Research Paper   Open Access

Simulation of Back Propagation Neural Network for Iris Flower Classification

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ABSTRACT:*One of the most dynamic research and application areas of neural networks is classification. In this paper, the use of matlab coding for simulation of backpropagation neural network for classification of Iris dataset is demonstrated.   Fisher's Iris data base collected from uci repository is used. The data set contains 3 classes of 50 instances each, where each class refers to a type of iris plant. Sepal length, sepal width, petal length and petal width are the four features used to classify each flower to its category. The three classes of the flower are Iris Setosa, Iris Versicolor and Iris Verginica. The network is trained for different epochs with different number of neurons in the hidden layer. The performance of the network is evaluated by plotting the error versus the number of iterations, furthermore by testing the network with different samples of the iris flower data. The successfully trained network classified the testing data correctly; indicating 100% recognition.*
Keywords:*Classification, back propagation, artificial neural network, iris flower*

I.   INTRODUCTION

Classification is one of the most frequently used decision making tasks of human activity. A classification problem arises when an object needs to be assigned into a predefined group or class based on a number of observed attributes related to that object. Many problems in business, science, industry, and medicine can be treated as classification problems. Examples include deformed banknote identification [1], bankruptcy prediction [2], credit scoring [3], quality management [4], speech recognition [5] and handwritten character recognition [6].

Artificial Neural Networks (ANN) are widely used for pattern recognition and classification owing to the fact that they can approximate complex systems that are difficult to model using conventional modelling techniques such as mathematical modelling. Although significant advancement has been made in classification related areas of neural networks, various issues in applying neural networks still remain and have not been totally addressed. In this research todemonstrate how some of these issues can be tackle, back propagation neural network is simulated for iris flower dataset classification, by writing a matlab code.

II.   PREVIOUS WORKS

There are so many experts research on iris flower dataset. R.A. Fisher first introduced this dataset in his famous paper 'The use of multiple measurements in taxonomic problems' [7].

Later, Patrick S. Hoey analysed the Iris dataset via two distinct statistical methods; He first plotted the dataset onto scatterplots to determine patterns in the data in relation to the Iris classifications. Furthermore, develop an application in Java that will run a series of methods on the dataset to extract relevant statistical information from the dataset. With these two methods, with these two methods he made a concrete prediction about the dataset [8].

In a seminar VitalyBorovinskiy demonstrated the solution of iris flower classification problem by 3 types of neural networks; multilayer perceptron, radial basis function network, and probabilistic neural network. The result indicates that multilayer perceptron performed better both during the training and testing [9].

The adaptation of network weights using Particle Swarm Optimization (PSO) as a mechanism to improve the performance of Artificial Neural Network (ANN) in the classification of IRIS dataset was proposed by Dutta D., Roy A., Reddy k [10].

An Artificial Neural Network (ANN) is an information processing tool that is inspired by the biological nervous system such as the brain. Artificial Neural Networks (ANN) are widely used to approximate complex systems that are difficult to model using conventional modelling techniques such as mathematical modelling. The most common applications are function approximation (feature extraction), and pattern recognition and

classification. There is no exact available formula to decide what architecture of ANN and which training algorithm will solve a given problem. The best solution is obtained by trial and error. One can get an idea by looking at a problem and decide to start with simple networks; going on to complex ones till the solution is within the acceptable limits of error. There are different neural network architectures.

The basic architectures include multi-layered feed-forward networks (Figure 2.0) that are trained using back-propagation training algorithms.
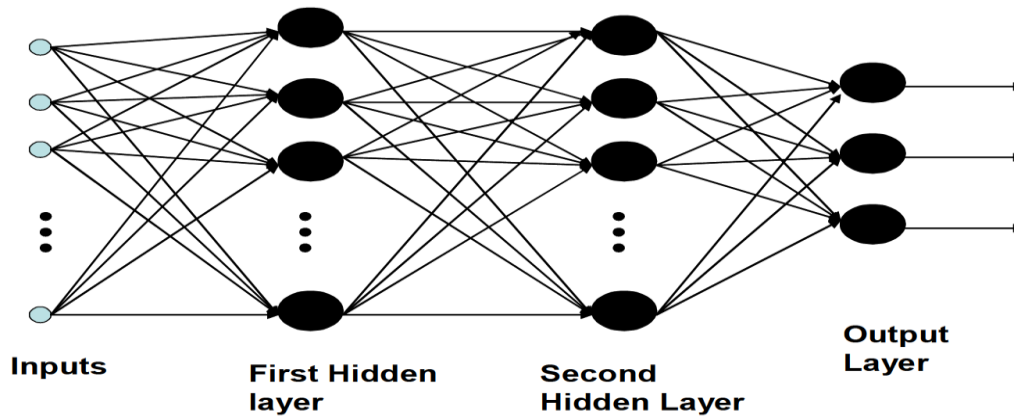

