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International Journal Of Engineering And Computer Science ISSN:2319-7242
Volume 2 Issue 11 November, 2013 Page No. 3278-3281

Adaptation in Neural Networks: A Review

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Abstract: ***Adaptation is the neural networks property that a neural network system should provide. Due to the challenge of high complexity and poor generalization of different models of neural network, many researchers were motivated to work in the field of adaptation in neural networks. Adaptation helps neural networks to generalize and adapt the data easily. Adaptive neural network framework is a collection of techniques in which structure of the network is adapted during the training according to a given problem. In this paper, we review the different adaptation technique of the neural network. These adaptation techniques include- structural adaptation, functional adaptation and training parameters or weight adaptation. To achieve architectural and functional adaptation many pruning, constructive and cascading algorithm were proposed in the literature by many researchers. To attain the functional adaptation the slope of the sigmoidal function is adapted during training and to satisfy the adaptive property of neural network weight adaptation is performed by every neural network model that results in better convergence and good generalization.***

Keywords: Adaptation, constructive and cascade correlation algorithms, genetic algorithm, particle swarm optimization.

1. Introduction

There are many types of neural network model which are proposed by various researchers for classification and regression tasks. But among them the multilayer feed-forward type neural networks are most popular because they provide flexible structure and there are large numbers of feed-forward learning algorithms are available. The generalization ability and learning accuracy of supervised learning in feed forward neural networks depend on several factors such as network architecture which include hidden nodes and connection topology between nodes, choice of activation function for each node and the training parameters like learning rate and weights [5]. These factors of the neural network model are either fixed prior to training or dynamically adjusted or changed during training of the network for a given problem. If these factors are not appropriately chosen then they may cause the under fitting and over fitting of the network which can result in a poor generalization of the network. So, adaptive neural network framework provides a solution to these kinds of problems to some extent. In adaptive neural network framework these factors are dynamically adjusted. Adaptive model neural networks enable the network model to be constructed along with the training process.

The neural network model which satisfies the adaptive property of neural network is able to adjust its parameter, weights, functions and architecture in order to let the system to handle the scenarios during training. Adaptation can be done in three ways (Figure 1):

1. By evolutionary technique
2. By learning or non-evolutionary technique
3. Hybrid technique

The evolutionary technique includes global optimization techniques like genetic algorithms, particle swarm optimization that evolves the network architecture with weights. Evolutionary algorithms are used to adapt the network architecture, connection weights and learning rules according to the problem environment. When we use evolutionary algorithms then we need to determine the proper encoding scheme, evolutionary operators and suitable parameter settings because in evolutionary algorithms these things assure the success of the algorithm. Evolutionary algorithms are population based so they have no need for gradient information.

Non evolutionary technique performs adaptation with the help of learning which include many neural network algorithms like various classification algorithms, pruning algorithms, constructive and cascading algorithms. Now it is proved by many researchers that constructive algorithms are advantageous over pruning algorithms because in pruning algorithms it is not known how large the initial network should be. It starts with the oversize complex model and then prunes the redundant weights and hidden nodes contained in the network. So, pruning algorithms require more computational cost. It is advisable to use constructive algorithms instead of pruning algorithms.

The hybrid technique uses both the evolutionary and non-evolutionary techniques in same network. We can use particle swarm optimization with back-propagation neural network or feed forward neural network for the same neural network model [10]. Many researchers used this technique for classification purpose and in many cases this technique gives better result than using a single technique. Genetic algorithms and particle swarm optimization algorithms has the strong ability to find the global optimistic result and back-propagation algorithm has the ability to find local optimistic result. So the fundamental idea for hybrid approach is to provide optimal solutions.

