A STUDY ON SOFT COMPUTING APPROACH IN WEATHER FORECASTING

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ABSTRACT

Weather forecasts based on temperature, wind speed and relative humidity are very important attributes in agriculture sector as well as many industries which largely depend on the weather condition. Therefore, having accurate weather forecasting information may allow farmers to make good decision on managing their farm. Soft computing is an innovative approach to construct computationally intelligent systems that are supposed to processes humanlike expertise within a specific domain, adapt themselves and learn to do better in changing environments, and explain how they make decisions. The weather forecasting model based on soft computing is easy to implement and produces desirable forecasting result by training on the given dataset. The technique of soft computing such as BPNN, RBFN, PSONN and ANFIS are used in this study to test the performance in order to investigate which technique for weather forecasting is most effective and least of error. 720 hours of Johor Bahru weather data are used in this study in order to test their result of prediction based on MSE and RMSE. Besides, the experiment regarding the effect of different input nodes which applies tapped delay line method and different hidden nodes are also used to investigate whether previous data affects the performance. The result shows that ANFIS with input temperature, humidity, wind speed, weather condition(t), and weather condition(t-1) with the previous data will give the lowest MSE and RMSE, 7.0853e-3 and 8.4174e-2 consequence than other soft computing approaches.

ABSTRAK

Ramalan cuaca memainkan peranan yang penting kepada beberapa sektor industri terutamanya dalam sektor pertanian yang sangat dipengaruhi oleh keadaan cuaca. Oleh itu, mempunyai ketepatan mengenai maklumat ramalan cuaca mampu membolehkan pekebun menentukan dan menguruskan kebun mereka dengan lebih baik dan berkesan. Pengkomputeran lembut adalah sebuah pendekatan inovatif untuk membangun sistem komputasi yang cerdas seperti otak manusia dalam domain yang spesifik, senang menyesuaikan diri dan belajar untuk memperbaikkan diri dalam perubahan lingkungan, serta menjelaskan bagaimana mereka membuat keputusan. Teknik pengkomputeran lembut seperti rangkaian neural Algoritma Rambatan Balik (ARB), RBFN, rangkaian neural Pengoptima Partikal Berkelompok (PPB) dan ANFIS telah digunakan dalam kajian ini untuk menguji prestasi peramalan cuaca sama ada peramalan cuaca akan menjadi lebih berkesan, kurang keralatan atau tidak. 720 jam cuaca Johor Bahru digunakan dalam kajian ini dengan tujuan untuk menguji prestasi peramalan cuaca berdasarkan Ralat Min Kuasa Dua (RMKD) dan Ralat Min Punca Kuasa Dua (RMPKD). Selain itu, eksperimen mengenai nodus input yang berbeza dengan menggunakan teknik menoreh melambatkan kaedah garisan dan perbezaan nodus tersembunyi juga akan disiasat supaya dapat mengetahui sama ada data sebelumnya menpengaruhi keputusan output atau tidak. Hasil keputusan tersebut telah menunjukkan bahawa ANFIS dengan input suhu, kelembaban, kecepatan angin, keadaan cuaca(t) dan keadaan cuaca(t-1) memberikan RMKD dan RMPKD yang terendah iaitu 7.0853e-3 dan 8.4174e-2 berbanding dengan pendekatan pengkomputeran lembut yang lain.

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LIST OF ABBREVIATIONS

ANFIS	Adaptive Network base Fuzzy Inference System
ANN	Artificial Neural Network
FNN	Fuzzy Neural Network
GA	Genetic Algorithm
MSE	Mean Square Error
RMSE	Root Mean Square Error
RBF	Radials Basis Function
RBFN	Radials Basis Function Network
PSONN	Particle Swarm Optimization Feed-Forward Neural Network
BPNN	Backpropagation Neural Network

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Weather forecasting is the application which combines science and technology to predict the state of atmosphere for future time at a given location. Weather forecast is very important because it can be used to protect life and property. Weather forecasts are based on temperature; wind speed and relative humidity are very important attributes in agriculture sector as well as many industries which largely depend on the weather condition (Carson *et al*., 2007). For example, excess heavy rain may cause floods, an extended period of dry weather may cause drought and a similar statement can be made about pilots, fishermen, mountain climbers, etc. Therefore, having accurate weather forecasting information may allow farmers to make good decision on managing their farm (Maqsood and Abraham, 2006). Besides that, temperature forecasts are used by utility companies to estimate demand over coming days. People also use weather forecasts to determine what to wear on a

given day and also used to plan outdoor activities around these events, and to plan ahead.

