COMPARATIVE STUDY ON THE EFFECT OF ACTIVATION FUNCTIONS IN NEURAL NETWORK FOR RUBBER TREE DISEASES DETECTION

HARYANI BINTI MOHD RASIDI

A project report submitted in fulfillment of the
requirements for the award of the degree of
Master of Science (Computer Science)

Faculty of Computer Science and Information Systems
Universiti Teknologi Malaysia

MAY 2011

Special for my beloved husband, my family and friends. Thanks for being here and always support me.

ACKNOWLEDGEMENTS

Alhamdulillah, thank to ALLAH S.W.T for the blessing and guiding me until I was able to complete this project. I would like to draw my highest appreciation to my supervisor Assoc. Prof. Dr. Siti Zaiton Binti Mohd Hashim for her guidance, encouragement and support for me throughout period of time on doing this project.

I am also indebted to Rubber Industry Smallholders Development Authority (RISDA) and Malaysia Rubber Board (MRB), Melaka for their cooperation in giving the data that have been used for this project.

Also, I would like to extend my sincere thankful to my husband, parents and family because giving their encouragement and support for me to complete this project successfully. Finally, to all my colleagues for their help and support and but not least, very special thanks to the late Assoc. Prof. Dr. Mat Nor B. Mat Sap for his help and support. *Al-Fatihah*. Thank you.

ABSTRACT

The rubber tree (*Hevea brasiliensis*) is grown extensively in South-East Asia, especially in Malaysia, for the production of natural rubber and, increasingly, timber. However, rubber tree generally attacked by pests or diseases such as root disease, white root, red root, brown root, leaf disease and the others. In this study, four types of diseases will be seen namely *Fusicoccum*, *Corynespora*, *Collelotrichum* and *Oidium*. Generally known that neural networks may be used for nonlinear analysis of complex data. As such, the purpose of this study is to evaluate the usefulness of Artificial Neural Networks (ANNs) applied to rubber tree for diseases detection. The ANNs used in the present study were based on a feed forward layered model with input, hidden, and output layers, on which a backpropagation learning model was implemented. The focus of study also to investigate the effect of activation functions on accuracy, efficiency and performance of disease detection. Four activation functions will be compare which are Hyperbolic Tangent Sigmoid, Linear, Radial Basis and Triangular. This study also will be focus on how to convert an image data to the conventional input data. The preprocessing process of the sample image such as image enhancement, image filtering has been performed before the process feature extraction will be applied. The techniques that will be used for feature extraction of image using the gabor filter method. The output of this filter will be used for the classification purpose in order to determine the characteristics of rubber tree diseases image. 10-fold cross validation techniques will be applied in order to measure the percentage of accurately of this classifier.

ABSTRAK

Pokok getah (*Hevea brasiliensis*) berkembang secara meluas dalam Asia Tenggara, terutama di Malaysia untuk pengeluaran getah asli dan kayu. Bagaimanapun, pokok getah biasanya diserang oleh binatang perosak atau penyakit-penyakit getah seperti penyakit akar putih, akar merah, akar perang, daun, batang dan lain-lain. Dalam kajian ini, empat jenis penyakit akan dilihat iaitu *Fusicoccum, Corynespora, Collelotrichum* dan *Oidium*. Secara umum, *neural network* boleh digunakan untuk menganalisis data kompleks tak linear seperti mengesan penyakit pokok. Oleh itu, tujuan kajian ini adalah untuk menilai kegunaan *Artificial Neural Networks (ANNs)* yang digunakan ke atas pokok getah untuk pengesanan penyakit pokok getah. Dalam kajian ini, *ANNs* menggunakan model *feed forward layered* dengan lapisan input, tersembunyi dan hasil yang mana pembelajaran model *backpropagation* dilaksanakan. Fokus kajian ini juga untuk menyiasat kesan fungsi pengaktifan pada ketepatan, kecekapan dan prestasi pengesanan penyakit. Empat fungsi pengaktifan akan dibandingkan iaitu *Hyperbolic Tangent Sigmoid, Linear, Radial Basis* dan *Triangular*. Kajian ini juga menumpu kepada bagaimana untuk menukar satu data imej kepada data input konvensional. Prapemproses imej seperti *enhancement* dan *filtering* dilaksanakan sebelum proses pengekstrakan ciri digunakan. Setelah itu, teknik-teknik tersebut digunakan untuk pengekstrakan cirri dengan menggunakan *gabor filter*. Hasil akhir daripada proses ini akan digunakan sebagai input untuk tujuan pengkelasan bagi menentukan ciri-ciri bagi penyakit pokok getah. Teknik pengesahan untuk mengukur peratusan ketepatan kedua-dua pengkelas ini adalah dengan menggunakan teknik *10-fold cross validation.*

