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# A Novel Approach in Training Functional Link Artificial Neural Network with ABC Optimizer

**Sunny Roy**

M. Tech Scholar, Information Science Department, MSRIT

**Abstract:** ***The topic artificial neural network (ANN) matured to a great extent in the past few years and specially with the advent of very high performance computing and has caught very big potential in pattern recognition, prediction, and classification of dataset. One of the famous neural network is Functional link artificial neural network (FLANN) is easier to train as it imposes less architectural complexity(no hidden layer) and is still able to handle a non-linear separable classification task. This paper focuses on classification technique on biomedical data in training a Functional link artificial neural network (FLANN) using artificial bee colony optimization (ABC) and predict the accuracy in classification.***

**Keywords:** ANN, FLANN, ABC, Classification

## 1. Introduction

Artificial Neural Network (ANN) derives its origin from the working of human brain. ANN is an information processing model which consists of multiple single processing units(neurons), these neurons are massively parallel in nature which performs highly complex computations. The sole goal of ANN is to make a computer learn something so that network would adapt to a given dataset. ANN, like people learn by example. These abilities make ANN suitable for pattern recognition, speech recognition or data classification problem [1]. For Classification task, ANN need to be trained for the networks to be able to produce the desired input-output mapping. For training purpose a set of example data are feed to the network and connection weights, which is also called synaptic weight, are adjusted by using a learning algorithm.

Classification is a data mining technique used to predict group membership for data instances, we are given a set of instances, called a training set, where each instances consists of several features or attributes. In this paper, we proposes training of FLANN with Artificial Bee Colony (ABC) optimizer as learning algorithm in order to achieve better result in classification of microarray data. Microarray is a powerful technology for biological exploration which enables to simultaneously measures the expression level of activity of thousands of genes per tissue samples. A microarray is typically a glass slide on to which DNA molecules are fixed in orderly manner at specific locations called spots (or features). Microarray analysis is widely used technology for studying gene expression on a global scales [1],[2] &[3].

The primary goal of this paper is to study the benefits of performing supervised classification on microarray dataset. The organizational flow of the rest of the paper is as follows: Section 2 focuses on literature survey. Section 3 discusses about FLANN and Section 4 explains Artificial Bee Colony algorithm. The proposed model is discussed in section 5. Section 6 presents the simulation result of the proposed learning scheme. Finally paper concludes in section 7.

## 2. Literature Survey

Lot of research work have been carried out in past on the evolutionary artificial neural network using particle swam optimization and number of models have been proposed. This section discusses related work done.

In paper [5], Satchidanada et al, proposes an improved particle swarm optimization (PSO) based evolutionary Functional Link Artificial Neural Network (ISO-FLANN) for the task of classification. The proposed model have been compared with MLP(Multilayer Perceptron), SVM(Support Vector Machine) and FLANN with gradient descent and results obtained are better than other models. This model is an effort to evolve Higher order neural network (HONN), in particular FLANN using PSO. The model uses the weight value obtained by ISO and set of optimized functional expansion for the expansion of the feature vector, the method successfully overcome non-linearity of the classification problem.

In [6], A. Bolaji et al, presents a survey on Artificial Bee Colony Algorithm, where they explore the advantage of ABC algorithm and its application in different field. The major part of research of ABC algorithm is concentrated to solve diverse set of problems like Scheduling applications, Bioinformatics application, image processing applications etc. over 97 research article has been studied. In 2005 ABC was developed using multidimensional and multivariable optimization problems. In 2007 it was used for training of artificial neural network and results were compared with other benchmark algorithm such as Genetic algorithm(GA), particle swarm optimization (PSO) Differential evolution (DE). In later year many researcher starts to modify and hybridized ABC algorithm to tackle different problem in different domain.

Many researcher have also proposed Ant colony optimizer (ACO) algorithm to solve the data mining classification problem[7]. These classifiers are inspired by natural behavior of ant. The paper proposes a new method based on ant miner1 and produces higher accuracy rate and with few rules. Many a research have also proposed BAT algorithm to

update weight of neural network.

