Ship Transformer Gases in Oil Protection Using Neural Network Simulation

Javad Azarakhsh [1,*]

Lecturer, Chabahar Maritime University, Iran

Abstract

Power transformer is one of the major apparatus in the ship power system. Power transformer breakdown or damage interrupts ship power distribution system. Hence, to manage the life of transformers and to reduce failures some measures are being adopted. According to the moist environment of the sea dissolved Gas Analysis (DGA) is a reliable and commonly practiced technique for the detection of incipient fault condition within power transformer. This paper presents the application of Artificial Neural Network (ANN) for detecting the incipient faults in power transformer by using dissolved gas analysis technique. Using historical transformer failure data, ANN model was developed to classify seven types of transformer condition based on the percentage of three hydrocarbon gases .

In this paper, to simulate the neural network performance, we used two methods, genetic and RPROP algorithms.

Keywords: Quayside Cranes, Container Loading / Discharging, Productivity, Cycle-Time Analysis

[*] Corresponding author:
E-mail address: Azarakhsh@cmu.ac.ir
Postal Address: Chabahar Maritime University, Chabahar, Iran.

1 Introduction

Dissolved gas-in-oil analysis (DGA) is a common practice in transformer fault. Electrical insulation such as mineral oils and cellulosic materials degrade under excessive thermal and electrical stresses forming byproducts gases which can serve as indicators for the type of stress and its severity. In this way, gas-in-oil concentrations, relative proportion of gases, and gas generation rates (gassing rates) are used to estimate the condition of a transformer. Commonly used gases include hydrogen (H2), methane (CH4), acetylene (C2H2),ethylene (C2H4), ethane (C2H6), carbon monoxide (CO) and carbon dioxide (CO) [1,2,3]. DGA techniques include the conventional key gas method, ratio methods, and recently, the artificial intelligent methods. The key gas method relates “key gases” to “fault types” and attempts to detect four types of fault (overheating of oil, overheating of cellulose, partial discharge, arcing) based on key gas contents (C2H4, CO, H2, C2H2). The ratio methods are coding systems that assign certain combination of codes to a specific fault type. The codes are generated by calculating gas ratios and comparing the ratios to pre-defined ratio intervals. A fault condition is detected when a code combination fits the code pattern of the fault [4,5,6]. A recursive algorithm suitable for microprocessor based power system relaying and measurement has been proposed in [7]. Many authors described application of Artificial Neural Network (ANNs) in power systems [8,9]. In [10] and [11], it was suggested that a feed-forward neural network (FFNN) has been trained to discriminate between power transformer magnetizing inrush and fault currents. Genetic Algorithm (GA) has been introduced to train the ANN architecture.GA has been used for training of ANN for fault classification in parallel transmission line in [12].

2 Neural Network

In the neural network the most basic information - processing unit is the neuron model. The neural model organized in three or more layers, such as input layer (one or more), hidden layer (one or more) and single output layer, use a back-propagation for training, presented in Fig. 1.

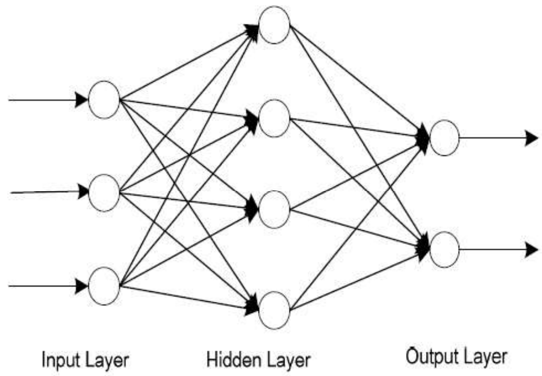

Fig. 1. General Architecture of Artificial Neural Network (ANN)

3 Genetic Algorithm

GA is an optimization technique based on the principle of genetics and natural selection. A GA allows a population composed of many individuals to evolve under specified selection rules to a state that maximizes the “fitness”.

The classical optimization methods have limitations in searching for global optimal point. Due to the fact that GA is a multipoint search method rather than the conventional single point search methods.GA promises the global optimum point to be reached. Moreover GA uses only the value of objective function. The derivatives are not used in the search procedure. In GA, the design vector is represented as string of real numbers, each number represents a ‘variable’. This string is called a ‘chromosome’.GA starts with a group of chromosomes known as ‘population’. The basic operations of natural genetics-reproduction, crossover and mutation are implemented during numerical optimization. “Reproduction” is a process in which the individuals are selected based on their fitness value relative to that of the population. Thus individuals with higher fitness values have a greater chance of being selected for mating and subsequent genetic action. After reproduction, the ‘crossover’ is implemented. Crossover is an operator that forms a new chromosome called ‘offspring’ from two parent chromosomes by combining part of the information from each. So, first two individuals are selected from the mating pool generated by the reproduction operator. Next, a crossover is performed by taking random weighted average of two parents. The off springs obtained from crossover are placed in the new population The ‘mutation’ is performed after crossover. Mutation functions make small random changes in the individuals in the population, which provide genetic diversity and enable the genetic algorithm to search a broader space.