Figure 1: Multi-layered feed-forward neural network

III.   METHOD AND METHODOLOGY:

3.1 Problem description

Fisher's Iris data base (Fisher, 1936) is perhaps the best known database to be found in the pattern recognition literature. The data set contains 3 classes of 50 instances each, where each class refers to a type of iris plant. One class is linearly separable from the other two; the latter are not linearly separable from each other. The data base contains the following attributes:

1). sepal length in cm
2). sepal width in cm
3). petal length in cm
4). petal width in cm
5). class:
- Iris Setosa
- Iris Versicolour
- Iris Virginica

Fisher's Iris data base is available in Matlab (load fisheriris) and in Internet (for example, on http://archive.ics.uci.edu/ml/datasets/Iris).   The goal of this work is to use an Artificial Neural Network to classify a specimen into its category using the above mentioned four features. This is done by using Multilayer Perceptron (MLP) feedforward network using backpropagation training algorithm.

3.2 Software and Data Pre-processing:

One can develop ANN architectures and write training algorithms in any known higher level language (e.g C or Matlab). MATLAB has a proven tool box that helps one apply, already developed training algorithms, to solve the problem. MATLAB also has a GUI based system. This windows-based platform provides a step-by-step visual procedure to build, train and simulate the ANN. For this work a matlab code is written to simulate the network. Matlab R2016b is used.

The features obtained from many specimens are actually considered as raw data. Some amount of pre-processing is always carried out on the input and output data in order to make it suitable for the network. These procedures help obtain faster and efficient training.

Since there are three classes of flowers, a three-state numerical code must be assigned. The network must be trained to reproduce the code at the outputs. The output can be left in decimal form where the decimal numbers 1, 2, and 3 represent the classes or the classes can be coded in binary form. For this problem the outputs are coded as:

1.   I. Setosa : Code [0.1 0.1 0.9]
2.   I. Versicolor: Code [0.1 0.9 0.1]
3.   I. Verginica: Code [0.9 0.1 0.1]

3.3 Data Setup:

The data set file is saved in the matlab folder as *irisdata.mat*. The file is loaded using the command *loadirisdata;* in the code. This command uploads the file and includes all the variables setup in the current workspace. The data is divided as follows:

Training inputs (4×120): 4 rows by 120 columns. The number 4 represents the features which will be presented, one-by-one, in parallel fashion. Each pattern of 4 features is called a vector and there are 120 such vectors for training.

Target outputs (3×120): There are three outputs for each feature vector. There are 120 such vectors for training and will be the targets for the input vectors.

Test inputs (4×30): Once the network has been trained, it has to be tested on data that it has not seen before. 30 vectors are used for testing the network.

Test outputs (3×30): These are the expected classes for the test inputs. The simulated outputs of the network will be compared to these actual classes in order to determine the performance of the trained network.

3.4 Network Architecture Details:

Following network parameters are considered:

Input Layer: A single layer of none processing neurons is used. Since there are four features in the input data four neurons are used in the input layer.

Output Layer: Single layer of processing neurons, since the output of the network is in 3 elements vector form, the output layer will have three neurons.

Hidden Layer: One hidden layer is used. The number of neurons in hidden layers is experimented. With each combination of number of neurons in the hidden layer the network is trained and the error function (sum squared error) is plotted. The number of neurons that ensures the best generalization is chosen.

Activation functions: At each processing neuron an activation function is required to determine how that neuron is activated. Sigmoid activation function is used in both the hidden and output layers.

Synaptic weights and Bias: The synaptic weights between input and hidden layer neurons, and hidden to output layer neurons and the hidden layer bias are randomly initialized using *rand command* which is later adjusted and updated according to backpropagation training algorithm.

Epochs: The number of iterations is also experimented. The error function is plotted versus the number of iterations. The number of iterations that ensures the best generalization is chosen.