## 3. Functional Link Artificial Neural Network (FLANN)

FLANN is flat network with no hidden layers. This makes FLANN structure simple with very less complex computational overheads. The advantage of such structure is that it allows FLANN to operate with faster convergence rate and takes less time in computation i.e it is easier to train. On the other hand such structure also put some constraints, since it is linear in nature, it fails to map the complex non-linear problems. Microarray dataset are highly complex and non-linear in nature. To bridge this gap the FLANN structure uses a single layer feed forward neural network and functionally expands the input vector to overcome the linear mapping problem. There are three different polynomials for functional expansion of input pattern in FLANN, Chebyshev, Lengendre and power series. Out of these three Chebyshev is best suited. The Chebyshev polynomials are a set of orthogonal polynomials defined as the solution to the chebyshev differential equation and denoted as Tn(x).
The higher order Chebsyhev polynomials are generated by the recursive formula:
$T_{n+1}(x)=2xT_{n(x)}–T_{n-1}(x)$

The first few Chebyshev polynomials are:
T0(x) = 1
T1(x) = x
T2(x) = 2x2-1
T3(x) = 4x3-3x
T4(x) = 8x4-8x2+1

## 4. Artificial Bee Colony (ABC) Optimization

ABC is a new swarm intelligence based optimizer algorithm, which simulates the foraging behavior of a honey bee swarm for solving multidimensional and multivariable optimization problem (Karaboga, 2005). In this model, the colony of artificial bees contains three groups of bees: employed, onlookers and scouts bees. First half of the colony consists of the artificial employed bees and the second half includes the onlookers. For every food source, there is only one employed bees i.e the number of employed bees in the colony is equal to the number of food source around the hive. The employed bees uses random multidirectional search space in the food source area(FS). On finding a food source they return to hive with three crucial information, 1) the direction 2) its distance from the hive and 3) the profitability information i.e the nectar quantity of the food source and perform the waggle dance to let onlooker bees to evaluate the information. The onlooker bees observe the waggle dance to decide whether an food source(optimal solution) is acceptable or not. The decision to choose a food source depends on the probability value based on the fitness. In case the nectar amount of new food source is higher than that of the last one in their memory, they memorize this new position of food source and erase the previous one. The employed bee becomes a scout bee when food source has been exhausted and are responsible for carrying out random searches in the environment for finding a new food source.

The major advantages which ABC holds over other optimization algorithms include its[6] & [8]:-
- Simplicity, flexibility and robustness.
- Use of fewer control parameters as compared to others.
- Ease of implementation with basic mathematical and logical operations.

The intelligent behavior of bees can be summarized as follows:
1) In the initial phase, scout bees starts exploring environment in random direction in order to find the food source.
2) After finding the food source scout bees becomes employed bees and starts exploring food source. After collecting information bee returns to hive to share the information with onlooker bees by performing waggle dance.
3) Onlookers bees waiting in the hive choose food source depending upon the frequency of waggle dance which is proportional to quality of food source.
4) Stop exploitation of food source abandoned by the bees. If food source is abandoned employee bee becomes scout bee and start exploring environment in random direction.
5) Memorize the best food source found so far.

## 5. Classification with FLANN-ABC model

Inspired by the flexibility and robustness offered by the swarm based meta-heuristic algorithm, this paper proposes to implement ABC algorithm as the learning scheme in the FLANN training. But before conducting any biological experiment which deals with high dimensional data such as prediction, classification etc first thing to do is to apply feature reduction. High dimensional data contains large number of features, among those features only some amount of feature will be effective to predict those diseases. Feature reduction reduces irrelevant, misleading feature, time complexity of training and increases classifier efficiency. Factor analysis is proposed for this purpose. Once the data is normalized and reduced it can be feed as input to train the network and make prediction. The detail of experimental evaluation is focused below.

