PREDICTION OF TEMERLOH RIVER WATER LEVEL FOR PREDICTION OF FLOOD USING ARTIFICIAL NEURAL NETWORK (ANN) METHOD

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ABSTRACTS

The purpose of this project is to research more about the flood occurrence in Temerloh, Pahang. The data mining approaches using artificial neural network (ANN) techniques will be use to conduct this research for flood estimation. ANN model will be use to estimate river water level by taking present river water level data. The research will be trained using back propagation method to estimate the flood water level at Temerloh River. ANN's trained using backpropagation are also known as "feed forward multi-layered networks" trained using the backpropagation algorithm. 14 years of rainfall data is get from Department of irrigation and drainage (DID). Rainfall data of 10 years(2000-2010) will be training data to predict the others 4 years(2010-2014) river water level using python software with 1000-4000 iteration of data. At the end of the project we can make parameter model that can use as a tools to predict accurately water level data and achieve high accuracy of flood forecasting. From the result we can see that in this research the best prediction for water level data at Temerloh River is 3-hr lead-time with 6 input 1 output in 4000 iteration because it produce the best CE with 0.998.The average RMSE also less than 500 mm with only small difference error in percentage.

ABSTRAK

Tujuan kajian ini dilakukan adalah untuk mengkaji fenomena alam kejadian banjir di Temerloh, Pahang.Ramalan paras tinggi air dilakukan menggunakan kaedah rangkaian neural tiruan atau *artificial neural network (ANN)* dalam kajian ini. Seterusnya, kajian ini dilakukan dengan mengambil data takat paras air sungai di Temerloh Pahang. Kajian ini akan dilatih menggunakan kembali kaedah pembiakan untuk menganggarkan paras air banjir di sungai Temerloh. ANN yang dilatih menggunakan rambatan balik juga dikenali sebagai "*feed forward multi-layered networks*" dilatih menggunakan algoritma rambatan balik itu. 14 tahun data hujan dapat daripada Jabatan Pengairan dan Saliran (JPS). Data hujan 10 tahun (2000-2010) akan melatih data untuk meramalkan empat tahun yang paras air (2010-2014) sungai menggunakan perisian "python" dengan 1000-4000 lelaran data. Pada akhir projek kita boleh membuat model parameter yang boleh digunakan sebagai alat untuk meramalkan dengan tepat data paras air dan mencapai ketepatan yang tinggi daripada ramalan banjir. Dari kajian ini ramalan yang terbaik untuk data paras air di Sungai Temerloh adalah 3-jam mendahului masa dengan enam data masuk satu data keluar dalam 4000 lelaran kerana ia menghasilkan ralat korelasi yang terbaik dengan 0,998. Berdasarkan keputusan purata RMSE juga kurang daripada 500 mm dengan perbezaan hanya kecil dalam peratusan ralat paras air.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Flood can be described as the occurrence of overflowing or influx of water beyond its normal confines or outpouring of water. When the rain water traps in a particular land area and the water flow rate out from the area is slower than the rain water accumulated, therefore, flood happen. Recently, flooding is one of the most destructive natural disasters that happened in Malaysia. Flood in Malaysia become more serious and dangerous due to deforestation, urbanization and agricultural development.

Since 1660s especially in 1971 Malaysia have face dramatic flood event with dramatic lives and property losses billion of malaysian ringgit. This make Malaysia goverment taken several positive steps and seriously planning to envisage flood mitigation projects in its national plans. The Malaysian Department of Irrigation and Drainage (DID) has estimated that people (22% of the population) are potentially affected by floods annually. The yearly economic damage caused by flooding is estimated at approximately US$300 million approximately 29,000 km2, or 9%, of the total land area and more than 4.82 million (Hazi Mohammad Azamathulla, Aminuddin Ab. Ghani, Cheng Siang Leow, Chun Kiat Chang and Nor Azazi Zakaria, 2011)

The purpose of this project is to research more about the flood occurrence in Pekan, Pahang. Flood overflow are frequently occur at the East Peninsular of Malaysia and the worst is during monsoon season in November until December. In low land area, the flood is more likely to occur compared to high land area. In Pahang, most of the rural areas are located near to the rivers and the rain water can easily trapped and

overflow from the rivers itself. For example, the overflow of water from Sungai Lembing and Kampung Panching happened due to the heavy rainfall occurred every year and leads to flooding in the area of Kuantan City.