4 ANN Training Algorithms

A. Resilient Backpropagation (RPROP) Algorithm

Resilient Backpropagation is a modification of the ordinary gradient descent back-propagation. To overcome the inherent disadvantages of pure gradient-descent, Resilient Backpropagation (RPROP). The basic principle of RPROP is to eliminate the harmful influence of the size of the partial derivative on the weight step. As a consequence, only sign of the derivative is considered to indicate the direction of the weight update but not the magnitude.

B. GA Based Training of ANN

The genetic algorithm (GA) is a well known optimization technique based on the principles of genetics and natural selection and doesn't require derivative information for optimization. Unlike back propagation algorithm, it provides global minima of optimization function. In the proposed method, GA has been used for finding weights and biases of Artificial Neural Network. Then the next part is to define a fitness function which can be used as an evaluation function to optimize the weight set. The fitness function used here is mean square error (MSE), which has been obtained by applying all training sets (Input and Target) for each weight set in the population.

5 Present Approach

The number of neurons in the hidden layer remains variable for each diagnosis criterion, depending upon the complexity. Each neuron model receives input signals, which are multiplied by synaptic weights. An activation function transforms these signals into an output signal to the next neuron model.
In this paper, we have proposed ANN structure:
4 Input nodes and 5 output nodes (classes), say N1.

N1 accepts the concentration (ppm) of the gases (C_2H_2, C_2H_4, C_2H_6, H_2 and CH_4) on input and predicts the condition of the transformer as healthy or faulty as output.
First of all, the N1 is trained with historical data based on actual gas records collected from Punjab State Electricity Board. The 77 dissolved gas analysis (DGA) samples were collected. These DGA samples associated with their real fault types were classified with the help of various DGA interpretative techniques, by the Electricity Board experts after internal examination of the suspected

transformers and the subsequent analysis. The graphical representation of the dataset of dissolved gases (in ppm) is shown in Fig. 2.

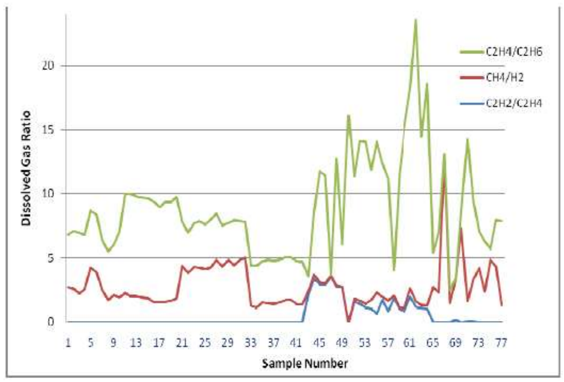

Fig. 2: Dataset of Dissolved Gas Concentration (in ppm)

N1 has been trained using RPROP and Genetic algorithms, tested with several combinations of data, trained for 3500 epochs resulting in the train recognition accuracy of 90.4%. During the training process, the number of hidden neurons and network weights and momentum were adjusted until required accuracy was obtained. The graph between mean square error (MSE) and epoch is shown in Fig. 3.

