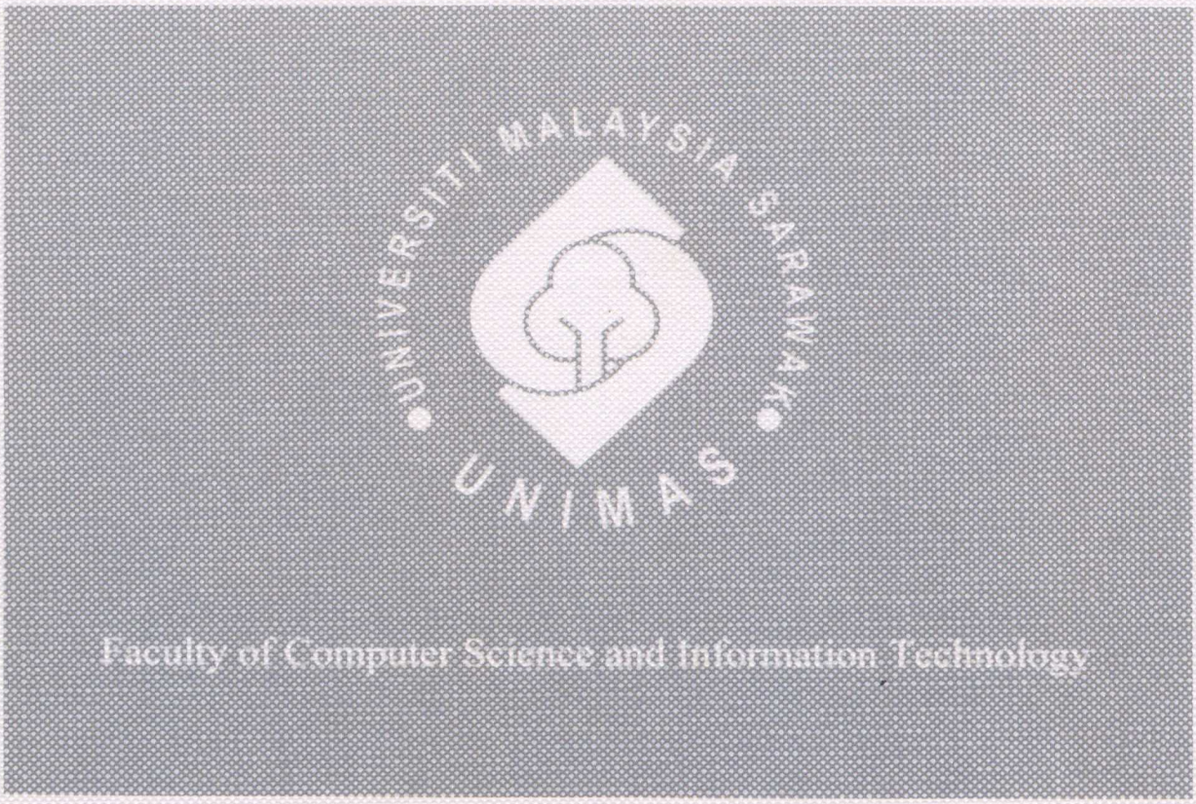

WEATHER FORECASTING USING ARTIFICIAL NEURAL NETWORK

Wong Wei Keat

Bachelor of Computer Science with Honours
(Software Engineering)
2014

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WONG WEI KEAT

This project is submitted in partial fulfillment of the
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RAMALAN CUACA DENGAN MENGGUNAKAN KAEDAH *ARTIFICIAL NEURAL NETWORK*

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Table of Contents

List of Figures

List of Tables

Abstract

This project studies the better weather forecasting approaches. In this study, Kuching city been selected as the study area. The Kuching meteorology data used in this study is collected from the Malaysian Meteorological Department. Artificial neural network (ANN) is adopted in this study as ANN has better performance and it can perform weather forecasting better than conventional weather forecast model. Two neural network algorithms, Back Propagation (BPNN) and Radial Basis Function (RBFNN) were tested with the Kuching meteorology data set. Both neural network models are trained and tested with different testing criteria, thus the results and performance generated by these two neural network algorithms were compared. The experimental results showed that the BPNN model has better performance in weather forecasting compared to RBFNN.

