



Weather Forecasting for Batu Pahat Using Neural Network

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Abstract

Nowadays, weather forecasting plays a vital role in human activities. The complexity of data gathering in the meteorology department and high technical costs lead to inaccurate weather forecasting. Due to minimize this problem, an application using an artificial neural network (ANN) has been developed to forecast weather conditions using the Matlab compiler. This application will help users to define the weather conditions daily well and make early preparation to encounter uncertainty. This application performs in Multilayer Perceptron (MLP) using the back-propagation (BP) algorithm. The data is undergoing training and testing based on actual data obtained from the Malaysian Meteorological Department. The result will show in graph plotting for the training and testing process. Predictive accuracy for each step of stimulation will measure using Mean Square Error (MSE) graph in this application. Therefore, this application will be able to assist the Malaysian Meteorological Department to forecast weather, so our government and people have sufficient time to prepare and solve.

Keywords: Multilayer Perception (MLP); Back propagation; Artificial Neural Network (ANN)

1. Introduction

Weather forecasting is the application that predicts the future state of the atmosphere in time and location. It is often used to predict and analyze the change in climatic conditions that may cause harmful natural disasters. In Malaysia, data is gathered by satellites and transmitted to an earth station for weather forecasting. Weather parameters such as temperature, relative humidity, mean evaporation, and wind speed, are captured using images taken by satellites [1]. However, the complexity of data gathering in the meteorology department and high technical costs lead to a problem for weather forecasting. Therefore, a study has been carried out to develop an application for weather forecasting for BatuPahat using an artificial neural network [2]. The objective is to set up Graphical User Interface (GUI) using Artificial Neural Network modeling technique to predict evaporation and wind direction weather parameters in BatuPahat.

ANNs provide solutions to many types of non-linear problems that are difficult to solve using traditional techniques. Most meteorological processes often show time and spatial variability and face non-linear problems related to physical processes, spatial and temporal scales, and uncertainty in parameter estimates. It is our hope that this new perspective on physics constants will point to a more substantial and evidence-based approach to physics sciences.

2. Background Information

An artificial neural network (ANN) is an interconnected group of artificial neurons that has a natural characteristic of storing and making available experimental knowledge for use. The first and simplest form of the neurofeedback network, Perceptron, was introduced by Rosenblatt in 1957 [3]. This original Perceptron model has only one layer, and the inputs are fed directly to the output unit through the scaled connections. Although the awareness began promising at the beginning, it was eventually proven that it was not possible to train the continue to recognize multiple categories of patterns [4]. Then, in 1960, the MLP model was developed, which gradually became one of the most commonly used neural network structures.

2.1. Multilayer Perceptron

A multilayer perceptron (MLP) is a feed-forward neural network with consists of hidden layers [5]. A network consists of an input layer of source neurons, at least one hidden layer of mathematical neurons, and a layer resulting from neurons [6]. The hidden layer is between the input and output layers. The input node provides signals that spread in a forward direction on a layer-by-layer basis [7].

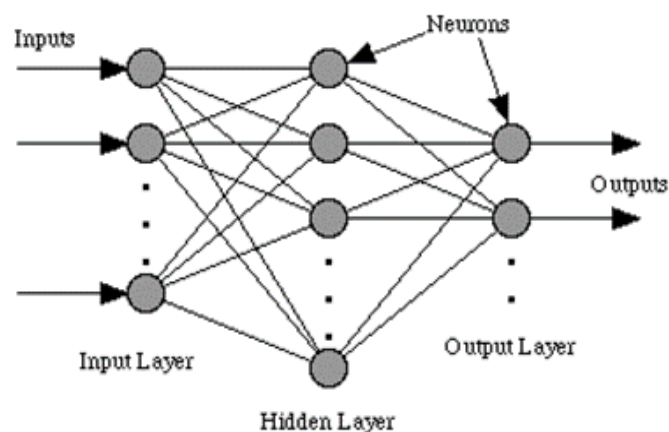


Figure 1: Multilayer Perceptron [6]

MLP has an additional layer as a hidden layer that can increase the strength of the training process. MLPable implements some functions such as the XOR logical function or non-linear function.