Structural and non structural measures has adopted in Malaysia to reduce the impact of flood problem that happen since the worst flood in history in 1971. Structural measures include such measures as river deepening , widening and straightening, to reduce the magnitude of the flood, but at the same time this approach often transfers the flooding problem further downstream. Computer models used in non structural measures to quantify the effects of human interference to the river system. This tools already widely used in many countries worldwide, but the application of sophisticated models is still relatively new in Malaysia. Before any structural measure was taken it is important to make analysis and researhe of the flood events with the help of flood models to understand the flood behaviour. Therefore, before any amendments are implemented within a catchment and the flood plain, river engineers must evaluate the potential extent and impact of flood events and advise the implementing agencies as to what steps need to be undertaken to provide further preventative measures to avoid the anticipated flood problems that might occur.

Several methods are introduced to obtain the data about flood occurrence in Pekan. The data mining approaches using artificial neural network (ANN) techniques will be use to conduct this research for flood estimation. ANN model will predict river water level by taking rainfall present river water level data.

1.2 STUDY AREA

The Pahang River basin is located in the eastern part of Peninsular Malaysia between latitude N 2° 48'45" and N 3° 40' 24" and between longitude E 101° 16' 31" and E 103° 29' 34". Sungai Pahang is the longest river in Peninsular Malaysia of about 435 km in figure 1. This river begins to flow in a south east and south direction, passing along several major towns such as Kuala Lipis, at the mouth of the river bearing the same name on Sungai Jelai; Jerantut, the gateway to Taman Negara Sungai Tembeling; Temerloh, midway on the river at its confluence with Sungai Semantan; and finally turning eastward at Mengkarak in the central south of the catchment and flowing through the royal town of Bandar Diraja Pekan near the coast before discharging into the South China Sea. Major towns are located on or near Sungai Pahang and its tributaries: Pekan, the royal town at its mouth; Temerloh midway on the river at its confluence with Semantan; Jerantut, the gateway to Taman Negara on the Tembeling; and Kuala Lipis at the mouth of the river bearing the same name on the Jelai.

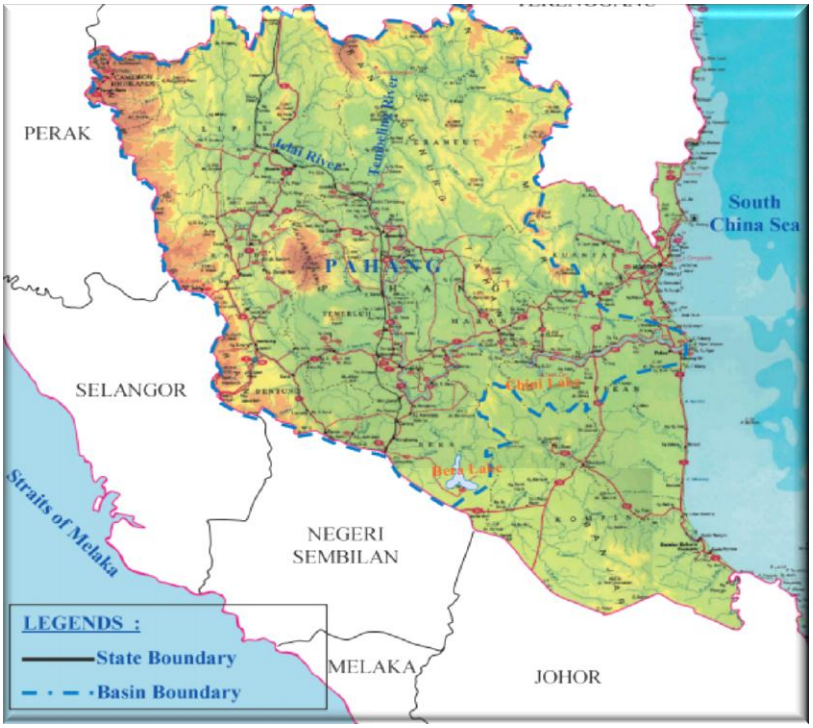

Figure 1.1: List of Pahang River

Temerloh was one of the most effected place during flood disaster in 2007 and cause many distruction interms of economical and enviroment . This research will more focus on Temerloh River that one of the parth flow of Pahang river near the coast before discharging into the South China Sea. Located on the banks of the Pahang River 50 km south of Kuantan and Pekan is the Royal Town of the Malaysian state of Pahang Darul Makmur. Population in district of Pekan is 105,587 people that have three Mukim Ganchong, Kuala Pahang and Bebar. The data set used in this study was obtained from the Malaysian Department of Irrigation and Drainage (DID) . The water level data was taken at Temerloh Pahang station during this research ; figure 1.2.