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ABBREVATION	DESCRIPTION
AI	Artificial Intelligence
ANN	Artificial Neural Network
BP	Backpropagation
GA	Genetic Algorithm
GFNN	Generalized Feed Forward Neural Network
GIS	Geographic Information System
RBFNN	Radial Basis Function Neural Network
MLP	Multi Layered Perceptron
MRB	Malaysia Rubber Board
MLPNN	Multi Layered Perceptron Neural Network
MSE	Mean-Squared Error
NN	Neural Network
PSO	Particle Swarm Optimization
RBF	Radial Basis Function
ROI	Region of Interest
TRAINLM	Levenberg-Marquardt

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Introduction

The rubber tree (*Hevea brasiliensis*) is grown extensively in South-East Asia, especially in Malaysia, for the production of natural rubber and, increasingly, timber. Malaysia is one of the main South-East Asian rubber producers: in 1997, a total area of 1.564 million was planted with rubber, predominantly by smallholders. In 1999, the total rubber production for Malaysia was 0.9 million tones and its export value was 3115 million Malaysian Ringgit (approx. US$0.8 million; 2 percent of total Malaysian exports).

In Malaysia, rubber is relatively free from attack by indigenous pests or diseases, and no such species accompanied the plant from its area of origin in the Amazon. The most damaging disease of rubber trees is root diseases such as white root, red root, brown root, leaf abscission, black scratched disease and the others. In comparison, investment in early warning systems is quite limited. Staffs from the Rubber Research Institute of Malaysia and the Department of Agriculture carry out

regular surveys of rubber diseases every two to three years. These are primarily intended to identify indigenous disease problems, so that recommendations for suitable solutions may be made for different areas.

In the previous work, many researchers use neural network to solve similar problem such as from Liu. G *et al.* (2005) about an artificial neural network-based expert system for fruit tree disease insects pest diagnosis. The researcher use neural network to predict the development tendency of fruit tree disease and can improve accuracy, visibility and predictability of diagnosis. The other researcher that involve in solving disease environment is Rizwan et al. (2007). The title of the research is a Radial Basis Function Neural Network (RBFNN) approach for structural classification of thyroid diseases. This research demonstrates the strong utility of an artificial neural network model for structural classification of thyroid diseases. The advantages in this research are we do not assume a specific model in neural network technique because it learns from the data to establish the input and output relationship. Because of its ability to identify non-linear relationships, neural network is a useful analytical tool to establish the global structure-activity relationships.

Artificial neural networks (ANNs) are being evaluated as a way to predict rubber tree diseases. On the other hand, it is generally known that artificial neural networks (ANNs) may be used for nonlinear analysis of complex data. The purpose of this study is to evaluate the usefulness of ANNs applied to rubber tree for diseases detection. The ANNs used in the present study were based on a feed forward layered model with input, hidden, and output layers, on which a back-propagation learning model was implemented. An artificial neural network (ANN) is a system based on the operation of biological neural networks, in other words, is an emulation of biological neural system (Figure 1).

