PREDICTING NOISE-INDUCED HEARING LOSS (NIHL) IN TNB WORKERS USING GDAM ALGORITHM

SYED MUHAMMAD ZUBAIR REHMAN GILLANI

A thesis submitted in fulfilment of the requirements for award of the

Degree of Masters

In

Information Technology

Faculty of Computer Science and Information Technology

University Tun Hussein Onn Malaysia

MAY 2012

DEDICATION

For my beloved mother and father

ACKNOWLEDGEMENT

I am grateful to all the people who have made major or minor contributions to this research.

Firstly, all my thanks go to the one and only ALLAH SWT. He has always blessed me with his numerous blessings; this project would be a mere dream, if he had not been there with me. Oh Allah, I am thankful to you for your untiring support throughout my life and no thanks are enough to repay you ever. But there is one request, just stay with me forever and never leave me alone.

Secondly, I would like to pay me heartfelt thanks to the prestigious institute, UTHM for giving me an opportunity to study here and fulfil my dreams of becoming a researcher. Also, I am very grateful to ORICC of UTHM for supporting this research under the Fundamental Research Grants Scheme (FRGS) Vote No. 0737.

In particular, I would like to express my sincere gratitude to my supervisors, Associate Prof. Dr. Nazri Mohd. Nawi and Prof. Mohd. Imran Ghazali for their continuous support, technical guidance and assistance in finishing this project.

I would also like to extend my thanks to Tenaga National Berhad (TNB) for providing useful information and real time data of Noise-Induced hearing loss (NIHL) victims.

I am also thankful to my parents and my siblings for believing in me and supporting me in all my endeavours.

In the end, I am thankful to all my friends who have encouraged me and helped me in my research.

ABSTRACT

Noise is a form of a pollutant that is terrorizing the occupational health experts for many decades due to its adverse side-effects on the workers in the industry. Noise-Induced Hearing Loss (NIHL) handicap is one out of many health hazards caused due to excessive exposure to high frequency noise emitted from the machines. A number of studies have been carried-out to find the significant factors involved in causing NIHL in industrial workers using Artificial Neural Networks (ANN). Despite providing useful information on hearing loss, these studies have neglected some important factors.

The traditional Back-propagation Neural Network (BPNN) is a supervised Artificial Neural Networks (ANN) algorithm. It is widely used in solving many real time problems in world. But BPNN possesses a problem of slow convergence and network stagnancy. Previously, several modifications were suggested to improve the convergence rate of Gradient Descent Back-propagation algorithm such as careful selection of initial weights and biases, learning rate, momentum, network topology, activation function and 'gain' value in the activation function.

This research proposed an algorithm for improving the current working performance of Back-propagation algorithm by adaptively changing the momentum value and at the same time keeping the 'gain' parameter fixed for all nodes in the neural network. The performance of the proposed method known as 'Gradient Descent Method with Adaptive Momentum (GDAM)' is compared with 'Gradient Descent Method with Adaptive Gain (GDM-AG)' (Nazri, 2007) and 'Gradient Descent with Simple Momentum (GDM)' by performing simulations on classification problems. The results show that GDAM is a better approach than previous methods with an accuracy ratio of 1.0 for classification problems like

Thyroid disease, Heart disease, Breast Cancer, Pima Indian Diabetes, Wine Quality, Australian Credit-card approval problem and Mushroom problem.

The efficiency of the proposed GDAM is further verified by means of simulations on Noise-Induced Hearing loss (NIHL) audiometric data obtained from Tenaga Nasional Berhad (TNB). The proposed GDAM shows improved prediction results on both ears and will be helpful in improving the declining health condition of industrial workers in Malaysia. At present, only few studies have emerged to predict NIHL using ANN but have failed to achieve high accuracy. The achievements made by GDAM has paved way for indicating NIHL in workers before it becomes severe and cripples him or her for life. GDAM is also helpful in educating the blue collared employees to avoid noisy environments and remedies against exposure to excessive noise can be taken in the future to prevent hearing damage.