Generally, there are two methods to be used in weather forecasting which is empirical or dynamical approach (Lorenz, 1969). The empirical approach is based upon the occurrence of analogues and is often referred to by meteorologists as analogue forecasting. This approach normally is useful for predicting local-scale weather if recorded cases are plentiful. Dynamical approach is based upon equation and forward simulations of the atmosphere and is often referred to as computer modeling. This dynamical approach is useful for modeling large-scale weather phenomena and may not predict short-term weather efficiently. Most of the weather forecasting systems combined both empirical and dynamical approach. However, not much attention has been paid to the use of soft computing in weather forecasting (Abraham *et al*., 2004). Soft computing is an innovative approach to construct computationally intelligent systems that are supposed to processes humanlike expertise within a specific domain, adapt themselves and learn to do better in changing environments, and explain how they make decisions (Abraham *et al*., 2004). The weather forecasting model based on soft computing are easy to implement and produces desirable forecasting result by training on the given dataset (Abraham *et al*., 2004).

One of the popular soft computing techniques is ANN which perform nonlinear mapping between inputs and outputs, has lately provided alternative approaches to weather forecasting (Hung *et al*., 2008). Most meteorological processes often exhibit temporal and spatial variability, and are further plagued by issues of non-linearity of physical processes, conflicting spatial and temporal scale and uncertainty in parameter estimate (Maqsood *et al*., 2004). With ANNs, there exists the capability to extract the relationship between the input and output of a process, without the physical being explicitly provided (Maqsood *et al*., 2004).

Therefore, ANNs are suitable to be used in the problem of weather forecasting under consideration. Among the various types of ANN techniques, Radial Basis Function Network (RBFN) is most commonly in time series prediction. The RBFN is a popular alternative to the Multi-Layered Perceptron network (MLPN) which is not well suited to larger application but can offer advantages over the MLPN in time series analysis application such as weather forecasting (Maqsood and Abraham, 2006). Besides that, Neuro Fuzzy is a combination of ANN and Fuzzy logic in such a way that Neural Network learning algorithms are used to determine the parameters of Neuro Fuzzy. Because of that, Neuro Fuzzy is also well suited to the problem of weather forecasting and also will improve the weather forecasting accurate.

In this project, the main purpose is to find out how well the proposed of soft computing models are able to understand the periodicity in these patterns so that long-scale prediction can be made. This would help one to anticipate with some degree of confidence the general pattern of weather (temperate, wind speed, relative humidity, weather condition) to be expected in the coming hour. In this project, the 720 hour of weather data that will be taken is from the Weather Underground available from http://www.wunderground.com and its temperature, wind speed, relative humidity and weather condition will be used in the process of carrying out this weather forecasting project.

1.2 Problem Background

Weather forecasting for the future is one of the most important attributes in forecasting because an agriculture sector as well as many industrial largely depends

on the weather condition. For example, the agriculture sectors in Malaysia also largely depend on weather in order to get a good agriculture yield. Normally, weather forecasting is done by using the data captured by remote sensing satellites. The weather parameter such as temperature, extend of rainfall, cloud condition, wind streams and their directions, are projected by using the image taken by these meteorological satellites to make future prediction trends. Besides that, the satellite-based system is expensive and requires a complete support system where it is capable of providing only such information, which is usually generalized over a large geographical area.

Besides that, existing weather forecasting normally use ANNs approach. Neural Network is used to include knowledge or functional relationship from instances of sample data (Nyongesa and Rosin, 2000). This is very useful when it is not possible to develop analytic models but the system need observable (Nyongesa and Rosin, 2000). Neural Network relationships are usually automatically learned from a training process that iterates through a sample data (Nyongesa and Rosin, 2000). Besides this, most meteorological processes often exhibit temporal and spatial variability, and are further plagued by issues of non-linearity of physical processes, conflicting spatial, temporal scale and uncertainty in parameter estimates. With ANNs, there exists the capability to extract the relationship between the inputs and outputs of a process, without the physics being explicitly provided (Maqsood *et al*. 2004).