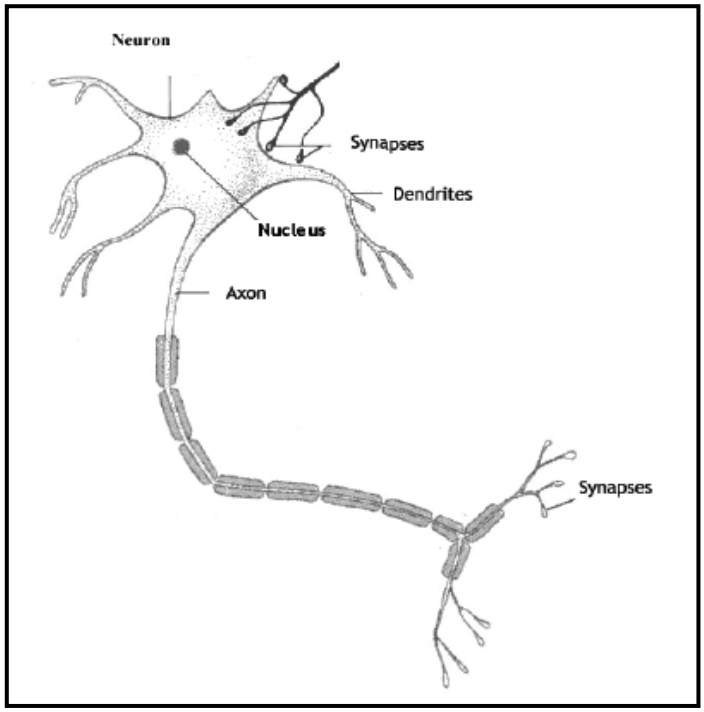

Figure 1.1 The biological neuron

The focus of study to investigate the effect of activation functions on accuracy, efficiency and performance of disease detection. Kamaruzzaman. J and Aziz. S (2002) presents an inverse tangent activation function for hidden and output units. This paper compare of accelerate backpropagation technique that used Sigmoid and Tangent Hyperbolic (Commonly used), Logarithmic (Recently used) and Arctangent (Proposed) activation function. The result from this research is use of arctangent activation function yields better learning speed. The second research from Sopena. J et al. (1999), about neural networks with periodic and monotonic activation functions: a comparative study in classification problems compare the performance of sigmoid and sine activation function. With sine activation functions, a multilayer perceptron can learns much more quickly than one using sigmoid functions. Therefore, this research aims to compare some activation function for detecting rubber tree diseases especially in leaf diseases to see the better performance result between them. The activation function acts as a squashing function, such that the output of a neuron is between certain values (usually 0 and 1, or -1 and 1). Activation functions for the hidden units are needed to introduce nonlinearity into the network. Without nonlinearity, hidden units would not make nets more powerful than

just plain perceptrons (which do not have any hidden units, just input and output units).

Many different neural network structures have been tried, some based on imitating what a biologist sees under the microscope, some based on a more mathematical analysis of the problem. The most commonly used structure is shown in Fig. 1.2. The number of input nodes n is determined by the number of attributes contained in the training and testing sets (Valverde *et al*., 2005). The research from Arulampalam. G and Bouzerdoum. A (2003) about generalized feed forward neural network architecture for classification and regression was presented generalized feed forward architecture for classification and regression. Overall, the results show that the GFNN classifiers can solve problems with simple structures. The power of these networks is lies with the neuron model used. In this project, feed forward neural network are chosen as a network model because it was the first and arguably simplest type of artificial neural network devised. In this network, the information moves in only one direction, forward, from the input nodes, through the hidden nodes (if any) and to the output nodes. Three architecture need to compare based on number of neural network nodes that show in Chapter 2.

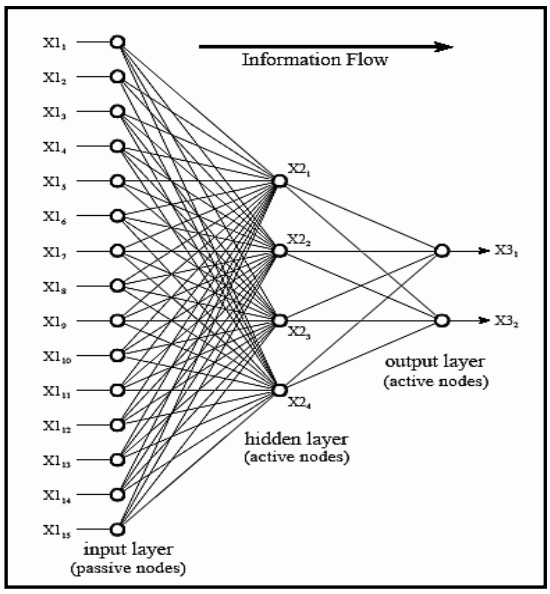

Figure 1.2 The most common structure for neural networks

To detecting rubber tree diseases, we need to cluster the image data. When use an image as a data, this study also will be focus on how to convert an image data to the conventional input data. The preprocessing process of the sample image such as image enhancement, image filtering has been performed before the process feature extraction will be applied. The techniques that will be used for feature extraction of image using the Gabor filter method.