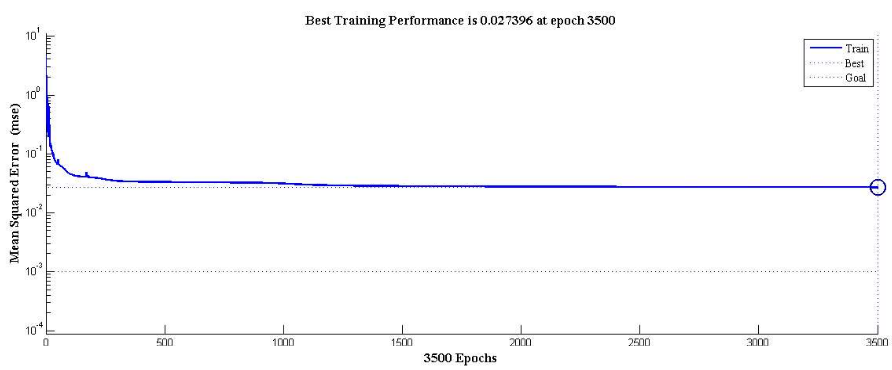

Fig. 3. Performances of ANN trained with RPROP

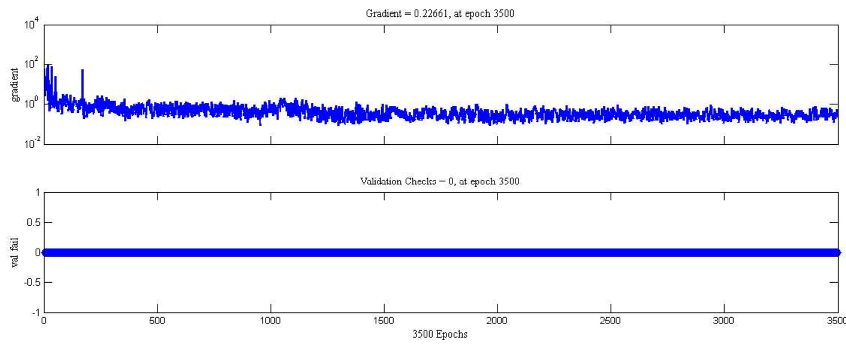

Fig. 4. Training state

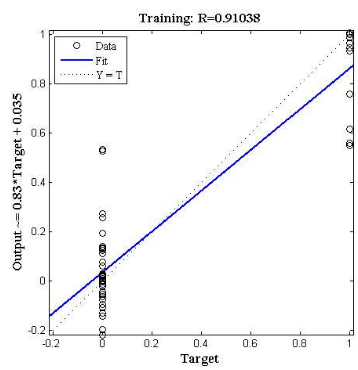

Fig. 5. Regression

Network parameters taken for the ANN structure have been listed below:

1. Learning Rate = 0.05
2. Momentum Constant = 0.7
3. Tolerance = 0.001

6 Results and Discussions

Neural network has been used to train the existing DGA data and then fault detection is done.

Table 1. Artifical Neural Network (ANN) Structure

ANN Structures	Input Nodes	Output Nodes	Max. no. of epochs	Test Recognition Accuracy
N1	4	5	3500	90.4%

The accuracy of the simulation are shown in the following matrixs. Accuracy is slightly lower because little data available to us.

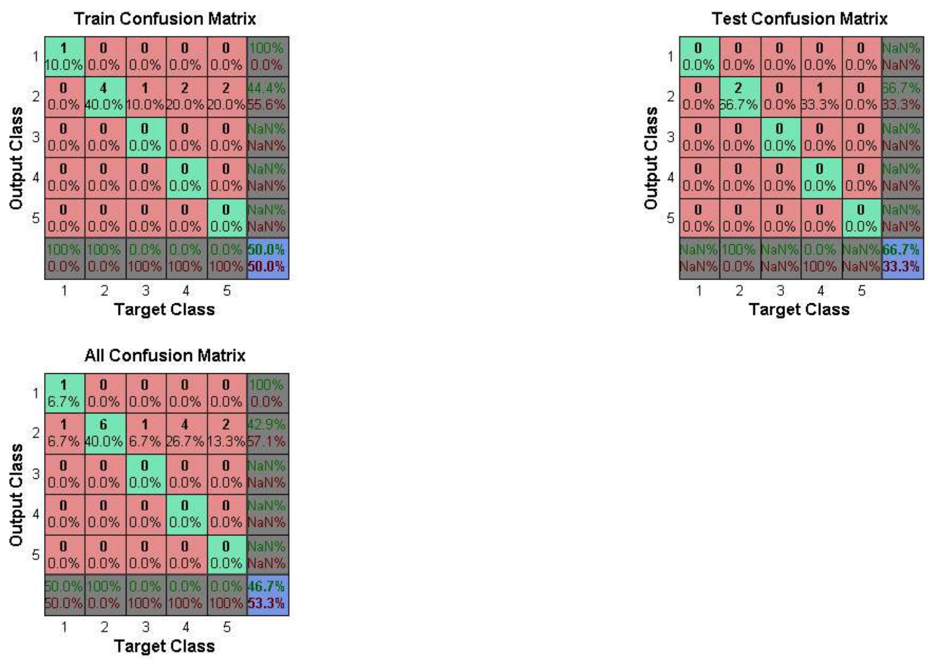

Fig.6.confusion matrix

Table. 2. Performance Error

ANN Architecture	Best Performance Error			
	RPROP Trained ANN			GA trained ANN
	Logsig	tansig	Hardlim	
4-13-5	0.00082479	0.016665	0.04444	0.0761089

7 Conclusion

In the proposed scheme, neural networks have been used to diagnose the incipient faults in power transformers through the analysis of dissolved gases in oil.

In this paper, an artificial neural network based pattern recognition method has been presented for the backup protection of Transformer unit. The ANN is trained separately with Resilient Backpropagation algorithm (RPROP) and Genetic Algorithm (GA) for all the possible cases of simulated data under different operating conditions of transformer and generator.

Table 2 shows the performance errors for all cases. As one can find from these results, the RPROP algorithm produced better results than GA with the present network architecture.

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