Because of this, weather forecasting using Neural Network only predicts the future values according to a pattern, information and due to this, the results of weather forecasting may be are imprecise and vague. Besides this, the major disadvantages of Neural Network are its relatively slow convergence rate (Zweiri *et al*., 2003) and solutions being trapped at local minima (Kuok *et al*., 2010). Basically, Neural Network with backpropagation learning is a hill climbing technique which is

like running the risk of being trapped in local minima, where every small change in synaptic weight increases the cost function (Kuok *et al*., 2010). Therefore, the Neural Network will stuck where there exists another set of synaptic weights for which the cost function is smaller than the local minimum in weight space. This made termination of the learning process at local minima by backpropagation is undesirable (Kuok *et al*., 2010).

1.3 Problem Statement

Variability of weather and climatic factors, especially those atmospheric parameters will be the major forcing for daily precipitation event. If we could recognize such a variability pattern and use it for future trajectory, hourly weather condition prediction will be very much feasible.

One method to understand the underlying pattern is by using a pattern trainer like RBFN where the network consists of three-layers: input layer, hidden layer, and output layer. The neurons in hidden layer are of local response to its input and known as radials basis functiom (RBF) neurons, while the neurons of the output layer only sum their inputs and are called linear neurons. It is well known that neural network training can result in producing weights in undesirable local minima of the criterion function. This problem is particularly serious in recurrent neural networks as well as for Neural Network with backpropagation learning with highly non-linear activation functions, because of their highly non-linear structure, and it gets worse as the network size increases (Maqsood and Abraham, 2006). This difficulty has motivated many researchers to search for a structure where the output dependence

on network weights is less non-linear. The RBFN has a linear dependence on the output layer weights, and the non-linearity is introduced only by the cost function for training, which helps to address the problem of local minima. Additionally, this network is inherently well suited for weather prediction, because it naturally uses unsupervised learning to cluster the input data (Maqsood and Abraham, 2006).

Another method to understand the underlying pattern is by using a pattern trainer using a neural network system until it reaches the minimum trained errors. Currently, such facility is possible by using a combination of a neural network and Fuzzy logic system (Aldrian and Djamil, 2008). On the other hand, ANFIS method, which is integration of ANN and fuzzy logic methods, has the potential to capture the benefits of both these methods in a single framework. ANFIS eliminates the basic problem in fuzzy system design (defining the membership function parameters and design of fuzzy if–then rules) by effectively using the learning capability of ANN for automatic fuzzy rule generation and parameter optimization. (Bacanli *et al*., 2009).

Another hybrid method is called Particle Swarm Optimization Feed-Forward Neural Network (PSONN) which can improve the convergence rate of Neural Network and avoid solutions being trapped at local minima (Kuok *et al*., 2010). According to Van den Bergh and Engelbrecht (1999), PSO is made up of particles, where each particle has a position and a velocity. The idea of PSO in NN is to get the best set of weight (or particle position) where several particles (problem solution) are trying to move to the best solution and this will avoid the solution trap at local minima (Kuok *et al*, 2010).

1.4 Project Aim

The aim of this project is to implement weather forecasting using soft computing approaches namely Neural Network, RBFN, ANFIS, PSONN and compare its performance in terms of comparing their Mean Square Error (MSE) and Root Mean Square Error (RMSE).

1.5 Project Objective

Objectives to be achieved in this project are:

i. To investigate the efficiencies of soft computing approaches in weather forecasting.
ii. To compare performance in terms of minimum error rate for soft computing techniques in forecasting Malaysian weather.

1.6 Project Scopes

The scopes of this project are defined as follows:

i. Soft computing approaches used in this study are Neural Network, RBFN, ANFIS and PSONN.
ii. This study use error function such as MSE and RMSE to evaluate the performance of soft computing model.
iii. The weather forecasting data is only based on Malaysia (Johor Bahru) weather which is obtained from http://www.wunderground.com

1.7 Significance of the Project

This project is to study how the soft computing can be used to weather forecasting by using sample Malaysia weather data in an efficiency and minimum error rate. Therefore, this will be carried out to make comparison of performance between Neural Network, ANFIS, RBFN, PSONN and in weather forecasting to see whether it can give better result in weather prediction or not. The outcomes of this project can be contribute to verify the minimum error rate for weather forecasting and this project also will contribute in future works for soft computing in weather forecasting.