1.2 Problem Background

Rubber tree *(Hevea Brasiliensk)* diseases spread along planting lines and cause serious damage. A biological model and mathematical model was developed which allows the influence of their various parameters on the dynamics of an epidemic to be evaluated. The research from [Chadoeuf et. al, 1993] about the Modeling Rubber Tree Root Diseases Epidemics with a Markov Spatial Process that allowed to model epidemics and estimate the theoretical impact of various treatments according to their nature, efficiency, and mode of application. These methods are more particularly adapted to the study of industrial perennial crop plantations, where a lot of measured plants are available, but for which the biological background of the infecting pathogens is difficult to assess (especially, for root rotting agents).

The other research from Gang Liu (2003) about prediction fruit tree diseases and insect pests based on neural network. The system was trained by the history record data and then the ring spot was chosen as the research object to compare the predicted value with the actual value. The results indicate that the system can predict accurately, and fast. The foundation of neural network in a scientific sense begins with biology. neural network have several advantages, most important is the ability to learn from data and thus potential to generalize, i.e. produce an acceptable output for previously unseen input data (important in prediction tasks).

Activation functions for the hidden units are needed to introduce nonlinearity into the network. For backpropagation learning, the activation function must be differentiable and it helps if the function is bounded. So, activation function such as hyperbolic tangent sigmoid, linear, radial basis and triangular function will be applied to detect leaf diseases of rubber tree that we know many advantages based on neural network. The comparison between activation functions will be defined to produce the minimum error value and minimum period with produce the highest ability to detect rubber tree diseases. Consequently, the purpose of this research is to compare between some activation functions to detecting leaf diseases of rubber tree based on neural network that can predict accurately, fast and function robustly.

Gabor filters are one of tool for image analysis, face tracking, object recognition, texture analysis and have found widespread in use in computer vision (G. Loy, 2002). However by using the Gabor wavelets methods, high computational load are required normally for the computer vision aspect. Gabor filter use for edge detection and extraction of texture features, simulate simple and complex cells (visual cortex), simulate non-classical receptive field inhibition or surround suppression and use it for object contour detection, and explain certain visual perception effects. Gabor filter are apply to an image involves convolution with set of Gabor wavelets consisting of numerous wavelets kernels of the different wavelength and orientation. In order to minimize this problem, the selection of the relevant features should be applied to deal with this problem. In addition, Gabor filter can provide very good result on small images and further study is focus on higher resolution images.

1.3 Problem Statement

One major issue that remains unexplored is how to detect rubber tree diseases. In this regard, our problem statement is “is that possible using neural network can detect the leaf diseases of rubber tree”. The minor problem statements that support major problem are:

i. Can activation function affect the performance of detecting the leaf diseases of rubber tree?
ii. Which activation function comparison has strong output and minimum error value in detecting rubber tree diseases?
iii. Can backpropagation learning algorithm classify leaf diseases of rubber tree?

1.4 Project Aim

The project aims to investigate the uses of activation function in neural network to detect and classification leaf diseases of rubber tree based on back-propagation neural network. In other words, the aim of this project is comparing and choosing the better performance among activation function such as hyperbolic tangent sigmoid, linear, radial basis and triangular function. The architecture of neural network that chosen are feed-forward while three architecture need to compare based on number of neural network nodes to determine the accuracy of result. Before the process of training neural network, the data must be prepared from the raw image to the informative image using of Gabor filter for the feature extraction.