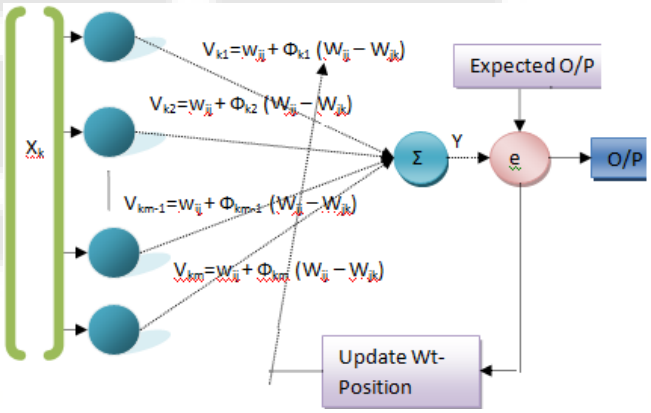


**Figure 1:** FLANN-ABC network

Data set consist of N X M element. And X={$X_1$… $X_N$} represent row vector of data. Training of network start by assigning random weight to the edges between the input

neurons and output neurons. Let there be class label C={1,2,…,s}. We need to train the network for 's' number of classes. Let assign random weight to network for each classes. These random weights are nothing but the food source coordinates for which bees need to memorize the neighborhood. Therefore as each weight represents coordinates, we provide two value to each weight one for x coordinate and other for y coordinates in between -0.5 to 0.5. As there are 's' class level and each class level have its own random weight, where each weight is represented by coordinates we get

w=0.5-rand (M,2*s)

Where 'rand' is a random function that return value in between 0 and 1. M is the total column, and 's' is the class level.

The ABC algorithm used for training the FLANN is summarized as follow:

1) RRead the input dataset.
2) IInitialize the input parameters, Colony size (CS), number of food source (FS = CS/2), maximum cycle number(MCN), limit for scout.
3) Initialize a population of solutions $x_{ij}$ , where i= 1….FS(food source)
4) Calculate fitness value and select number of food source for FS number of employed bees or onlookers bees.
5) Set cycle =1
6) Produce new food source for the employed bees using equation
   $V_{ij} = X_{ij} + \emptyset_{ij}(X_{ij} - X_{kj})$
   Where k is a solution in the neighborhood of i, $\emptyset$ is random number between [-1,1] and evaluate them.
7) Evaluate the fitness value using
   $fit_i = \begin{cases} \frac{1}{1+f_i} \text{ if } f_i>0 \\ 1 + abs(fi), \quad if \quad fi < 0 \end{cases}$
8) Apply the greedy selection process for employed bees. If new food source posses highest fitness value set $trail_i$ = 0 else set $trail_i$ = $trail_i$ +1. Trail is number of each solution $x_{ij}$ .
9) Calculate probability values $p_i$ for the solution $x_{ij}$ using
   $Pi = \frac{fit_i}{\sum_{n=1}^{SN} fit_n}$
10) Produce the new food source s for the onlookers from the selected food source using probability values and evaluate fitness value of them.
11) Apply greedy selection process for the onlookers. If new food source posses highest fitness value set $trail_i$ = 0 else set $trail_i$ = $trail_i$ +1
12) Determine the abandoned solution for the scout bees on $trail_i$ value, if exists, and replace it with new randomly produced solutions
    $x^i_j = x^j_{min} + rand(0,1)\ (x^j_{max} - x^j_{min})$
13) Memorize the best solution achieved and cycle = cycle =1 until maximum number of cycle reached
14) Save updated FLANN new weight.

One cycle (or iteration) is combination of forage and waggle dance in this model. The computation is done for a specific number of iteration (MCN). Output produced by the FLANN-ABC is checked with the expected output and error is calculated. The best solution is found during the iteration is the final output.

## 6. Simulation Result

Simulation is carried out on computer having working platform of matlab 7.4.1 with configuration 2.53GHz core i3-M80 intel CPU having 2.0gb RAM in a 64-bit operating system. For simulation process, two benchmark classification datasets are considered, IRIS, HEART Disease. All datasets are collected from UCI machine learning repository.