IV.   RESULT AND DISCUSSION

A backpropagation neural network is simulated to classify iris flower dataset; by writing a program code using matlab. 120 out of the total 150 instances in the data set with their corresponding target outputs were used for training the network. The simulation was carried out using Intel ® core ™ i5-4200U CPU @ 2.29 GHz PC with 4GB RAM, windows 10, 64-bit OS, and MATLAB 2016b software.

The network was trained for 1000 epochs first with three neurons in the hidden layer and then with four neurons in the hidden layer. The network was retrained for 10000 epochs with three neurons hidden layer and later with four neurons in the hidden layer.

The performance of the developed network was assessed by plotting the error versus the number of iterations, furthermore by testing the network with a different 30 samples of the iris plant data (10 from every iris plant class). The error graph and the testing data classification result are presented below.
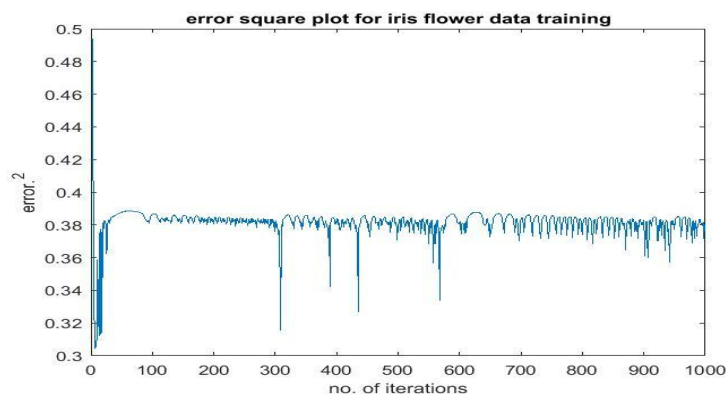

Figure 2: Error square plot for 1000 Epochs with 3 neurons in the hidden layer

Table I: Test data classification for 1000 Epochs with 3 neurons in the hidden layer

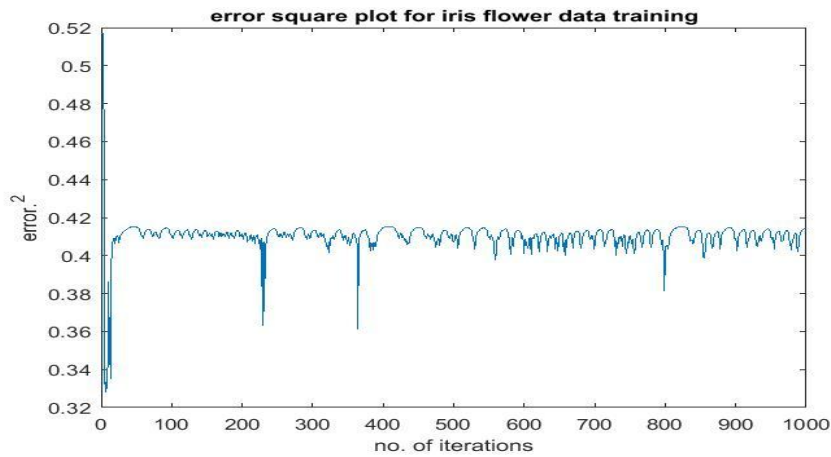| Iris Plant	Total Number of Test Samples	Number of Classified Samples	Number of Unclassified Samples
Iris Setosa	10	9	1
Iris Versicolor	10	0	10
Iris Virginnica	10	0	10

Figure 3: Error square plot for 1000 Epochs with 4 neurons in the hidden layer

Table II: Test data classification for 1000 Epochs with 4 neurons in the hidden layer