1.5 Objectives of the Project

This project aims to accomplish the following objectives:

i. To study the Gabor filter for feature extraction method especially in detecting the leaf diseases of rubber tree
ii. To investigate the leaf diseases of rubber tree based on backpropagation neural network
iii. To apply and compare some of activation function for the purpose of detecting leaf diseases of rubber tree

1.6 Project Scope

This project entails the following scope:

i. The data of rubber tree diseases are collected from Rubber Industry Smallholders Development Authority (RISDA), Melaka and Malaysia Rubber Board (MRB), Melaka.
ii. The data consists of four data set of leaf diseases
iii. 25 data for each data set and the total images is 100 samples
iv. 18 data from each set is declare as a training data and 7 data from each set as a testing data
v. Four major of leaf diseases are investigate: *Oidium*, *Collectotrichum*, *Phytophthora* and *Corynespora*
vi. Gabor wavelet is used for image feature extraction
vii. Four activation function will be used : hyperbolic tangent sigmoid, linear, radial basis and triangular function to use in this research

viii. Feed-forward multilayer perceptron and back-propagation learning algorithm are applied

ix. Mean-Squared Error (MSE) is used to quantify the error of the network

x. To validate the accuracy of classification using 10-fold cross validation

xi. Matlab 7.0 software will be used in this study

1.7 Significance of Project

Nowadays, rubber tree diseases give several of problems to many people, rubber company and economy Malaysia. Diseases is attacking rubber tree that causes ire-eversible drying-up of latex flow and causing marked falls in production and economic losses. Detecting the rubber tree diseases is not simple task. Different techniques are being used in the trading community for prediction tasks. In recent years the concept of neural networks has emerged as one of them.

This project need to be perform to defines the activation function that produce the minimum error values and shortest period with together produce the highest detecting rubber tree diseases. Feedforward multi layered perceptron and back-propagation learning algorithm are choose as a basic for this project. This model is selected because the model is general and very effective in detecting diseases using neural network. Neural network is widespread and consist of several of model, methodology and technique and Gabor filter method for the feature extraction is used to identify the diseases of rubber tree.

1.8 Organization of the Report

This report is organized into five chapters. The first chapter presents the introduction of the study, problem background, project aim, scope, objectives and the significance of the project. Chapter 2 discussed the previous work and the literature review of existing techniques for detecting rubber tree diseases. Next, the methodology of the project is discussed in Chapter 3 and Chapter 4 presents the experimental result and discussion of the research that has been studied. The last chapter is the conclusion and suggestion for future works what will be implemented later.

1.9 Conclusion

This chapter generally discusses the problem statement, objective, scope and significance of the studies. In other word, this chapter gives a general idea of overall situation and the flow of research. To sum up, neural network is important roles in detecting rubber tree diseases. This study also focuses on evaluating four activation functions: hyperbolic tangent sigmoid, linear, radial basis and triangular function based on back-propagation neural network as a learning algorithm.

REFERENCES

Abraham, A. *Artificial Neural Networks*. Handbook for Measurement Systems Design. John Wiley and Sons Ltd., London: pp. 901-908. 2005.

Ahmadian. A and Mostafa. A (2003). *An Efficient Texture Classification Algorithm using Gabor Wavelet*. IEEE

Aivazhagan.S, Ganesan. L, Padam Priyal.S (2003). *Texture Classification Using Gabor Wavelets Based Rotation Invariant Features*. Science Direct.

Ali Zilouchian and Mo Jamshidi (2001). *Intelligent Control Systems Using Soft Computing Methodologies*, CRC Press

Andrew (2006). *An Artificial neural Network Improves Prediction of Observe Survival in Patients with Laryngeal Squamous Carcinoma*. Springle Link

Bhuiyan, A.A. and Liu, C.H. (2008). On Face Recognition using Gabor Filters. *International Journal of Signal Processing 4;3 Summer 2008*. 195-200.

Cardenas E.O (2008). *MLP Neural Network And On-Line Backpropagation Learning Implementation In A Low-Cost FPGA*, ACM

Cassiicola (2007). *Causal Agent of the Leaf Fall Diseases of Rubber Tree*. Science Direct: Neurocomputing

Cornelius T. Leondes (2003). *Intelligent Systems, Technology and Application, volume III, Signal, Image and Speech Processing*. CRC Press

Daqia. J and Genxinga. Y (2001). *Influences of Variable Scales and Activation Functions on the Performance of Multilayer Feedforward Neural Networks*. Science Direct: Neurocomputing