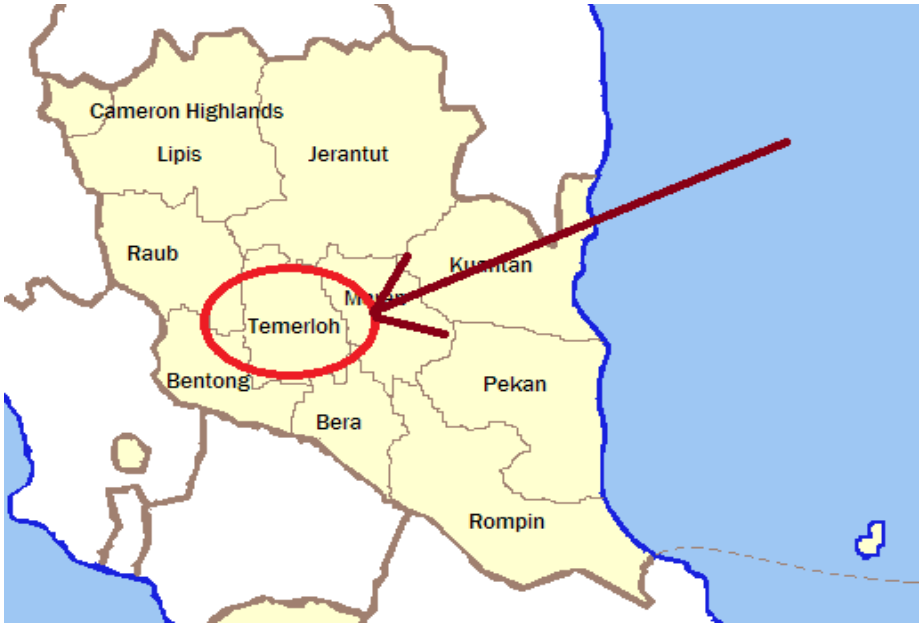

Figure 1.2: Pahang State Mapping

1.3 PROBLEM STATEMENT

Pahang is the largest state in peninsular Malaysia and the 3rd largest state in Malaysia after Sabah and Sarawak. Kuantan is the main capital of Pahang that have population range between 350000-400000 people and known as fast commercial located city at east-coast Malaysia. For the past few years Kuantan had pass through a one of the biggest natural disaster on earth; flood. In December 2013, Kuantan have faced worst flood phenomena that cause much destruction and loses.

Kuantan Municipal Council (MPK) has attributed the floods in this town and nearby areas to the unusually heavy rainfall and denied that the allegedly unmanaged drainage system was the primary cause (Borneo Repost). President of MPK Datuk Zulkifli Yaakob said that the main cause flood in Dec 2013 was the amount of rainfall experience is equivalent the total rainfall for 3 months about 970 mm and because of that the river to burst their banks especially Kuantan river. There was damage estimated at more than RM7 million to schools in Pahang that effected 41 school and 6 districts. Pekan, 3,464 flood victims were placed at 26 relief centers, in Temerloh at 22 relief centers, Jerantut, Maran, Rompin, Bera and Lipis at four relief centers. Due to heavy rainfall up to 1 meters water level on the road several main roads are closed to traffic.

In history show that Pahang River already causes many losses of property and life at Temerloh Pahang. Improper implementations of hydrology practice for river management and follow by deforestation and un-planned land use make prevention of losses was a challenging task during wet season cause by northeast monsoon season.

The critical problem that happens during this disaster was lack of information and warning from authorities on when the flood will happen to make the resident or people in every place to get ready and make earlier preparation to face it. No mechanism can avoid flood but only prediction can be made to save lives and reduce.

Flood estimation can give earlier warning to resident by knowing the river water level that can warn the flood event that will happen. The lack of intelligent tools to produce correct data of water level to estimate the flood event makes the authorities

especially weather unit hard to make correct prediction every time flood disaster will happen. Pekan is district of Pahang that experiences the flood event which causes the road and some place electricity had been shutdown to prevent any bad things happen.