**Description of Dataset**:

***Iris dataset***: This is the perhaps the best known dataset to be found in classification problem literature. Based on multivariate characteristics of a plant species, the dataset consists of 150 instances where each instances have 4 attributes and instances are divided into three classes namely Iris setosa, iris versicolor, iris virginicia. Each class contains equal number of instances i.e 50.

***Heart Disease dataset:*** This dataset set have 270 data instances , 2 classes and 5 attributes. This database is related to people diagnosed with heart problem. Class 1 contains 150 instances and Class 2 contains 120 instances.

Table 1 and 2 shows confusion matrix for Iris and heart disease respectively. With the confusion matrix accuracy percentage prediction for each class can also be found out. It shows how the predictions are made by the model. The rows represent the known class of the data and columns represent the predictions made by the model. The elements in diagonal shows the number of classifications correctly identified for each class, and off - diagonal elements show the errors made by classifier. Figure 2 shows the error plot over semilogy graph. And Table 3 shows the accuracy percentage achieved for different dataset.

**Table 1:** Confusion matrix for Iris

| | | Predicted class | | |
|---|---|---|---|---|
| Known class | | Class 1 | Class 2 | Class 3 |
| | Class 1 | 20 | 0 | 0 |
| | Class 2 | 0 | 19 | 1 |
| | Class 3 | 0 | 2 | 18 |

**Table 2**: Confusion matrix for heart disease

| | | Predicted class | |
|---|---|---|---|
| Known class | | Class 1 | Class 2 |
| | Class 1 | 10 | 0 |
| | Class 2 | 3 | 2 |

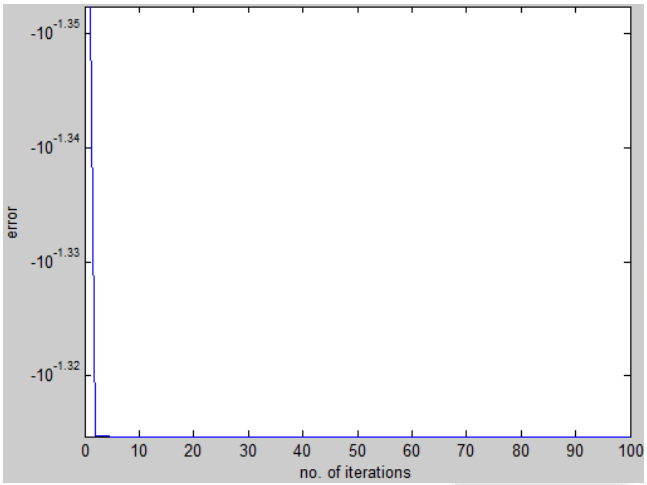


**Figure 2:** Error plot over semilogy graph

**Table 3:** Accuracy percentage

| Name of data set | Percentage of accuracy |
|---|---|
| Heart disease | 71.33 |
| Iris | 95.66 |

## 7. Conclusion and Future Scope

In this work the proposed model, FLANN-ABC performs the task of pattern classification for multiclass classification on unseen data quite well and successfully overcome the non-linearity of the classification problem. For the dataset Iris and Heart disease, the proposed model successfully trains the FLANN for solving classification problems with better accuracy percentage. Due to simplicity in architecture and computational efficiency of proposed model it can also be employed with other problems of data mining. Even the accuracy level of the proposed classifier is encouraging; FLANN and ABC need some more advances in computational chemistry, computational biology and advent of modified algorithm to achieve better accuracy percentage. In future scope, with more advanced learning algorithm, a more accurate classifier can be designed to achieve better result in classification. Classification problem can be extended to different database of different domain like weather forecasting, traffic classification, web related dataset etc. Here the proposed model is evaluated only on microarray dataset. In future different classifiers can be combined to achieve optimum result.

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## Author Profile

**Sunny Roy** is pursuing M. Tech (4th sem.) from MSRIT, Bangalore in Software Engineering. He received B. Tech degree in computer science from RPSIT, Patna in 2012, India