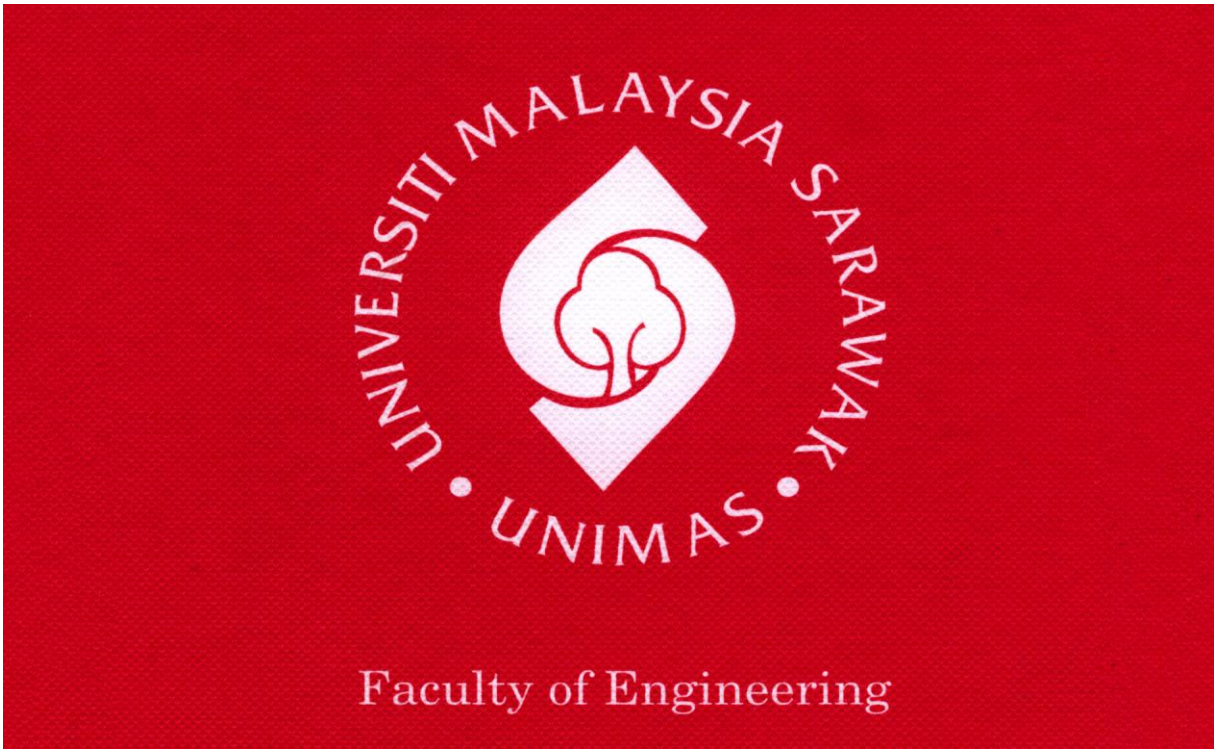

HOURLY WATER LEVEL PREDICTION OF SUNGAI BEDUP CATCHEMNT USING PRE-DEVELOPED ANNs MODEL FROM SINIAWAN CATCHMENT

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Bachelor of Engineering with Honours
(Civil Engineering)
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UNIVERSITI MALAYSIA SARAWAK

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SESI PENGAJIAN: 2008/2009

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HOURLY WATER LEVEL PREDICTION OF SUNGAI BEDUP CATCHEMNT USING PRE-DEVELOPED ANNs MODEL FROM SINIAWAN CATCHMENT

CALVIN HONG CHIAO CHUN

This project is submitted to
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To my beloved parent and all my family members.