1.4 OBJECTIVES OF THE STUDY

In order to achieve a successful study, three objectives as a guideline of outcomes have been determined. The objectives are;

i. To achieve high accuracy of flood forecasting
ii. To make parameter model that can use as a tools to predict accurately water level data.
iii. Ability to predict potential flooding severity.

1.5 SCOPE OF STUDY

The study method used in this research is artificial neural network (ANN) and analyze the result using python software. The data that use was water level data of Pahang River for the past 14 years. Data will be taken from Pahang river in specific at Temerloh area and will be estimate using ANNs method and make comparison with the actual data for the suitability of this method to use for this research. All the data will be research and predict it level at different interval of time such as three hour and six hour.

1.6 SIGNIFICANCE OF STUDY

Prediction of flood using artificial neural network (ANN) model will act as a medium to get relevant information of possible impending floods in populated locations. Using this model as a tool to predict water level at Sungai Pahang will decrease economic loses and human suffering at Pekan, Pahang. The result is important if the ANN model can give accurate or sufficient accurate forecasts, even one day a head, the planning for the subsequent flood emergency measures can be better planned and executed. This can make lower the risk for harm and especially human life loss.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

A simple definition of flooding is water where it is not wanted. Another, more comprehensive definition of a flood is defined as a general and temporary condition of partial or complete inundation of normally dry land areas from overflow of inland or tidal waters from the unusual and rapid accumulation or runoff of surface waters from any source. The Australian Government introduced a standard definition of flood for certain insurance policies In November 2011. This definition is applicable when an insurer offers flood cover for a home building, home contents, small business or strata title insurance policy. For this purpose a flood is defined as the covering of normally dry land by water that has escaped or been released from the normal confines of: any lake, or any river, creek or other natural watercourse, whether or not altered or modified; or any reservoir, canal, or dam. [Bureau of Transport and Regional Economics, 2001].

2.2 CIRCUMSTANCES OF FLOOD

In Malaysia, flood occurrence is very general among Malaysians. According to Leigh, C. and Low, K.S., (1972), "An appraisal of the flood situation in West Malaysia", paper presented at the Symposium on Biological Resources and National Development, Faculty of Agriculture, University of Malaya, Malaysians are historically a riverine people as early settlements grew on the banks of the major rivers in the country.

Coupled with natural factors such as heavy monsoon rainfall, intense convection rain storms, poor drainage and other local factors, floods have become a common feature in the lives of a significant number of Malaysians.

In general, flooding occurs commonly from heavy rainfall when natural watercourses do not have the capacity to convey excess water but not necessary. They can result from other phenomena, particularly in coastal areas where inundation can be caused by a storm surge associated with a tropical cyclone, a tsunami or a high tide coinciding with higher than normal river levels. Dam failure, triggered for example by an earthquake, will result in flooding of the downstream area, even in dry weather conditions. Other factors which may contribute to flooding include:

i. Volume, spatial distribution, intensity and duration of rainfall over a catchment;
ii. The capacity of the watercourse or stream network to convey runoff;
iii. Catchment and weather conditions prior to a rainfall event;
iv. Ground cover;
v. Topography; and Tidal influences.

2.3 FLOOD FORMS

2.3.1 NORMAL FLOOD

Normal floods are seasonal floods which occur annually during the northeast monsoon season between Novembers to March. During these floods the waters do not normally exceed the stilt height of traditional Malay houses. Thus, people living in stilt houses in the rural areas on the east coast are well adapted to normal floods

2.3.2 MAJOR FLOOD

It is the major floods, which are “unusual” or “extreme” events. Major floods also have their origins from seasonal monsoon rains but statistically occur once every few years (but occur in consecutive years in 1970 and 1971 in Pekan). These floods are extensive, severe and unpredictable and result in significant loss of life, damage to crops, livestock, property and public infrastructure. Other classifications such as “flash flood”, “tidal flood”, “river flood” and “monsoon flood” may be grouped as normal or major floods depending on the severity. Flood-prone areas in Malaysia have been mapped by the Drainage and Irrigation Department (DID) on the basis of the extent of past floods. It is evident that most of the extensive flood-prone areas are located along the coastal plains and riverine areas. This statement is clearly mentioned in the journal "Increasing flood risk in Malaysia: causes and solutions", Disaster Prevention and Management: An International Journal, Vol. 6 Iss: 2, pp.72 – 86 (Ngai Weng Chan, 1997).