Abstrak

Projek ini mengkaji penyelesaian yang lebih baik untuk ramalan cuaca. Dalam kajian ini, bandar Kuching telah dipilih sebagai kawasan kajian. Data meteorologi Kuching yang digunakan dalam kajian ini dikumpul daripada Jabatan Meteorologi Malaysia. Kaedah *Artificial Neural Network* (ANN) digunapakai dalam kajian ini.ANN mempunyai prestasi yang lebih baik dan ia boleh menghasil ramalan cuaca yang lebih baik dari pada model konvensional ramalan cuaca. Dua algoritma *neural network*, *Back Propagation* (BPNN) dan *Radial Basis Function* (RBFNN) telah diuji dengan data meteorology Kuching. Kedua-dua model *neural network* akan dilatih dan diuji dengan kriteria yang berbeza, dengan itu keputusan dan prestasi *neural network* akan dihasilkan dan kedua-duanya akan dibandingkan. Keputusan uji kaji menunjukkan bahawa model BPNN mempunyai prestasi yang lebih baik dalam ramalan cuaca berbanding RBFNN.

Chapter 1. Introduction

1.1 Overview

Malaysia, a country covered by a huge region of agriculture. As agriculture is one of the most important sectors that contribute to the Malaysia economy, so the Malaysia economy is highly dependent to the weather condition (Wong, 2007). This is because a bad weather condition might always affect the economy of the country due to the bad crops growth condition. So weather forecasting is vital to predict the best season for crops planting and preventing the crops from being harmed by the chaotic weather condition.

Back in 1960s,due to the advancements of supercomputers, few weather forecasting models are designed to make weather prediction more accurate and effective (Goto, 2007). The most common weather forecasting model is the conventional numerical model. But the forecast accuracy of this model is relatively low because this model is unable to extract the dependencies from measured data and complement with analytic knowledge to provide accurate forecasting result (Chang et al., 2001). Moreover, the existing of uncertainty caused by the incomplete modelling of natural processes in this model and inaccurate of initial state of atmosphere has greatly reduces the accuracy of the weather forecast result (Goto, 2007). Besides that, conventional numerical model is not suitable for long scale prediction because the uncertainty will become larger due to the chaotic nature of atmosphere (Shrivastava et al., 2012).

Recently in the context of hydrological, Artificial Neural Network (ANN) has been widely used for weather prediction, flood forecasting, evapotranspiration estimation and stream flow prediction. Dawson and Wilby (1998) proved the application of ANN in flow forecasting in England using hourly hydrometric data. An ANN model constructed by Tokar and Johnson (1999) used to forecast daily precipitation, temperature and snowmelt in Maryland. Besides that, ANN has been applied in precipitation prediction (Hall et al., 1998), flood forecasting (Chang et al., 2001) reference evapotranspiration estimation (Wang et al., 2008), rainfall forecasting (Babel et al., 2009; Baboo and Shereef, 2010; Devi et al., 2012) and rainfall-runoff estimation (Chen et al., 2013). Most of the previous studies applied daily and monthly hydrometric data into ANNs for long term predictions. Hence, the purpose of this study is to establish weather forecast models using daily meteorology data using ANN techniques.

1.2 Problem Statement

A lot of weather forecasting solutions are available ranging from manual to automated approaches, some of them are labor intensive and time consuming. Using conventional numerical weather forecast model for weather forecasting is obsolete today (Goto, 2007). On the other hand, neural network has a remarkable ability to derive and extract rules, trends and meanings from complicated noisy and imprecise weather data (Babel et al., 2009; Devi et al., 2012).The two main ANN algorithms used for weather forecasting are: Back Propagation Neural Network (BPNN) and Radial Basis Function Neural Network (RBFNN). The reason of applying BPNN and RBFNN is discussed in literature reviews section and project methodology section.

Therefore, this project intends to study these two ANN models using the available weather data that collected from the Malaysian Meteorology Department. There are few research questions that need to be answered through this project.