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LIST OF NOTATIONS

ANNs	-	Artificial Neural Network
MLPs	-	Multilayer perceptrons
LMS	-	Least Mean Square
GRRN	-	Generalized Regression Neural Network
BP	-	Back Propagation
FFBP	-	Feed Forward Backpropagation
CSI	-	Critical Success Index
trainscg	-	Scale conjugate
trainrp	-	Resilient back propagation
traincgf	-	Fletcher-Reeves update
E^2	-	Coefficient of efficiency
R	-	Coefficient of correlation
t	-	Time
P	-	Precipitation
N	-	Normal long-term precipitation
T	-	Tide level
W	-	Water level
DID	-	Department of Irrigation and Drainage
Sg	-	Sungai

SPT - Standard Penetration Test

CPT - Cone Penetration Test

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ABSTRACT

This study proposes the application of Artificial Neural Network in the prediction of water level under tidal influence for Sadong Basin. An Artificial Neural Network is undoubtedly a robust tool for forecasting various non-linear hydrologic processes, including the water level prediction. It is a flexible mathematical structure which is capable to generalize patterns in imprecise or noisy and ambiguous input and output data sets. In this study, the ANNs were developed specifically to forecast the hourly water level for Sg. Bedup Station. Distinctive networks were trained and tested using hourly data obtained from the DID Department in Kuching. The performances of the ANNs were evaluated based on the coefficient of efficiency, E^2 and the coefficient of correlation, R. The back propagation algorithm was adopted for this study. The models used in this study is the network trained with scaled conjugate gradient algorithm (*trainscg*) with two hours of antecedent data, learning rate and the number of neurons in the hidden layer of 0.8 and 40 respectively. In this study, the models generated the R value for testing of 1.00 when it trained. It has been found that the ANN has the potential to solve the problems of water level prediction. After appropriate trainings, they are able to generate satisfactory results during both of the training and testing phases. Further, the strength and limitations of ANNs had been discussed, based on the resulted obtained in this study.

ABSTRAK

Kajian ini menganjurkan aplikasi Rangkaian Neural Buatan dalam meramal paras air akibat kesan paras pasang surut untuk Sadong Basin. Rangkaian Neural Buatan merupakan satu alternatif yang efektif dalam meramalkan pelbagai proses hidrologi tidak linear, termasuk ramalan paras air di sungai-sungai. Ia merupakan struktur matematik yang fleksibel dimana ia berupaya membuat kesimpulan secara menyeluruh terhadap suatu bentuk keadaan yang kurang jelas, dengan set data input dan output yang kurang tepat. Dalam kajian ini, Rangkain Neural Buatan dibangunkan secara spesifik untuk meramal paras air setiap jam untuk Stesen Sg. Bedup. Rangkaian yang berbeza dilatih dan diuji menggunakan data setiap jam yang diperolehi daripada Jabatan Pengairan dan Saliran, Kuching. Prestasi Rangkain Neural Buatan dinilai berdasarkan Pekali Kecekapan, E^2 dan Pekali Perkaitan, R. Algoritma '*back propagation*' telah diaplikasikan dalam kajian ini. Nilai bagi R untuk fasa ujian telah dicapai oleh rangkaian yang menggunakan dua jam terdahulu, menggunakan 'learning rate' 0.8 dan bilangan neuron 40. Rangkaian ini telah dilatih dengan 'trainscg'. Setelah melaksanakan latihan yang sesuai, keputusan yang memuaskan telah dicapai untuk kedua-dua fasa latihan dan ujian. Selain itu, kekuatan dan kelemahan rangkaian ini turut dibincangkan, berdasarkan keputusan yang telah diperolehi dalam kajian ini.

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION TO THE STUDY

Most civilization was developed along the rivers because the river provides access to and from the sea coast, irrigation for plantation, water and food supplies. However most of the benefits have always been counterbalanced by the dangers of flood as it is a common disaster faced ever since the older century. Floods can happen either in the rural area or in the urban area. Therefore in order to control or reduce flood, an accurate forecast of water level of river is extremely important.