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2. **Award of 2nd Best Paper in ICT Category:** M. Z. Rehman, N. M. Nawi, and M. I. Ghazali (2011). *Predicting Noise-induced hearing loss (NIHL) and Hearing Deterioration Index (HDI) in Malaysian Industrial Workers using GDAM algorithm.* **Proc.** Malaysian Technical Universities International Conference on Engineering and Technology (MUiCET 2011), Batu Pahat, Malaysia, 13-15 November 2011.

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1.	**M.Z. Rehman, N. M. Nawi, R. Ghazali (2012).** *Studying the effect of adaptive momentum in improving the accuracy of gradient descent back propagation algorithm on classification problems.* In: International Journal of Modern Physics (IJMPCS): Conference Series Vol.1 (1).	**Journal**
2.	**M. Z. Rehman, N. M. Nawi, M. I. Ghazali (2012).** *Predicting Noise-Induced Hearing Loss (NIHL) and Hearing Deterioration Index (HDI) in Malaysian Industrial Workers using GDAM Algorithm*. In: Journal of Engineering and Technology (JET), UTeM, Vol.3 (1).	**Journal**
3.	**N. M. Nawi, M. Z. Rehman, M. I. Ghazali (2011).** *Noise-Induced Hearing Loss Prediction in Malaysian Industrial Workers using Gradient Descent with Adaptive Momentum Algorithm*. In: *International Review on Computers and Software (IRECOS).* Vol. 6 (5).	**Journal**
4.	**M. Z. Rehman, N. M. Nawi (2011).** *The Effect of Adaptive Momentum in Improving the Accuracy of Gradient Descent Back Propagation Algorithm on Classification Problems.* PP. 380-390. In: CCIS Journal of *Software Engineering and Computer Systems*. Springer Heidelberg. Vol. 179 (6).	**Journal**
5.	**M. Z. Rehman, N. M. Nawi (2011).** *Improving the Accuracy of Gradient Descent Back Propagation Algorithm (GDAM) on Classification Problems, 861-870.* In: *International Journal on New Computer Architectures and Their Applications (IJNCAA).* Vol. 1 (4), pp. 861-870.	**Journal**
6.	**M. Z. Rehman, N. M. Nawi, M. I. Ghazali (2011).** *Noise-Induced Hearing Loss (NIHL) Prediction in Humans Using a Modified Back Propagation Neural*	**Journal**

Network. International Journal on Advanced Science, Engineering and Information Technology, Vol. 1(2). 185-189.

7.	**M. Z. Rehman, N. M. Nawi (2012).** *Verifying the Accuracy of GDAM Algorithm on Multiple Classification Problems*. MUiCET 2012.	**Conference**
8.	**M. Z. Rehman, N. M. Nawi, M. I. Ghazali (2011).** *Predicting Noise-Induced Hearing Loss (NIHL) and Hearing Deterioration Index (HDI) in Malaysian Industrial Workers using GDAM Algorithm*. MUiCET 2011. **(Silver Award: 2nd Best Paper in ICT Category)**	**Conference**

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LIST OF SYMBOLS AND ABBREVIATIONS

ANN	-	Artificial Neural Networks
BMI	-	Body-Mass-Index
BPNN	-	Back-Propagation Neural Network
BPAM	-	Back-Propagation with Adaptive Momentum
DOSH	-	Department of Occupational Safety and Health, Malaysia
GDAM	-	Gradient Descent with Adaptive Momentum
GDM	-	Gradient Descent with Momentum
GDM-AG	-	Gradient Descent with Momentum and Adaptive Gain
HDI	-	Hearing Deterioration Index
high	-	highest value in the interval [0,1]
Hz	-	Hertz
KHz	-	Kilo-Hertz
L	-	lower bound
low	-	lowest value in the interval [0,1]
LHL	-	Left Hearing Loss
MLP-ANN	-	Multilayer Perceptrons Artificial Neural Networks
NIHL	-	Noise-Induced Hearing Loss
NIOSH	-	National Institute of Occupational Safety and Health
PTS	-	Permanent Threshold Shift
rand	-	Random number generator built-in function of Matlab
RHL	-	Right Hearing Loss
RSI	-	Rothman Synergy Index
SPL	-	Sound Pressure Level
TNB	-	Tenaga Nasional Berhad
TTF	-	Time-To-Failure
TTS	-	Temporary Threshold shift
n	-	Number of nodes in the output layer