- Which ANN model is better for accurate weather forecasting?
- What are the construction properties of neural network that is able to provide a good weather forecast result?
- What are the minimum weather forecast data that are required in these chosen models (BPNN and RBFNN) for weather forecast processes?

1.3 Objectives

The objectives of conducting this project are comparing the suitability of the two ANN algorithms in weather forecast model for weather forecasting; identify ways on constructing a reliable, accurate and efficient weather forecast model structure using the chosen artificial neural network, determine the minimum weather data that is suitable for the weather forecasting, train and test the neural network models using the collected historical meteorology data and last but not least to investigate the performance of using BPNN and RBFNN in weather forecasting.

1.4 Scope of Project

The scopes of this project are

- The implementation of weather forecasting was focus in Kuching city, Sarawak, Malaysia.
- Comparing two ANN weather forecast models, the BPNN and the RBFNN to identify the suitable model for better weather forecasting.

1.5 Expected Outcome

A suitable and better ANN based weather forecast model will be produced which has the capability to produce a reliable, accurate and efficient weather forecast result for Kuching city, Sarawak, Malaysia.

1.6 Significance of Project

This project studies the artificial neural network for weather forecasting. The study area for this project is focused in Kuching city, Sarawak. The output of this project will contribute to building a reliable, accurate and efficient weather prediction method for weather forecasting using ANN.

1.7 Project Schedule

The time schedule for this project starts from 11 September 2013 until 1st May 2014. The details will be shown in Appendix A.

1.8 Project Outline

1.8.1 Chapter 1: Introduction

This chapter will cover the problem statements, objectives, methodology, scopes, project significance, project schedule and the project outlines.

1.8.2 Chapter 2: Background Study and Literature Reviews

This chapter covered the identification of overall resources used and the reviews of similar approaches on conducting the study.

1.8.3 Chapter 3: Introduction to Project Methodology

This chapter included the methodology stages and its sub-process on conducting this study throughout the whole project.

1.8.4 Chapter 4: Results and Evaluation

This chapter consists of the results generated from the conducted study and evaluation toward the results.

1.8.5 Chapter 5: Conclusion

This chapter provides the expected outcomes of the project study and the conclusion of the study.

Chapter 2. Literature Reviews

2.1 Background Study

2.1.1 Artificial Neural Network

An Artificial Neural Network (ANN) model is a new computational methodology used for information processing, performed multifactorial analyses, solving the non-linear relationship problem, and extracting noisy data from the pattern (Babel et al., 2009; Devi et al., 2012). This network was inspired by the biological neural system in the way it process information (Devi et al., 2012).

An ANN is interconnected by a group of artificial neurons that have the ability to learn and store knowledge and to produce desire result. The number of hidden nodes and layers are used to optimize the performance of result based on input situation (Hall, Books & Doswell, 1998). The advantage of the artificial neural network is the ability to capture complex inputs and outputs relationship. Besides, that it is also able to represent both linear and non-linear relationship directly from the data being modelled which traditional linear models are not capable to do that when facing the non-linear data (Baboo & Shereef, 2010). By adjusting the weights connection lines which appear between the nodes, the artificial neurons by using a collection of input data which called the training set, the artificial neural network is able to perform tasks such as output prediction, pattern recognition, data classification, function approximation and so on after learning process and successful training.

The main objective of conducting this study is to identify the suitable neural network for weather forecasting by using two different neural network architectures. Back Propagation Neural Network (BPNN) and Radial Basis Function Neural Network (RBFNN) are selected in this study. The technique of selection of these two ANN to be used in this project is through literature reviews. Further explanation of reasons BPNN and RBFNN been selected in this study has been done in chapter two.

2.1.2 Back Propagation Neural Network (BPNN)

A BPNN consists of at least three layers. There are the input layer, at least one or more intermediate hidden layer and the output layer. Historical weather parameters are taken as the input to the back propagation neural network. The BPNN will be trained continuously to learn the sequence and pattern of the weather behaviour until it produce satisfactory result when tested with other unseen weather parameters.

