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A New Approach for Function Optimization using Hybrid GA-ANN Algorithm

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Abstract—
Genetic algorithms are widely used among optimization algorithms due to its several advantages. But it mainly relies on objective function without which it has no utilization. A new approach for objective function formulation is proposed in this paper using Artificial Neural Networks which is lateral optimized using Genetic Algorithm. The results obtained are in good agreement.

Keywords- Artificial neural networks (ANN); Genetic algorithm (GA); objective function; back propagation neural network; optimization; fitness function.

INTRODUCTION

During the past three decades, Genetic Algorithms have been intensively studied. The exploitation of genetic algorithms has benefited the amounts of applications. Moreover, theoretical approaches on genetic algorithms have also helped researchers to understand the mechanisms of genetic algorithms [1].

The genetic algorithm is a method for solving optimization problems that is based on natural selection, the process that drives biological evolution. It is inspired from Darwin's original thoughts that states that life in this world in all its diverse and amazing forms was evolved by natural selection and adaptation processes controlled by the survivability of the fittest species. With this acceptance has come, the Genetic Algorithms (GAS) have utilized this nature's "selection and adaptation engine" and applied it to the solution of engineering problems [2]. The genetic algorithms have been applied to solve a variety of optimization problems that are not well suited for standard optimization algorithms, including problems in which the objective function is discontinuous, non-differentiable, stochastic or highly nonlinear [3].

The genetic algorithm repeatedly modifies a population of individual solutions. At each step, the genetic algorithm selects individuals at random from the current population to be parents and uses them to produce the children for the next generation. Over successive generations, the population "evolves" toward an optimal solution. Every individual is represented by its chromosome. Mostly chromosomes represented as a binary string. Sometimes there are more strings which are not necessarily of a binary type. The chromosome representation could be evaluated by a fitness function. The fitness equals to the quality of an individual and is an important pick factor for a selection process.

The genetic algorithm uses three main types of rules at each step to create the next generation from the current population:

- Selection rules select the individuals, called parents that contribute to the population at the next generation.
- Crossover rules combine two parents to form children for the next generation.
- Mutation rules apply random changes to individual parents to form children [4].

The basic cycle of genetic algorithms from beginning i.e. initial population to the selection and reproduction process is shown in Fig. 1.

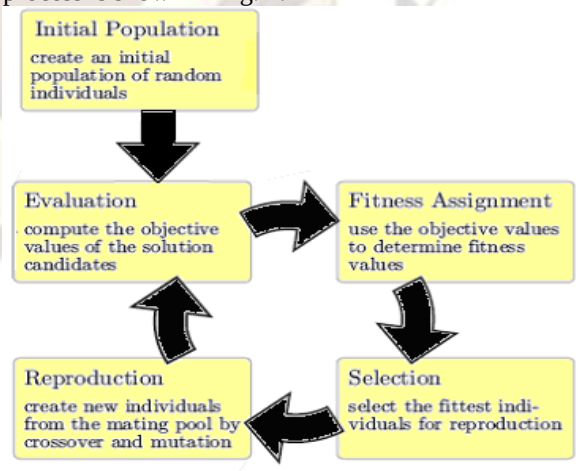

Figure 1. The basic cycle of Genetic Algorithms [3]

The rest of paper is organized as follows: The section II discusses the related work. The section III includes the Problem Formulation after the brief introduction about Genetic Algorithms in section I. The section IV includes Solution methodology. The section V reveals Results and section VI includes Conclusions followed by References.

A. Artificial neural networks

Artificial neural networks are found to be more flexible and better than other modelling methods. Based on the neural architectures of the human brain, ANN are described as group of simple processing units, known as neurons (nodes) arranged in parallel layers. Neurons are connected to each other by weighted connections. ANN provides linear and nonlinear modelling without the requirement of preliminary information and assumption as to the relationship between input and output variables. The reason being hidden layers of neurons between the input and output layers of the network and the nonlinear activation functions that are used to translate nodal input to output. This provides ANN an advantage over other statistical and conventional prediction methods such as logistic regression and numerical methods, in which nonlinear interactions between variables must be modelled in explicit functional form [7].