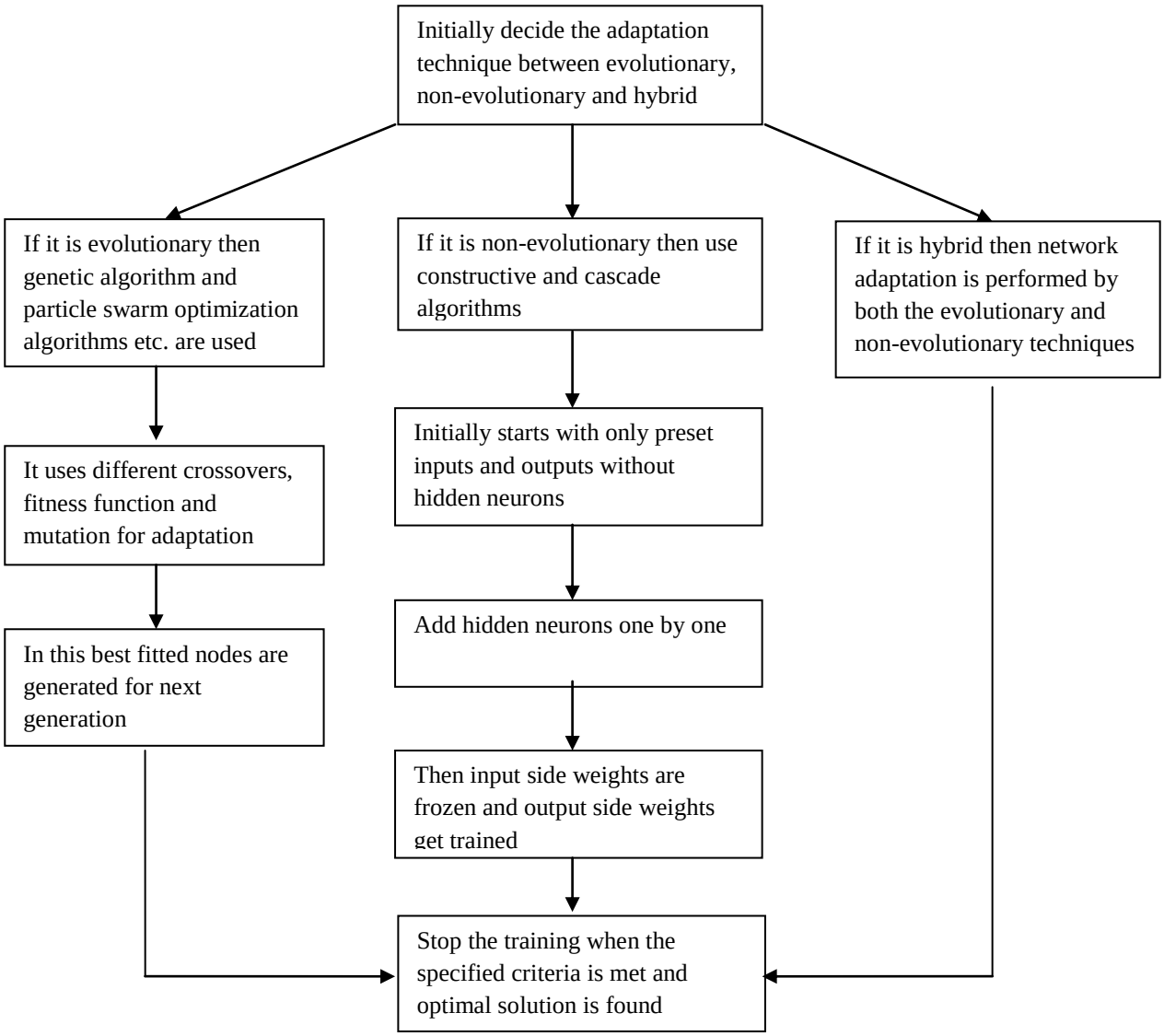

Figure 1: Adaptation Techniques

2. Different Adaptation Strategies

2.1 Structural Adaptation

Structural adaptation or structural change in neural network can be achieved by both the evolutionary and the non-evolutionary techniques. Evolutionary techniques include various algorithms for structural adaptation like SEPA (Structural Evolution and Parameter Adaptation) which is consistent with Genetic Algorithm and uses crossover and fitness function for architectural adaptation [3]. Non evolutionary technique includes various pruning, cascading and constructive algorithm.