t_k	-	Desired output of the k[th] output unit
O_k	-	Network output of the k[th] output unit
α_k	-	Momentum coefficient
O_j	-	Output of the j[th] unit
O_i	-	Output of the i[th] unit
w_{ij}	-	Weight of the link from unit i to unit j
w_{jk}	-	Weight of the link from unit j to unit k
w_{net}	-	Total Network Weights
$a_{net,j}$	-	Net input activation function for the j[th] unit
θ_j	-	Bias for the j[th] unit
y_{new}	-	new value obtained
y_{old}	-	old value in the data
$y_{\max}$	-	maximum and minimum of the old data range
$y_{\min}$	-	minimum of the old data range
T_i	-	predicted data
A_i	-	actual data
n	-	total number of input patterns
N	-	Number of values or elements
X'	-	first score
x_i	-	number of input patterns
Y'	-	second score
y_i	-	predicted patterns
%	-	percentage sign
U	-	upper bound

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CHAPTER 1

INTRODUCTION

1.1 Background of the Research

In the last three decades, Malaysian Industry has progressed a lot and has not only benefited Malaysian citizens in many ways but it also has caused adverse health effects on the Malaysian industrial workers. One of the major occupational health problems that an Industrial worker faces today is Noise-Induced Hearing Loss (NIHL). Noise-Induced Hearing Loss (NIHL) usually occurs due to continuous exposure to the noise levels of 90 plus decibels emitting from the heavy machines.

Noise-Induced Hearing Loss (NIHL) is a common occupational health problem identified among the workers working in the textile plants, basic metal industry, chemical industry, beverages and non-metallic mineral product industry. It was revealed in 1990's Audiometric (hearing loss test) survey by Department of Occupational Safety and Health, Malaysia (DOSH) that about 26.9 percent of industrial workers had a hearing threshold of 3000 - 6000 Hz which was greater than normal and 21.9 percent of workers were already suffering from detectable hearing loss (Leong, 2003). In another Audiometric test conducted at Stesen Janakuasa Sultan Ismail, Terengganu by Rizal (2002), it was revealed that Gas Turbine Station had the most number of NIHL effectees than Steam Turbine, Boiler or Pump Station. The test exposed that out of the 37 workers selected; about 39.6 percent of workers were already suffering from hearing loss.

Human ear plays a vital role in the human body; it is not only a source of hearing in humans but it also helps human body in maintaining its balance. Any problem with the hearing ability damages the human's life by reducing the quality of communication (Zaheeruddin & Jain, 2004). Noise-Induced Hearing Loss (NIHL) can be categorised as temporary or permanent, depending on how much sensorineural loss has occurred in the patient. Usually Noise-Induced Hearing Loss (NIHL) progresses unnoticed until it began to interfere with the communication and thus decreases the quality of life.

Seeing Noise-Induced Hearing Loss (NIHL) as a growing problem in the Malaysian Industry, Factories and Machinery (Noise Exposure) Regulations, 1989 has been passed by Department of Occupational Safety and Health, Malaysia (DOSH) in order to control the level of noise to permissible limits. In line with this, employers are required to abide the following stated regulations;

I. *No Employee shall be exposed to noise level exceeding equivalent continuous sound level of 90 dB (A) or exceeding the limits specified in the first schedule or exceeding the daily dose of unity.*
II. *No employee shall be exposed to noise level exceeding 115dB (A) at any time.*
III. *No employee shall be exposed to impulsive noise exceeding a peak sound pressure level of 140 dB(A).*

