Table 3.8: Age-group Recognition-traincg

3.1.3.2 Radial Basis Function

In this case as well RBF doesn‘t show any variation if spread and goal are modified consequently. Here, MSE is larger than backpropagation algorithm.The training statistics of RBF are below:

goal	spread	No of neurons	MSE
1.0	1.5	2	0.831723
1.0	2.0	2	0.831723
1.5	1.5	2	0.831723
1.5	2.0	2	0.831723

Table 3.9: Age-group Recognition-RBF

3.1.3.3 Layer Recurrent

There is not much difference in MSE in case of layer recurrent and backpropagation algorithm. But overall, MSE is minimized if no of neurons in hidden framework of network is set to be 30.

No of neurons	Iterations	MSE
10	13	0.503
20	8	0.455
30	9	0.259
40	6	0.518
50	10	0.415

Table 3.10: Age Recognition-Layer Recurrent

3.2 DISCUSSION

The tables for gender recognition, Parkinson disease recognition and age recognition show how different neural networks are generation different results. However, When results of one neural network architecture are observed, it shows that for a particular neural network if its parameters are varied then also MSE varies significantly. Hence, It can be concluded that different neural network have different classification results, as their architecture and design play a crucial role.

If the results are observed, it can be inferred that layer recurrent neural network performs better and minimizes the performance function which is MSE. It can also be concluded that present sequence depends upon the earlier one i.e. state of a subject is dependent upon its earlier state. RBF network also proved to be efficient and fast.

Further it can be done that these classification results can be obtained for a larger data so that accuracy can also be measured, however it will require some machine learning tools as well.

CHAPTER 4

CONCLUSION

The statistical tools for classification are linear and limited to the assumption on which they are developed. For a large data computation becomes time consuming as well as complex. Artificial Neural Networks are self adaptive and fast non-linear networks. ANN can tackle the problems which have not been solved via conventional methods. Each neural network architecture possess some characteristics which differentiate them from other popular methods and techniques.

Parkinson Disease mainly affects the neurons which makes it unable to control the movements for a person. Its causes are unknown and there is no cure. [Cho et al. (2009)] So, its detection at early stages it important, so that it can be controlled. Gender and Age- group recognition are used as biometric to identify persons. This project is supposed to be the primary step in the further works to be done in this field. A modular network can be developed which takes all these classifications into account. It will be both applicable in the field of Medical sciences as well as Biometric.

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