Flood-prone areas

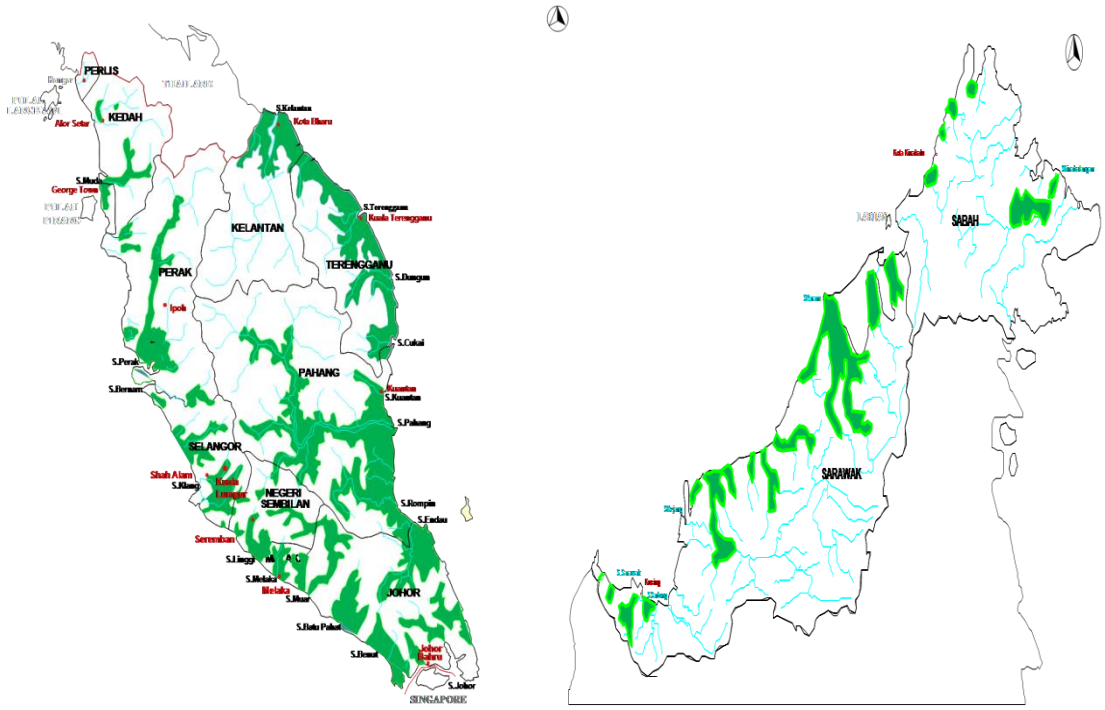

Figure 2.1 : Flood Prone Area in Malaysia

2.4 FLOOD IMPACT

Meanwhile, floods bring negative effects towards the nation, community and nature. Scientifically, floods are the most frequent natural hazards globally [Verdin, 2002], and the hazard of flooding can be divided into primary, secondary and tertiary effects. The primary effects of floods are those due to direct contact with the flood waters, with the water velocities resulting in floods as the discharge velocity increases. Secondary effects, such as disruption of infrastructure and services and health impacts, are secondary effects, while tertiary effects are viewed as the long-term changes that occur, for example changes in the position of river channels [Nelson, 2010].

Based on the objectives of this study, flood forecasting models are a necessity, as they help in planning for flood events, and thus help prevent loss of lives and minimize damage. Flood models are a major tool for mitigating the effects of flooding that provide predictions of flood extent and depth that are used in the development of spatially accurate hazard maps [M. F. Goodchild, 2006].

2.5 NATURE OF FLOOD

Most of the floods happen around us not same and have its own nature depends on the type of flood. There is 5 major type of flood in Malaysia.

2.5.1 River Floods

River flooding is a natural process and part of the hydrological cycle of rainfall, surface and groundwater flow and storage (Madani et al, 2007). Floods occur whenever the capacity of the natural or man-made drainage system is unable to cope with the volume of water generated by rainfall. Floods vary considerably in size and duration. With prolonged rain falling over wide areas, the resultant surface waters flow into a network of ditches, streams and tributaries. The volume increases as it flows downstream and combines with flows from other channels. At the points where the flow is beyond the capacity that can be contained in the river channel, water overflows the river banks and consequently floods the adjacent flood plain.

