IJCSE International Journal of Computer Sciences and Engineering Open Access
Research Paper Vol.-6, Issue-5, May 2018 E-ISSN: 2347-2693

Pattern Recognition of Iris flower using Neural Network based Particle Swarm Optimization

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Available online at: www.ijcseonline.org

Accepted: 24/May/2018, Published: 31/May/2018

***Abstract*—** In machine learning, classification is a technique to identify the category to which an observation belongs, based on a labeled training data. It is a task of approximating a mapping function from input variables to discrete output variables. Pattern classification delivers this approximation by automatically discovering the regularities in the data using learning algorithms. It is an important sub-topic of machine learning with interesting applications like speech recognition and classification of rocks. In this paper, propose a hybrid approach Artificial Neural Network with Particle Swarm Optimization (ANNPSO) algorithm for pattern recognition. The ANNPSO works under the two main principles, first the error is calculated by using artificial neural network and second, error is optimized using Particle swarm optimization algorithms. Model tested on well known standard pattern IRIS flower dataset. Performance of presented model is evaluated with five-fold cross validation which produces 99.33% testing accuracy. Experimental results are superior than the existing ones. Therefore, ANNPSO provides better testing results in Iris pattern classification problems.

***Keywords*—** Artificial Neural Network, Pattern Classification, Particle Swarm Optimization.

I. Introduction

Pattern Classification is a popular domain in Machine Learning which is used to solve a variety of real life problems today. Given a dataset, we examine its features, detect a pattern amongst them and attempt to recognize these patterns properly. This cumulative process is termed as 'pattern classification'. Pattern classification has proven to be a very important domain within Artificial Intelligence. A number of researchers have worked in the field of Pattern detection, recognition and have contributed to the vastly expansive domain of Machine Learning by implementing a number of different pattern matching algorithms, till date. Feed forward Neural networks, K-Nearest Neighbors, Classification Decision Tree, Support Vector Machine have been used for pattern classification, to enumerate a few. For implementing every such algorithm, it is crucial to have just the right split between training and testing datasets. Depending on the problem requirement, the available dataset and many other factors, an appropriate supervised or unsupervised learning dataset has been created and used. Amongst these standard pattern datasets are Iris, Pima, Glass, Liver datasets of the UCI Machine Learning Repository. There have been multiple attempts using many techniques to perform pattern detection and classification on all of these datasets till date; however, researchers have not been able to achieve a satisfactory amount of accuracy yet. As a result, they continue to work on pattern classification using these datasets. How the accuracy of pattern detection and recognition can be improved still poses an enigma to researchers working on this problem. Work on improving the testing accuracy, predicting the appropriate classes to which the samples from datasets belong and enhancing the performance of pattern classification is ongoing.

To contribute a share in this vast ocean of vital research on pattern detection and recognition, attempts have been made to implement an algorithm for pattern classification with an objective to give state-of-the-art results for the IRIS flower dataset. This powerful method is Artificial Neural Network based particle swarm optimization algorithm (ANNPSO), produces good results within a short span of time. The concept of Particle Swarm Optimization (PSO) was first introduced by James Kennedy and Russel Eberhart [1] in the year 1995, which presented a non linear function optimization which produced better results than linear optimization algorithms in pattern classification. In this work, authors, have attempted to implement a pattern recognition algorithm by treating the ANNPSO concept as foundational to yield a state of the art accuracy for IRIS dataset.

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The overview of paper is as follows: Section II describes the related work of pattern classification for IRIS flower dataset. Overall propose methodology and its learning algorithm is described in Section III. Experimental results and performance evaluation is explained in Section IV. Finally conclusion and future direction is described in section V.