In order to obtain an accurate estimation of water level, the following data is needed:-

- An accurate estimation of the runoff from a given rainfall event
- An accurate hydraulic model to predict the water level for a given discharge and tide level.

Artificial Neural Networks (ANNs) is model free estimators. This is because they are able to learn from examples and generalize the data given. Generally, they can be described as a human brain as they able to predict or forecast the output precisely. Therefore, this makes them well suited to situations where problem complexity precludes the development of models based on the first principles. (Haykin, 1994)

In recent years, computer models of the principal hydrological and hydraulic components of river floods have been successfully developed. In a very small catchment, a good forecast can be made on the basis of the intensity of the rainfall. However, for larger catchments as the one considered in this study, the flow characteristics will strongly influence the ability to make a good prediction.

On the other hand, conventional models require a great amount of detailed data. Examples of the detailed data are such as topographical maps, river networks and characteristics, soil characteristics, rainfall and runoff data. However these data are often not available and therefore pose a great difficulty for model calibration.

In addition, a sufficiently long lead-time for forecasting the necessary flood evacuation measures is required. For dissemination of flood information and other flood evacuation measures, computational speed of the models used are of absolute importance.

The excellent features of ANNs are the reasons why they have become an attractive computational tool. It was found that they are able to recognize the relation between the input and output variables without explicit physical consideration. Furthermore, they work well even when the training sets contain noise and measurement errors. They are also able to adapt to solutions overtime to compensate for changing circumstances, and they possess other inherent information-processing characteristics and once trained, they are easy to be used.

Examples of application of ANNs in engineering field are as follow:-

- Application in predicting the water level of a river under tidal influence
- Artificial Neural Networks for precipitation and water level prediction.
- Application of Artificial Neural Network for flood warning system
- Simulation of flood flow in a river system using Artificial Neural Network
- Solving problems in environmental engineering and geosciences

1.2 PROBLEM STATEMENT

Measurement of the runoff for a tidal reach is impossible because most rivers in Sarawak are usually flowing backward. Besides that, rainfall runoff model relies on quality and reliable input data which is most of the time not available. In order to build an accurate hydraulic model, river cross section and roughness are necessary.

River cross section is not uniform along the river. These are usually determined for a small number of cross sections. Roughness also varies along the river reach and the value to adopt is only estimated.

These factors make the estimation of water level very complex. Therefore, it is proposed that artificial neural network (ANNs) is used to estimate water level for a given rainfall event.

1.3 OBJECTIVE OF THE STUDY

The main objective of this study is to predict the hourly water level for Sg Bedup which is located at Sadong Basin using back propagation network developed by Maliana, S. (2004) for Siniawan Station located at Sg. Sarawak Basin.

Besides that, this study also aims to improve the pre-developed model by calculating the missing data such as missing precipitation and missing water level.

1.4 OUTLINE OF THE FOLLOWING CHAPTER

Chapter 1 : Brief Introduction and objective of this study.

Chapter 2 : Literature review on ANNs and application of ANNs in hydrology engineering.

Chapter 3 : Method developed for this study in order to achieve the objective.

Chapter 4 : Results from this study and discussions/comments on this study.

Chapter 5 : Conclusion/summary of this study and recommendation to further this study.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Artificial Neural Networks (ANNs) are a form of artificial intelligence which attempt to mimic the function of the human brain and nervous system. ANNs learn from data examples presented to them in order to capture the subtle functional relationships among the data even if the underlying relationships are unknown or the physical meaning is difficult to explain. This is in contrast to most traditional empirical and statistical methods, which need prior knowledge about the nature of the relationships among the data (Shahin, I., 2008).

ANNs are thus well suited to modeling the complex behavior of most hydrology engineering materials which, by their very nature, exhibit extreme variability. This modeling capability, as well as the ability to learn from experience, have given ANNs superiority over most traditional modeling methods since there is no need for making assumptions about what the underlying rules that govern the problem in hand could be (Shahin, I., 2008).