2.2. Back Propagation Algorithm

A neural network has to be trained using a certain learning algorithm. The learning algorithm is a procedure used to perform the learning process. The backpropagation is based on the weight updates from the output layer back to the input layer. It has been widely used as a learning algorithm in multilayer perceptron. The algorithm is examining the error in the output neuron by comparing it with the target value [8]. The algorithm has two properties. Firstly, the algorithm computes the network to find the actual output. The output node value is calculated based on input node values and a set of connection weights. The values from the input nodes are combined with the value of the hidden node to calculate the actual output [9]. The second feature is updating the weights by learning patterns. The error is generated based on the difference between the actual output and the required output [10, 11]. After that, the error is set from the output to hold the hidden layer. Finally, the error is used in both the hidden and output nodes to adjust the weights in that node to reduce the error [12].

This process is repeated for each row in the training set. One pass through all the training sets is called an epoch. The error rapidly decreased after several epochs until the error is considered to satisfy to meet the desired target. At that point, the network is to be trained to find the pattern in the testing dataset. The output produced is governed by equation (1):

$$Net_{kp} = \sum_j \omega_{kj} O_{jp} + \theta_k \quad (1)$$

3. WEATHER FORECASTING

Weather forecasting is a very key part of planning activities for next week. Weather forecasting is the use of science to predict future atmospheric conditions in a specific location. Weather forecasting has helped people travel safer without exposure to anything undesired in bad weather conditions like rain and fog [13]. In Malaysia, weather forecasts allow the public to know what elements of weather information can be expected in the next few days. In the intended application, three climate elements were chosen as the coefficient as the average evaporation and wind direction [14].

3.1. Mean Evaporation

Evaporation is a type of vaporization of a liquid that only occurs on a liquid. Boiling is also considered under vaporization which occurs within the entire surface mass of the liquid. Evaporation is an important part of the water cycle. The sun provides solar and heats energy that performs evaporation of water [15]. Evaporation occurs in oceans, seas, lakes, or other sources of water. Cloudiness and temperature are two major factors that affect the rate of evaporation in Malaysia.

3.2. Wind Direction

The true direction from which the wind is blowing at a given location. It is normally measured in tens of degrees from 0 to 360. It is expressed in degrees measured clockwise from the geographical north [16]. Wind vanes do not respond to changes in wind direction when the wind speed is less than one meter per second or two knots.

4. METHODOLOGY

CRISP-DM (Cross-Industry Standard Process for Data Mining) was chosen as the methodology for developing an application as weather forecasting using neural network application. This methodology plays a role in data management and prediction modeling that helps a company to make a good marketing strategy. There are six phases

found in CRISP-DM methodology which are problem understanding, data understanding, data preparation, modeling, evaluation, and deployment.