2.5.2 Regional Floods

Regional floods are also river floods but the events cover a wide area or region. This is typical in large river basins such as that of the Kelantan River, Terengganu River and Pahang River. In large flood plains with extensive river system, flooding can occur over a considerable period after the rainfall stops as it takes time for the large volumes of water to drain out of the catchment. In some cases floods occur in dry weather conditions (no rains) on the downstream section of the river catchment. This is due to heavy rains on the hilly upper catchment away from the points of the flood event and location. River floods in Malaysia usually occur during the monsoon seasons. This is especially so in the East Coast of Peninsular Malaysia during the North-East Monsoon months between October and March every year.

2.5.3 Urban Floods

Urban floods are those in built-up areas such as in cities, townships, commercial and residential areas. Urban floods affect more people and properties per unit area compared to those in agriculture and rural areas. Also the impact on traffic and services extends well beyond the physical location of the flood occurrence itself. The characteristics of urban flood can be more damaging and life threatening with roads becoming swift flowing channels, basements flooded and uncovered drains and bridges and crossings camouflaged by the flood waters.

2.5.4 Localized Floods

These are those occurring in small pockets of low-lying areas and often sensitive to small amount of rains. Being low-lying, natural drainage is difficult. Although some floods last only for a few hours, there are also areas that remain flooded for up to a month or more and well after the floods in the surrounding areas have receded. In this case, the flood water removal is mostly dependent on evaporation. One such area is in Buloh Kasap, Segamat, and Johor led to the colloquial term Banjir Termenong, literally, to “just sit, wait and ponder” whilst the flood takes its time to subside.

2.5.5 Flash Floods

A flood that rises and falls rapidly with little or no advance warning is called flash flood. Flash floods usually result from intense rainfall over a relatively small area. Flooding is usually due to intense local storms. This mostly happen in urban settings. The flood depths can be relatively shallow (100 mm or so) but there are cases of some being up to 2 meters depth but lasting less than 1 hour. In most cases the impact is not as severe as larger floods but, in urban areas, very disruptive to the daily routine of urbanites. As such these floods are also often termed as “nuisance floods”.

2.4 FLOOD WARNING SYSTEM

Flooding is a significant natural hazard that affects 2.7 million people within the 29,000 km2 of flood prone area in Malaysia. Flood forecasting and warning system have proven to reduce loss of lives, trauma of disaster and property damage in effective and economical ways. A timely and accurate flood forecasting and warning system can reduce loss of lives ,properties and disruption to socio-economic development as well as assisting the authority in flood rescue operations [Wardah Tahir and Hafizul Aimme Che Hamid, 2013].

The January 1971 flood that hit Kuala Lumpur and many other states had resulted in a loss of more than RM 200 million then and the death of 61 persons. Moreover, Johor 2006-07 flood due to a couple of “abnormally” heavy rainfall events which caused massive floods, the estimated total cost of these flood disasters is RM 1.5 billion, considered as the most costly flood events in Malaysian history.

After the 1971 Flood Disaster, the Malaysia Government establish two committees:-

i. The Permanent Flood Commission Committee to look into long term solutions to mitigate flood
ii. The National Flood Relief Committee: to reduce losses in the events of impending flood.

Based on the objectives of this study, flood forecasting models are a necessity, as they help in planning for flood events, and thus help prevent loss of lives and minimize damage. Flood models are a major tool for mitigating the effects of flooding that provide predictions of flood extent and depth that are used in the development of spatially accurate hazard maps [M. F. Goodchild, 2006]

CHAPTER 3

METHODOLOGY

3.1 ARTIFICIAL NEURAL NETWORK

Artificial neural network is modelling of mathematical or computational that has similarities of biological neural network (19 Aleksey Gladkov). In a study on the teaching and learning of Artificial Neural Network (Prodipto Das and Abhijit Paul, 2008) state that ANNs was a human perception based on mathematical model that can be used for performing a stated task based on availability of empirical data. Inspiration ANNs models came from motivation desire to produce artificial systems capable of sophisticated, perhaps "intelligent", computations similar to those that the human brain routinely performs, and thereby possibly to enhance our understanding of the human brain (Sucharita Gopal, 1998).