Noise-Induced Hearing Loss (NIHL) is found to cause many harmful effects in humans, but the latest improvements in Artificial Neural Networks (ANN) has paved way for researchers to predict various harmful effects of noise on humans such as human work efficiency in noisy environment (Zaheeruddin & Garima, 2005), speech interference in noisy environment (Zaheeruddin & Jain, 2005), noise induced sleep disturbance (Zaheeruddin & Jain, 2006), and noise induced annoyance (Zaheeruddin, 2006). Artificial Neural Networks (ANN) are modelled on the human brain and consists of processing units known as artificial neurons that can be trained to perform complex calculations like human brain. Unlike traditional methods in which an output is based on the input it gets, an Artificial Neural Networks (ANN) can be trained to store, recognize and estimate patterns without having the information about the form of function (Zheng, Meng, & Gong, 1992, Kosko, 1994, Basheer & Hajmeer, 2000, Krasnopolsky & Chevallier, 2003, Coppin, 2004).

Artificial Neural Networks (ANN) techniques, particularly Back-Propagation Neural Network (BPNN) algorithm has been widely used as a tool for discovering a mapping function between a known set of input and output examples. Despite providing effective solutions, the training process for an Back-Propagation Neural Network (BPNN) entail the designer to arbitrarily select parameters such as network topology, initial weights and biases, learning rate value, the activation function, value for gain in activation function and momentum. An improper choice of any of these parameters can result in slow convergence or even network paralysis, where the training process comes to a standstill or get trapped at local minima. Therefore, this research focuses on using Back-Propagation Neural Network (BPNN) model with an improvement on the momentum value to predict Noise-Induced Hearing Loss (NIHL) in industrial workers. Results from the prediction will be used in determining the noise hazards which directly influence the worker's health.

1.2 Problem Statement

Back-Propagation Neural Network (BPNN) is a supervised learning Artificial Neural Network (ANN) algorithm. Due to its ability to learn by calculating the errors of the output layer to find the errors in the hidden layers, Back-Propagation Neural Network (BPNN) is highly suitable for problems in which no relationship is found between the outputs and inputs (Coppin, 2004). However, BPNN has got a problem of slow convergence and network stagnancy. Nazri (2007) proposed an improved algorithm known as GDM-AG which increased the accuracy in the convergence rate by making the gradient slope smoother with the introduction of adaptive gain value. It was discovered during this research that changing the momentum term adaptively also can affect the performance of the BP. Therefore, this study tries to investigate and further proposes a new algorithm that will use adaptive momentum to remove oscillations in the gradient path and at the same time will keep the gain value fixed for all trials (Rehman, Nazri, & Ghazali). This study will validate the accuracy of the proposed algorithm by comparing with the conventional BPNN algorithm and GDM-AG proposed by Nazri (2007), on selected classification problems. This study will prove the effectiveness of the proposed algorithm by predicting the Noise-Induced Hearing Loss (NIHL) in the workers of Tenaga National Berhad (TNB).

1.3 Objectives of the Study

This study encompasses the following three objectives:

i. To propose an improved algorithm which improves the accuracy in the existing GDM-AG (Nazri, 2007) algorithm by choosing the optimal values for momentum coefficient.

ii. To assess the performance accuracy of the proposed algorithm with the conventional BPNN and GDM-AG algorithms on selected benchmark classification problems.

iii. To validate the proposed algorithm in predicting NIHL in Malaysian Industrial workers by using TNB data sets.

1.4 Scope of the Study

This study will focus on the use of improved BPNN to predict the level of Noise-Induced Hearing Loss (NIHL) in human workers which will help regulatory bodies to take precautionary measures in-order to reduce excessive emitting noises from the machines in an industry, so that Noise-Induced Hearing Loss (NIHL) in human workers can be reduced and the smooth running of Industrial process can be ensured.

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