2.2 ARTIFICIAL NEURAL NETWORK

An ANNs is a massively parallel-distributed information processing system that has certain performance characteristics. The development of ANNs as mathematical models of human recognition is based on the following rules:-

- Information processing occurs at many single elements called nodes, which are also referred to as units, cells or neurons.
- Signals are passed between nodes through connection links.
- Each connection link has an associated weight that represents its connection strength.
- Each node applies a nonlinear transformation called an activation function to its net input to determine its output signal.

ANNs are also defined as mathematical models of human cognition, which can be trained to perform a specific task based on available experiential knowledge (Govindaraju, 2000) or massively parallel distributed processors with normal propensity for storing knowledge and making it available for use (Haykin, 1994). They are typically composed of three parts: inputs, one or many hidden layers, and an output layer. Hidden and output neuron layers include the combination of weights, biases, and transfer functions. The weights are connections between neurons while the transfer functions are linear or nonlinear algebraic functions. When a pattern is presented to the network, weights and biases are adjusted so that a particular output is possible to obtain as cited in Kahya, E. *et al.*, 2007.

Typical neural network consists of layers of neurons with weight providing inter-neuron connection for storage of knowledge. A summing junction acts as an adder for summing input signals weighted by represented weights. An activation function provides limiting amplitude of the neurons output, typically between (0.0 – 1.0) or (-1.0 – 1.0). The structure of a typical neuron of an ANNs is shown in figure 2-1 (Shrestha, R.R., 2005).

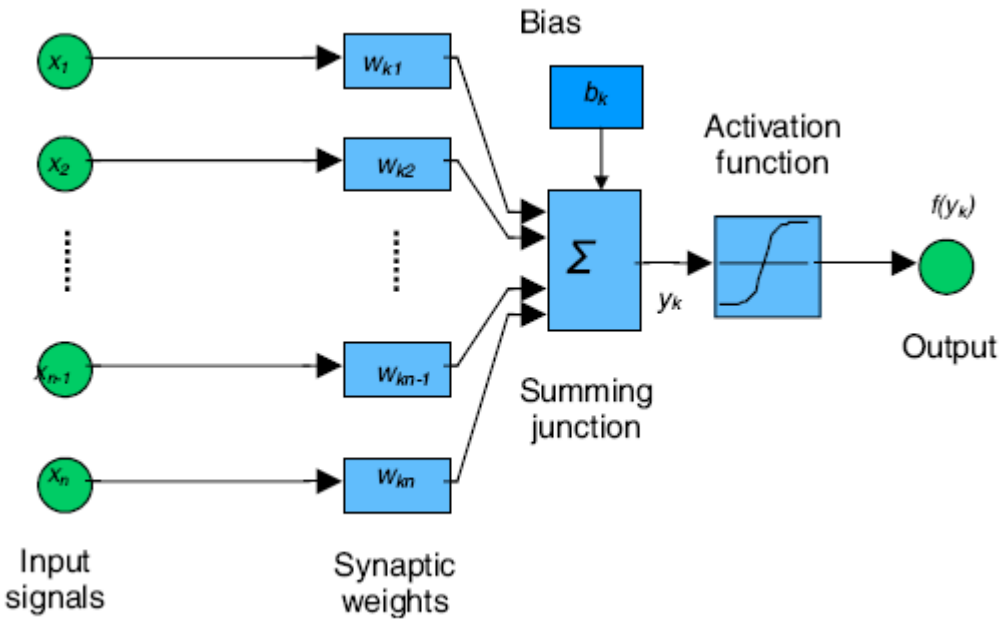

Figure 2-1 Structure of a Neuron of an ANNs

The ANNs may also consist of a number of hidden layers between the input and output layers. Such networks are commonly known as multilayer feedforward networks or multilayer perceptrons (MLPs). The MLPs are one of the most widely used types of neural networks, which can be trained in a supervised manner to solve highly non linear