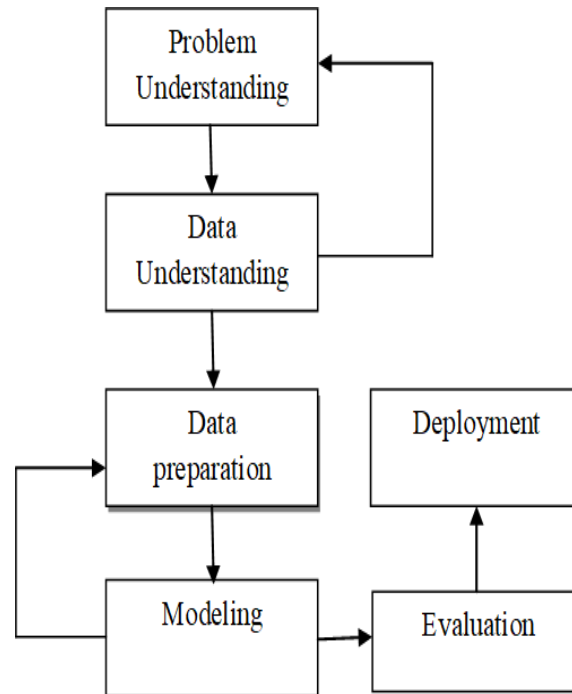


Figure 2: CRISP-DM Methodology Process

This model is an iterative model in which the data understanding, modeling, and evaluation phases move back and forth. The related information will be determined and gathered iteratively in the 3 phase which is the development of the application [17]. Using this methodology, an application based on a neural network that provides reliable information can be built. Data recorded from the meteorological department in Batu Pahat as mean evaporation and wind direction range between the years 2005-2009. In the data preparation stage, 60% of the data was used for training and 40% used for testing. The application was built with Matlab 7.10.0 (R2010a).

5. RESULTS

There is the main menu interface that allows users to use the application. There are 2 weather elements that allow users to perform forecasting about evaporation and wind direction for BatuPahat. The close button is to exit the application.

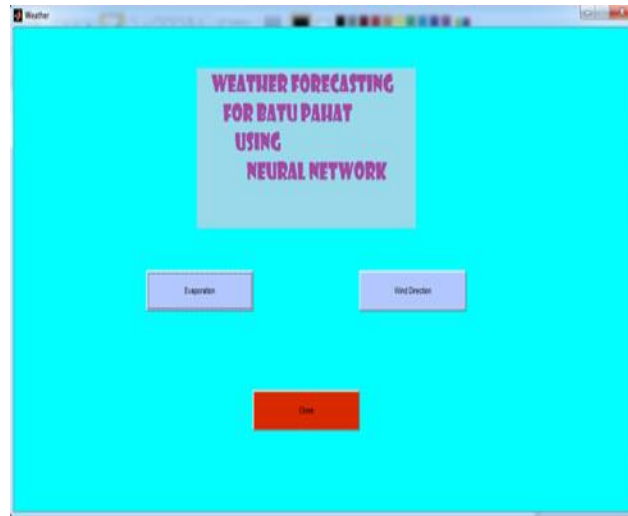


Figure 3: Main Menu



Figure 4: Interface for forecasting (Evaporation)

This interface allows the user to perform forecasting about evaporation. Users are needed to insert the learning rate, momentum, and input node in the input menu. Then, a user just clicks the run button to start the forecasting process. The procedures for forecasts wind direction are the same as evaporation.

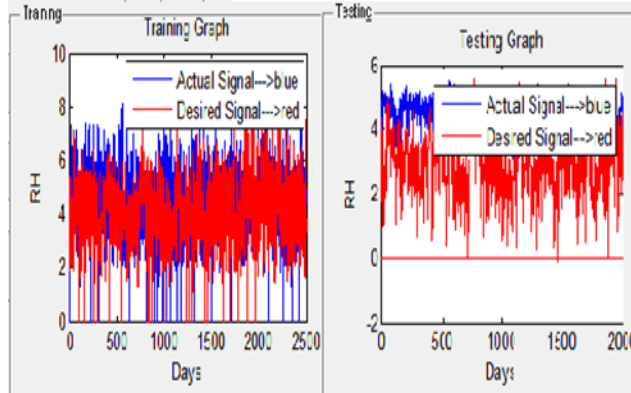


Figure 5: Results for evaporation

The result shows training and testing for evaporation. The standard unit used for evaporation is RH (Relative Humidity). It shows good accuracy for this forecasting with a Minimum Mean Square Error (MSE) after 3000 epochs as 0.0151039.