The Artificial Neural Network can be divided into two types - the forward and the feedback by the direction of the signal transmission. The back propagation (BP) neural network belongs to forward neural network model. Feed-forward networks often have one or more hidden layers of sigmoid neurons followed by an output layer of linear neurons.

Fig. 2. shows the basic principle of back propagation of Neural Networks.

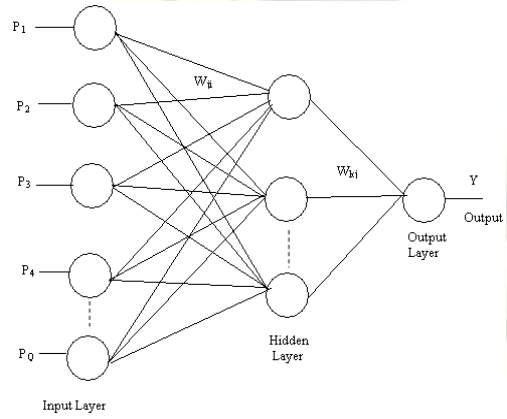

Figure 2. Back Propagation Neural Network

BP neural network model consists of input layer nodes, the output layer node and the hidden layer nodes. The output is given by first forward function and after that function transmission to the hidden layer nodes and then the output signal transmitted to the output layer node from the hidden layer. In the network training process, the weights of layer continuously adjust the process of learning through the signal being transmitted on each layer with the back- propagation repeatedly. The procedure continues until the network output error is reduced to an acceptable level or network model predict the desired test samples [8].

II. Related Work

Function optimization problem has been studied by many researchers in the past. We will discuss some important works done in the field of optimization.

Rahmat-Samii in [2] used Genetic Algorithm (GA) and Particle Swarm Optimization (PSO) in the designing of complex electromagnetic device such as profiled corrugated horn to feed an offset parabolic reflector antenna.

Konfrst in [4] describes the various applications of GA's in Numerical Mathematics and Graph Theory through Computer Science, Finance and Economics to Technology and Engineering.

III. Problem Formulation

The engineering design problems as rule contain finding the global optimum in the space with many local optima. Evolutionary algorithms including GA have property to escape the local extreme and have a better global perspective than the traditional gradient based methods. Certain class of optimal design problems contains multiple global extremes. Obviously, in latter case the algorithms manipulating with population instead of single solution such as Genetic algorithm are preferred [5].

But, deterministic optimization techniques such as the Monte Carlo, simulated annealing etc. or evolutionary optimization techniques such as genetic algorithm (GA) mostly rely upon the objective function, without which the optimization technique don't have utilization. An objective function is a mathematical function which is subject to optimization. But, Often in electromagnetics, the objective function (fitness function) that is used for optimization is multimodal, rigid, non-differentiable and also sometimes, computationally expensive to evaluate. Many times, the objective function cannot be relied upon due to its diffidence, especially when accuracy cannot be compromised. Thus, in such situations, artificial neural networks can provide very good solution for objective function formulation. The artificial neural networks can very well approximate the objective function which can be then optimized using optimization technique. In this paper, ANN-GA hybrid algorithm is proposed in which the ANN model is used as an objective function for the GA optimization technique. The proposed algorithm has utilization in every field, especially in those cases where the objective-function formulation is difficult, or the objective function is erroneous [6].

IV. SOLUTION METHODOLGY

In every field, especially in those cases where the objective-function formulation is difficult or the objective function is erroneous, the artificial neural network can be used as the objective function of any optimization algorithm. In this paper, ANN has been used as fitness function of genetic algorithm. The procedure opted is shown in Fig. 3.