The learning algorithm of BPNN consists of the propagation phase and the weight update phase (Devi et al., 2012). During the propagation phase, two propagation processes are involved that are forward propagation and backward propagation. Forward propagation of training pattern input through the neural network using the training pattern target in order to generate the deltas of all output and hidden neurons. In the weight update phase, each weight synapse will multiply its output delta and input activation to get a gradient of the weight and subtract a ratio of the gradient from the weight (Devi et al., 2012). The performance of the network such as speed and quality is influenced by this ratio is known as the learning rate. The greater the ratio, the faster the neuron trains. But on the other hand, the lower the ratio, the more accurate the training result will be. The errors are indicated by the gradient of a weight. Thus, the weight must be updated in the opposite direction. In order to produce a highly satisfactory performance, repeating the phases is necessary.

Besides that, the BPNN consists of two common learning modes. They are on-line and batch learning mode. During on-line learning mode, each propagation followed immediately by a weight update. On the other hand, batch learning propagations occur before updating the weights. There are feedbacks on these learning modes which the batch learning mode required plenty of memory capacity and on-line learning mode required more updates.

2.1.3 Radial Basis Function Neural Network (RBFNN)

A Radial Basis Function Neural Network (RBFNN) used a radial basis function as its activation function and is capable for universal approximation (Jareanpon et al, 2004). The most common activation function that has been used was the Gaussian function. RBFNN is useful when it comes to unknown function approximation, time series prediction, problems control and classification and curve fittings. It is crucial on determine the number of neurons in the hidden layer which might affects the complexity and generalizing capability of the network. In the input layer, there is a neuron for each predictor variable.

The input neurons will standardize the range of value and subtract the median and divide the interquartile range and feed the input neurons into the hidden layer. RBFNN network contains a single hidden layer only. A parameter vector called 'center' is used to compare with the network input vector to produce a radial symmetrical response. The network output is produced from the combination of response of the hidden layer and connection weights of the output layers. The performance of this network is indicated by the Mean-Square-Error (MSE) (Jareanpon et al, 2004). The main objective of RBFNN training is to approximate the underlying function of the system.

2.2 Literature Reviews

2.2.1 Flood Forecasting using Radial Basis Function Neural Networks (Chang et al., 2001)

Firstly, Chang et al. (2001) found the RBFNN is a suitable technique for a rainfall runoff model for prediction of flood which is three hours ahead in Lanyoung River, the most important river in north-eastern Taiwan. A modified Radial Basis Function Network (RBFNN) with min-max clustering is constructed to predict the one-hour-ahead, two-hour-ahead and three-hour-ahead flood flow during typhoon periods. The study result shown that RBFNN overcomes the non-linear relation between rainfall and runoff which could not been clarified by a conventional hydrological models.

2.2.2 An Adaptive RBF Network optimized using a Genetic Algorithm applied to Rainfall Forecasting. (Jareanpon et al., 2004)

On the other hand, in year 2004 Jareanpon et al. conducted a rainfall forecasting using an optimized RBFNN by using genetic algorithm. Genetic algorithm is an optimization methods that manipulates a string of numbers in a manner similar to the way chromosomes are changed in biological evolution. A database that consists of 30 years monthly rainfall data from 12 climate stations was used. In order to reduce the value of the sum square error (SSE), repeatedly feeding the test set of 2000 into the network until the end of the training data set is necessary. Thus, the output generated will be compared to the actual data in the time series. This study results in genetic algorithm optimized RBFN is a remarkable model for rainfall prediction of one year in advanced.

2.2.3 An ensemble of neural networks for weather forecasting. (Maqsood et al., 2004)

An evaluation of a collection of neural networks for weather forecasting had been done by Maqsood et al. (2004). Multi-layered perceptron network (MPLN), Elman Recurrent Neural Network (ERNN), Radial Basis Function Network (RBFNN), Hopfield Model (HFM), predictive models and regression techniques were included in this study. This study provides prediction of hourly temperature, wind speed, relative humidity and examines the applicability of the ANN approach for weather forecasting. A comparison between models conducted in the study has been done. The study result strongly favored that the performance of the RBFN is more promising and accurate than other methods.