FLETCHER. G.P (2006). *Adaptive Internal Activation Functions and Their Effect on Learning in Feed Forward Networks*, IEEE

Gershenson. C (2000). *Artificial Neural Network for Beginners*, IEEE

Guyota. J (2004). *Some epidemiological investigations on Colletotrichum Leaf Disease on Rubber Tree*, Science Direct:Neurocomputing

Guyota. J (2005). *Some epidemiological investigations on Colletotrichum Leaf Disease on Rubber Tree*, Science Direct:Neurocomputing

Hagan, M.T and Menhaj (1994). Training Feed-Forward Networks with Marquardt Algorithm. *Neural Networks, IEEE Transactions on*. 5(6), 989 – 993.

Hanna, A.I. and Mandic, D.P. (2002). *A Normalised Complex Backpropagation Algorithm*. IEEE, 977-980.

Hatami, S., Hossein, R., Kamarei, M. and Ahmadi, H. (2005). Wavelet Based Fingerprint Image Enhancement. *IEEE*, 4610-4613.

Huang, Z.K. and Huang, D.S. (2006). *Classification Based on Gabor Filter using RBPNN Classification*. IEEE, 759-762.

Inc. The MathWorks. In *http://www.mathworks.com/*.

Lamotte. F, Duviau. M, Sanier. C, Thai. R and Poncet. J (2006). Purification and Characterization of Cassiicolin, the Toxin produced By Corynespora S.A billings, H.B Jamaluddin and S.Chen. *A comparison of the backpropagation and recursive prediction error algorithm for training neural network*. IEEE

Lee. T. S (1996). *Image Representation Using 2D Gabor Wavelets*, IEEE

Liu. G (2005). *An Artificial Neural Network–based Expert System for Fruit Tree Disease and Insect Pest Diagnosis*, Science Direct:Neurocomputing

Loy, G. (2002). Fast Computation of the Gabor Wavelet Transform. *Digital Image Computing Techniques and Applications*. Science Direct:Neurocomputing

Pitchler. O, Teuner. A and Hosticka. B. J (1995). *A comparison of Texture Feature Extraction Using Adaptive Gabor Filtering, Pyramidal and Tree Structured Wavelet Transforms*, Elsevier

Ren. J.M (2005). *Neural Networks with Periodic and Monotonic Activation Functions: A Comparative Study in Classification Problem*, Springle Link

Rizwan (2007), *A Radial Basis Function Neural Network (RBFNN) Approach for Structural Classification of Thyroid Diseases*, Science Direct:Neurocomputing

Seng. W. C and Mirisaee. S. H (2004). *A New Method for Fruits Recognition System*, Springle Link.

Shen, S., Sandham, W.A. and Granat, M.H. (2003). Preprocessing and Segmentation of Brain Magnetic Resonance Images. *4th Annual Conference on Technology*

Application in Biomedicine. IEEE, 149-152.

Shim. C and Cheung. J.Y (1990). *A PC-Based Neural Network for Recognition of Difficult Syllables Using LPC Coefficient Different Microcomputer*, IEEE

Siti Mariyam, Dr (2009). *Advanced Artificial Intelligence*. Lecture Notes in Advanced Artificial Intelligence. Universiti Teknologi Malaysia, Skudai.

Sumbera. J (2001), *Histogram Equalization*, Elsevier

Tang, L., Tian, L. and Steward, B.L. (2003). Classification of Broadleaf and Grass Weeds using Gabor Wavelets and An Artificial Neural Network. *American Society of Agricultural Engineers*. 46(4): 1247-1254.

Wong. K. W and Chang S. J (2005). *Use of Periodic and Monotomic Activation Functions in Multilayer Feedforward neural Networks Trained By Extended Kalman Filter Algorithm*, IEEE

Yu, X., Efe, M.O. and Kaynak, O. (2002). A General Backpropagation Algorithm for Feedforward Neural Networks Learning. *Transaction on Neural Networks*. IEEE, 13(1): 251-254.

Zhang, G. and Ma, Z.M. (2007). Texture Feature Extraction and Description using Gabor Wavelet in Content-Based Medical Image Retrieval. *International Conference on Wavelet Analysis and Pattern Recognition*. IEEE, 169-173.