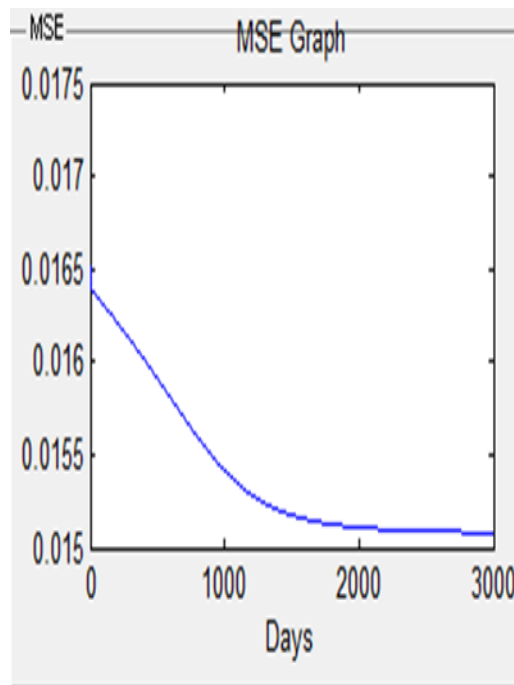


Figure 6: MSE Graph for evaporation

On the other hand, the standard unit used for wind direction is degree.

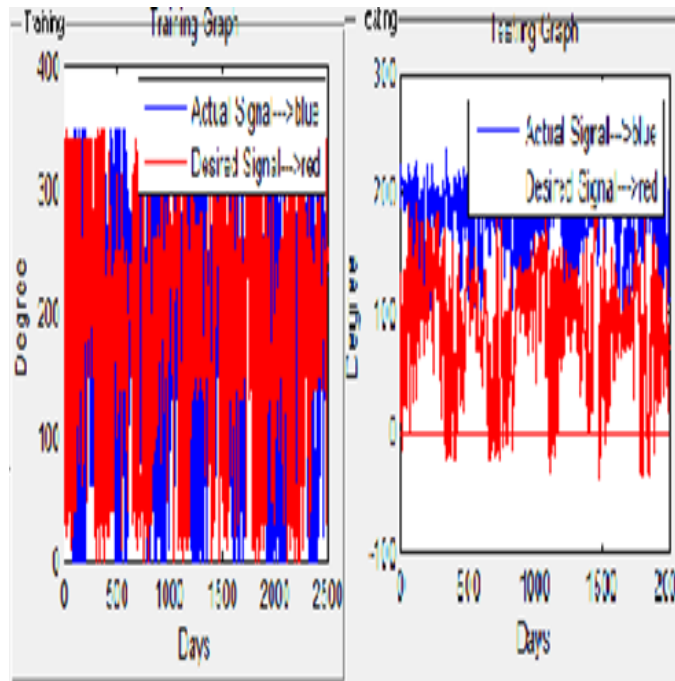


Figure 7: Results for wind direction

It shows good accuracy for this forecasting with minimum Mean Square Error (MSE) after 3000 epochs as 0.0704004.

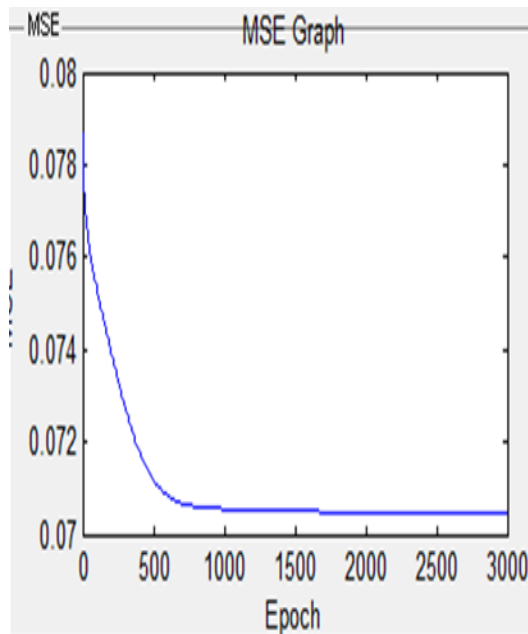


Figure 8: MSE Graph for wind direction

6. CONCLUSION

Artificial Neural Network (ANN) has gained great popularity in weather forecasting because of its functionality. The forecast result for using ANN techniques has been proved with good accuracy with minimum mean square error (MSE). This is because ANN provides solutions to many non-linear problems, which are difficult to solve in traditional weather forecasting.

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