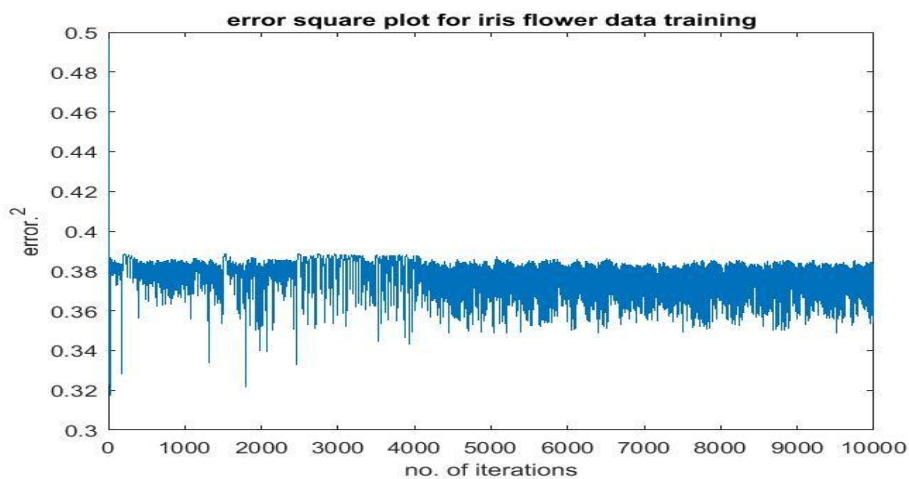| Iris Plant	Total Number of Test Samples	Number of Classified Samples	Number of Unclassified Samples
Iris Setosa	10	10	0
Iris Versicolor	10	0	10
Iris Virginnica	10	0	10

Figure 4: Error square plot for 10000 Epochs with 3 neurons in the hidden layer

Table III: Test data classification for 1000 Epochs with 4 neurons in the hidden layer

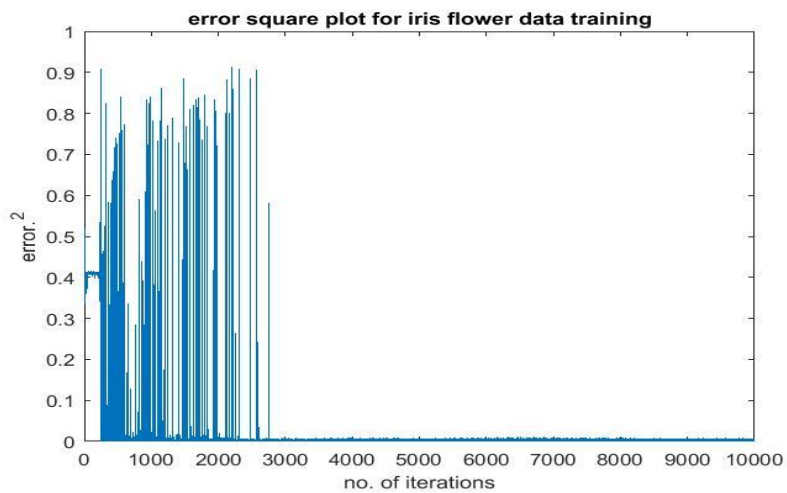| Iris Plant	Total Number of Test Samples	Number of Classified Samples	Number of Unclassified Samples
Iris Setosa	10	9	1
Iris Versicolor	10	0	10
Iris Virginnica	10	0	10

Figure 5: Error square plot for 10000 Epochs with 4 neurons in the hidden layer

Table IV: Test data classification for 10000 Epochs with 4 neurons in the hidden layer

Iris Plant	Total Number of Test Samples	Number of Classified Samples	Number of Unclassified Samples
Iris Setosa	10	10	0
Iris Versicolor	10	10	0
Iris Virginnica	10	10	0

Final parameters of the successfully trained neural network are presented in Table 4.5. The successfully trained neural network classified the testing data correctly; hence, 100% recognition is achieved.

Table V: Neural Network Final Training Parameters

Input Nodes	4
Hidden Nodes	4
Output Nodes	3
Iterations	10000

V. CONCLUSION

A backpropagation neural network has been simulated for iris flower dataset classification. The simulation is by writing a matlab code that uses matlab commands. Fisher's Iris data base collected from uci repository is used which is available on http://archive.ics.uci.edu/ml/datasets/Iris. The three classes of the flower were coded as; I. Setosa : Code [0.1 0.1 0.9], I. Verginica : Code [0.1 0.9 0.1] and I. Versicolor : Code [0.9 0.1 0.1]. The network was trained for 1000 epochs with different number of neurons in the hidden layer. The network was retrained for 10000 epochs. The performance of the developed network was evaluated by plotting the error versus the number of iterations, furthermore by testing the network with different samples of the iris flower data. The successfully trained neural network classified the testing data correctly; indicating 100% recognition. The research served as a means for understanding backpropagation neural network for pattern recognition and classification. It also gave opportunity to get more familiar with coding in matlab.

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