To find an optimal architecture there are three model selection techniques-one that perform a search through models, one that begins with a large complex model and then simplified and one that begin with a simple and small size model whose complexity is increased as the learning proceed [5]. In formal neural networks we have to define the architecture before the training but Cascade Correlation and the constructive algorithm that belongs to the third group those that begin with a small size network and alter the network structure by adding node, layers and connections as training proceeds for a given problem. Cascading architecture was proposed to overcome the moving target problem, the local minima problem, the step size problem and to keep off the scenario where we have to define the number of hidden layer's

node. This architecture adaptation process continues until the optimal solution is found. Constructive algorithms require less training time than those algorithms which starts training with the large and oversize networks and then apply pruning to the network architecture. The Cascade Correlation algorithm was first proposed by Fahlman and Lebiere in 1990 [1]. Cascade Correlation is a supervised constructive algorithm. It starts with a minimal size network then repeatedly trains and installs new hidden neurons one by one, generating a multilayer topology instead of just adjusting the weights in a network with a fixed topology. In this hidden node is connected to all original inputs of the network as well as previously trained hidden nodes. It is connected to the output node with input weight frozen after the training of current hidden nodes and all inputs of output node are trained again [5]. There are different constructive algorithms (like CasPer, A_CasPer, AT_CasPer and Layered_CasPer etc.) proposed by many researchers which uses candidate pool of hidden neurons, hidden neuron towers and layers of hidden neurons [9]. Layered_CasPer algorithm provides best results in terms of less computational cost, complexity and classification on large datasets [9].

2.2 Functional Adaptation

To achieve functional adaptation non evolutionary technique was used by many researchers. Functional adaptation in neural network can be attained by adapting the slope of the sigmoidal function during learning. Sigmoidal functions have the nonlinear capability so they are widely used at hidden nodes. Generally the slope of the sigmoidal function is fixed to some value before training and cannot be adapted to suit many different problems during training. If the slope of the sigmoidal function is controlled by the training data then we can achieve great nonlinear mapping capability. To attain the functional adaptation gradient decent optimization method is used during the training of the hidden node, input and output connection weights to minimize the error. From the previous research work we can say that the adaptive slope sigmoidal function is advantageous over traditional fixed slope sigmodal function which results in smoother learning, increase flexibility and better generalization.

Function approximation algorithms are mostly used for classification and regression tasks. There are many constructive algorithms which are reviewed by Kwok and Yenug 1997a. Among those the most popular algorithm for function approximation is cascade correlation algorithm [1].After that many variants of the cascade correlation algorithm were proposed. One of them is Cascade 2 algorithm which was also first proposed by Scott E. Fahlman and which directly minimize the residual error rather than maximizing its covariance with residual error. For functional adaptation Sudhir Kumar et al. uses ASCNNA (adaptive slope sigmoidal function cascading neural network algorithm) which is different from Cascade 2 algorithm in few steps. They shows that the functional adaptation can be attained through the adaptive slope sigmoidal function that prevents the non linear nodes from saturation and increase their learning capabilities [5][6]. With the help of slope sigmoidal function the step size of weight adaptation can be solved to some extent. Adaptive slope sigmoidal function helps the neural network to perform better so that it can be used in many applications.

2.3 Parameter Adaptation

To achieve parameter or weight adaptation both evolutionary and non-evolutionary techniques are used. In evolutionary techniques, various particle swarm optimization and genetic algorithm are used. We can apply these algorithms to different classification problems. These classification tasks can be performed by weight adaptation that is weights of the network are adjusted during training according to a given problem. In evolutionary techniques different crossovers are used which provide weight adaptation by recombination of weights instead of gradient learning [3]. Argha Roy et al. used particle swarm optimization algorithm with back-propagation algorithm for weight adaptation in classification problem [10].They used fitness value, particle velocity and position and back-propagation to update the weights. Non evolutionary techniques are also used for parameter adaptation. It includes various neural network basic algorithms like perceptron, back-propagation, pruning and constructive algorithms etc. Constructive algorithms allow a smaller number of parameters to be updated at the initial stage of training while large training data are required in pruning and other neural network algorithms. There are many algorithms that provide parameter adaptation as well as architecture adaptation. Weight adaptation is performed during the learning in every neural network architecture.

3. Conclusion

This paper presents an overview of different neural network adaptation techniques and various ways of neural network adaptation. In this paper, we have enlightened structural, functional and parameter adaptation in neural network which can be performed by evolutionary, non-evolutionary or by hybrid approaches. Adaptation is required for those algorithms that dynamically change the structure and weight of the network. Adaptation in neural network results in neural network model that requires less training time and provide better results, better generalization and less complex model. Future work in this area includes that in the structural adaptation we can reduce the number of connections by setting the limit to the maximum number of connections.

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Author Profile

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