II. RELATED WORK

Pattern Recognition is significant and actively searched characteristic of artificial intelligence. The field of pattern recognition has been explored widely by a number of researchers who as a result have developed various algorithms. The design of pattern of all these algorithms consists of three basic elements, i.e. data perception, feature extraction and classification. Many researchers have applied different classification techniques like as support vector machine (SVM), Neural Network, Fuzzy Hypersphere, decision tree etc, but no one has got the that much of accuracy to classify the IRIS dataset in to three types of classes. R. A. Fisher introduced the Iris flower dataset with four features which is the most popular dataset in pattern classifications [2]. In 2009, V. Borovinskiy [3] applied three different neural networks techniques (Multilayer neural network (MLP), Probabilistic neural network and Radial base function) on Iris dataset in which MLP given the highest 98.82 % accuracy. In 2011, H. Chang and A. Astolfi [4] a clustering algorithm is proposed for classification of Iris Flowers. Graph Theory approaches for clustering are used. Overall validation accuracy given by this model is 98%. V. Kumar and N. Rathee [5] presented a integrated clustering and classification model (J48 with K-means) to recognition of Iris dataset which gives the 98.66 % testing accuracy. In 2013, D. Dutta et al. [6] proposed the adaptation of network weights using PSO proposed as a mechanism to advance the performance of ANN in classification of IRIS dataset which produces 97.3 % validation accuracy. In 2014, S. Vyas and D. Upadhyay [7] presented a model of feed forward neural network on the basis of floral dimensions applied on Iris dataset which given the results 98.3 %. In 2017, S. T. Halakatti [8] applied different scikit machine learning tools with K nearest neighbor, logistic regression on Iris dataset which given 96.66% , 96% accuracy respectively. In 2017, K.H. Wandra and L.P. Gagnani [9] used the WEKA datamining tools with different machine learning algorithms (Multi Layer Perceptron, RBF, Naïve Bayes,J48) on IRIS dataset . MLP gives the better accuracy results 97.33 %. In 2018, Mohan P. M. et al. [10] proposed support vector machine techniques with different variation of SVM on Iris dataset which given the 96.7 % highest accuracy for Q-SVM.

III. METHODOLOGY

In this section, describe the hybrid model ANNPSO, how PSO algorithm is used to train the Back propagation neural networks (BPNN). A neuron corresponding to swarm particle with its weights will periodically communicate with each others. Artificial Neural Network (ANN) is a powerful technique to solve the problem in pattern classification. It always adjusts synaptic weights until acquired knowledge is achieved [11]. In BPNN algorithm, train the hidden weights against the output layer and then move on to next hidden layer; adjust such weights which produce required output. Hidden layers of neural network are capable to extract higher order of properties from the input features. For each neuron calculate the sum of input values with respective weights and then pass through the sigmoid activation function f(Y).

$$f(Y) = \frac{1}{1 + e^{-(\sum_i^n wixi + c)}}$$

Where, n is the total number of inputs, xi is the i^{th} input value wi is the respective i^{th} weight and c is the constants bias.

To minimize the error, generally gradient descent algorithm is used which gives local minima not global minima. To overcome this problem PSO is assembled with ANN which can produce global minima with non linear convex function so that its always gives the better results in pattern classification. For better optimization, PSO algorithm used two principles, first communication, which is informing measure tips to other particles. Second learning, concept of better is the major problem that optimizer should solve [12]. Then the optimizer learns the concept of better which is able to solve any kind of optimization problem because the solution optimizer problem is to find the best ones. So, if we know which the better is, we can discover the concept of best. In PSO algorithm every solution of a given problem consider as a particle which is able to move in a search land escape. In order to update the position of each particle two vectors are considered, position vector and velocity vector. The position vector shows the position of the particle in land escape and velocity shows the directions an intensity of movements. These two vectors updated in each iteration with position and velocity equation

$$\text{Position vector}: \quad X_i^{t+1} = X_i^t + V_i^{t+1}$$

$$\text{Velocity vector}: V_i^{t+1} = wV_i^t + c1r1(P_i^t - X_i^t) + c_2r_2(G_i^t - X_i^t)$$

Where,

X_i^{t+1} : Next stage iteration position

V_i^{t+1} : Velocity of next stage iteration

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X_i : Current position, V_i is current velocity
t : Iteration, w is inersia which maintain the current velocity

P :Personal best , G : Global best

c_1c_2 : Learning factors ,

r_1r_2 : Random numbers between 0 to 1.

In each iteration, each agent (particle) is updated using its personal best solution (Pbest) and best value from any particle in population (Gbest).

A. Pseudo code for PSO Algorithm

PSO utilise the number of particles also called agents that think about a swarm moving around in the search space give the impression of being for the best solution. Each particle adjusts its travelling speed with dynamism corresponding to flying knowledge of itself and its colleges. Each particle changes its position according to its current position, its current velocity, the distance between its current position and Pbest and the distance between its current position and Gbest.

```
For each particle
  {
   Initialise particle
   }
  Do until optimal error
  {
   For each particle
   {
     Calculate fitness value
     If the fitness value is better than Pbest
      {
        Set Pbest= current fitness value
       }
     If Pbest better than Gbest
      {
      Set Gbest= Pbest
      }
   }
   For each particle
  {
   Calculate particle velocity
   Use Gbest and velocity to update particle data

    }
```