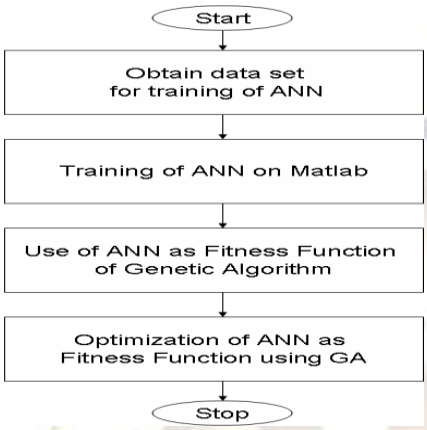

Figure 3. Solution methodology for optimization using Hybrid ANN-GA Algorithm

The software utilized for simulation is Matlab. Firstly, the ANN has been trained using back propagation training algorithm to approximate the desired objective function as shown in Fig. 4. The objective function chosen for training of ANN is

$$F(x) = x*(x-8)$$

The Fig. 4 shows the training of ANN for the above objective function. The figure dictates that the ANN is successfully trained to approximate the desired objective function. The trained network is then globally used in another function that is called by genetic algorithm tool as objective function.

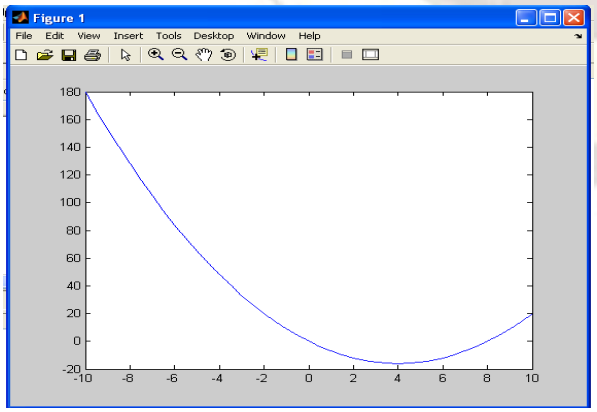

Figure. 6. 'F(x)' plotted versus 'x'

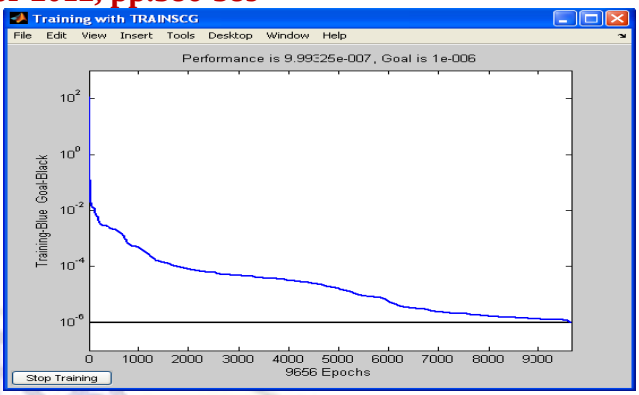

Figure 4. Trained ANN model

V. RESULTS AND DISCUSSIONS

The result in Fig. 5 shows the global optimum point given by genetic algorithm. The results provide the optimum value of variable 'x' that gives the minimum value of function F(x).

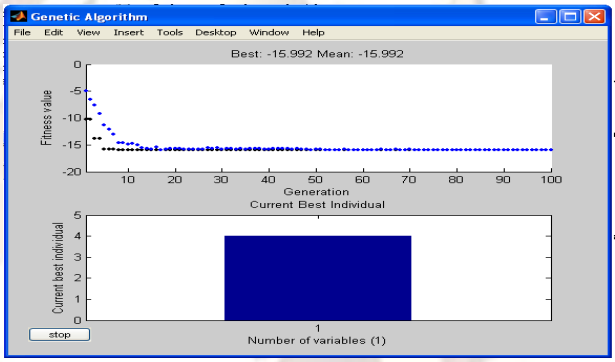

Figure. 5. Optimum results provided by genetic algorithm

The results provided by genetic algorithm in Fig. 5 are compared with function directly plotted in Fig. 6 and the comparison reveals that results are in good agreement.

VI. CONCLUSIONS

A novel based on hybridization of ANN and GA for formulation of objective function in optimization algorithm is presented in this paper. The results presented are in good agreement. This proposed technique has utilization in every field where objective function formulation is difficult or erroneous.

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