IV. EXPERIMENTAL RESULTS AND PERFORMANCE EVALUATION

Since each particle represent a neural network, multiple neural networks together to produce an optimization solution. Presented model combined two powerful techniques ANN and PSO in a way that it classifies the IRIS flower patterns correctly and gives state of the art results than the existing pattern classification techniques. Presented hybrid model ANNPSO does not put any constraint on Iris data of input patterns rather, it enhance the number to meet the demand of Iris flower pattern classification problem and model is tested on standard IRIS flower dataset with an average five-fold cross validation testing accuracy is 99.33%. Whereas the existing ANN method accuracy on the same dataset as 98 %. IRIS flower dataset contains 150 total samples; five-fold cross validation is used for performance evaluation purpose. In each K fold, 120 samples are used for training purpose and 30 samples for validation testing and its results found to be better than existing all pattern classification techniques. Comparative experimental results accuracy ANN and ANNPSO algorithms with each K-fold are depicted in the Table 1. The obtained result shows that combined ANNPSO approach is able to find out the global minima correctly which is able to appreciate recognition of IRIS flower patterns.

Table1. Comparative experimental results between ANN and ANNPSO

K- fold cross validation	ANN Accuracy (%)	ANNPSO Accuracy (%)
1	100	100
2	96.67	100
3	100	100
4	96.97	96.67
5	96.67	100
Average	**98 %**	**99.33 %**

Observing the experimental results from the Table 1, ANNPSO gives 100 % accuracy for different K (1,2,3,4) and in average it gives 99.33 % which is much better than ANN classifier. The graph to understand how loss was optimized with respect to each epoch iterations in ANN and ANNPSO algorithms is shown if Figure 1 and Figure 2 respectively. Comparison of different classification techniques for IRIS flower recognition with proposed model is shown in Table 2.

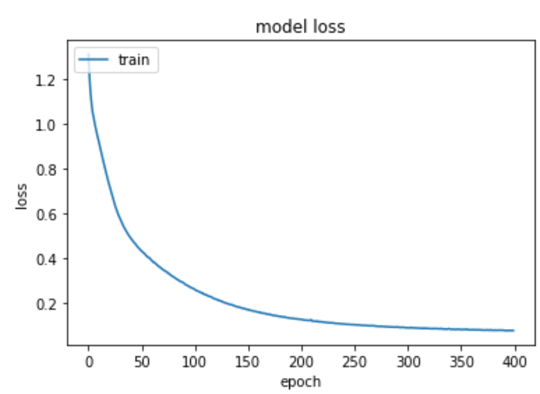

Figure1. ANN loss optimization

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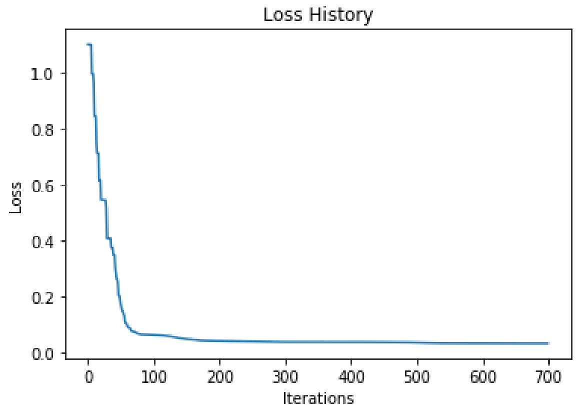

Figure2. ANNPSO loss optimization

Table2. Comparative description of ANNPSO with existing methods on pattern recognition of Iris dataset

Work reference and Year	Machine Learning Technique	Test Set Accuracy (%)
V. Borovinskiy [3] 2009	MLP	98.82
H. Chang and A. Astolfi [4] 2011	Graph Theory Clustering	98
V. Kumar and N. Rathee [5] 2011	Combine J48 with K-means	98.66
D. Dutta et al. [6] 2013	ANN	97
S. Vyas and D.Upadhyay[7] 2014	Feed Forward NN	98.3
S. T. Halakatti [8] 2017	KNN Logistic Regression	96.66 96
K. H. Wandra and L.P. Gagnani[9] 2017	MLP RBF Naïve Bayes J48	97.33 95.33 96 96
Mohan P. M. et al. [10] 2018	Q-SVM L-SVM FG-SVM	96.7 95.3 94
Proposed Model	**ANNPSO**	**99.33**

V. Conclusion and Future Scope

In this paper, we focused on hybrid ANNPSO model for recognition of IRIS flower into three types. The proposed model trains the feed forward neural network with particle swarm optimization non linear activation function. Every time all PSO particles maintain the best solution in the region and search around them the possibly of finding a better solution is really high. All movements towards a promising area to get the global optimum. Therefore PSO is a powerful stochastic optimization method with non convex function. Five-fold cross validation used for the better result computation. Presented model correctly classify the IRIS flower dataset patterns and gives testing accuracy 99.33% which is superior than the existing one. In future performance evaluation of presented model will checked with different well known standard datasets and also PSO algorithm will use in different classification techniques which can provide better results in pattern recognition problems.

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