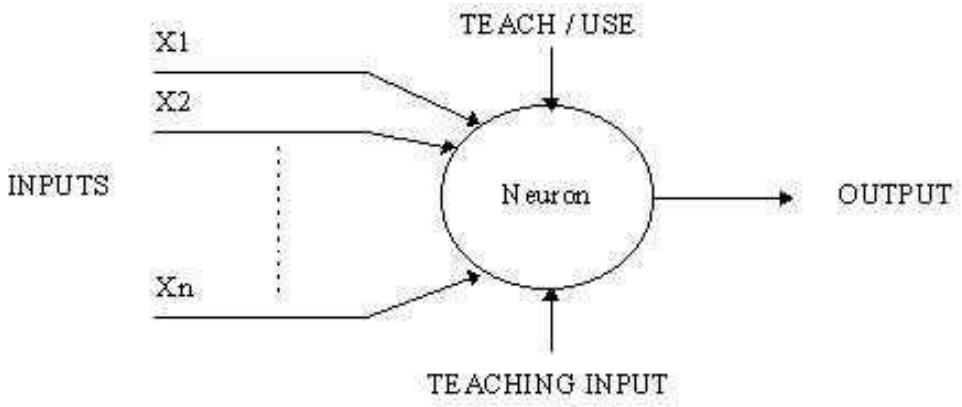

Figure 3.1 : ANN Neuron Model

Generally, ANNs was inspired by natural neuron from a system of interconnected nodes that can give outcome based on the input data such as in figure 1 (Mahmoud Nasr and Hoda Farouk Zahran, 2014).

The input layer receives the data from different sources. Hence, the number of neurons in the input layer depends on the number of input data sources. The neural network will learn through example by data classification and pattern recognition through system and configured for specific function or application. Specialize of neural network are capable to learn complex nonlinear input-output relationship by following the procedure and adapt themselves to the data. (Jayanta Kumar Basu, Debnath Bhattacharyya, Tai-hoon Kim, 2010).

3.2 EFFECT OF ANN

We can say that neural network approaches differ from old statistical techniques in many ways and the differences can be exploited by the application developer. It is a powerful for decision-making tools data are multivariate with a high degree of interdependence between factors data are incomplete, when many hypotheses are to be pursued and high computational rates are required (Irfan Y. Khan, P.H. Zope, S.R. Suralkar, 2013).

3.2.1 Advantages

The advantages in the utilization of a neural network can perform tasks that a linear program cannot and when an element of the neural network fails, it can continue without any problem (Xu Jian-Hao, 2011). The capability of the network to analyzing the data even if the data is incomplete or distorted and would possess the ability to conduct an analysis with data in non-linear fashion was one of the advantages of this method (James Cannady). The only real requirements for the ANN model are for sufficient data for flood modelling events, and the specification of appropriate neural network parameters values to be used.

Neural network models automatically handle variable interactions if they exist and are able to learn any complex non-linear mapping / approximate any continuous function and can handle non linearity's implicitly (Irfan Y. Khan, P.H. Zope, S.R. Suralkar, 2013).

3.2.2 Disadvantages

The neural network needs training to operate same like biological neural network train. Adjustable parameters to produce desired output by adjust the strength (weight) connection between the neuron needs involvement of training by compared the target and output values (D.J Livingstone, D.T. Manallack and I.V. Tetko, 1996). Unlike expert systems, analyses and estimation of information provides probability the data matches or not with the characteristic that has been trained to recognize. The dependent on accurate training of the systems, training data, and the training methods that are used are critical (James Cannady).Process of training is an important aspect, and the performance of an ANN is crucially dependent on successful training (ASCE Task Committee,2010).

ANNs requires high processing time for large neural networks. The training routine requires a very large amount of data to ensure that the results are statistically accurate (James Cannady). Larger neural networks may require high processing time for training to operate (Ramapulana Nkoana, 2011).

3.3 BACK PROPAGATION

The research will be trained using back propagation method to estimate the flood water level at Pekan River. ANN's trained using backpropagation are also known as "feedforward multi-layered networks trained using the backpropagation algorithm (Haijie Cai, B. Eng, M. ASc, 2010). Generally neural network consist of three layers, input, hidden and output layer. Each layer consists of neurons and the layers are interconnected by sets of correlation weights, which enable the network to process the data (Jorge O. Pierini and Eduardo A.Gómez, 2009). Referring to figures 1, neuron in the previous layer will give signal to each neuron and those signal will be multiplied by random separated weigh value. The input weighed are being totalize and passed through a limiting function which scales the output to a fixed range of values. Each link that applied to connect between layers of neuron has a unique weighting value. There are non-linearly scaled between 0 and +1 and the output value is use on the next layer. Back propagation learning algorithm is use as a method to adjusting the weight between the layers. This method is learning from example.

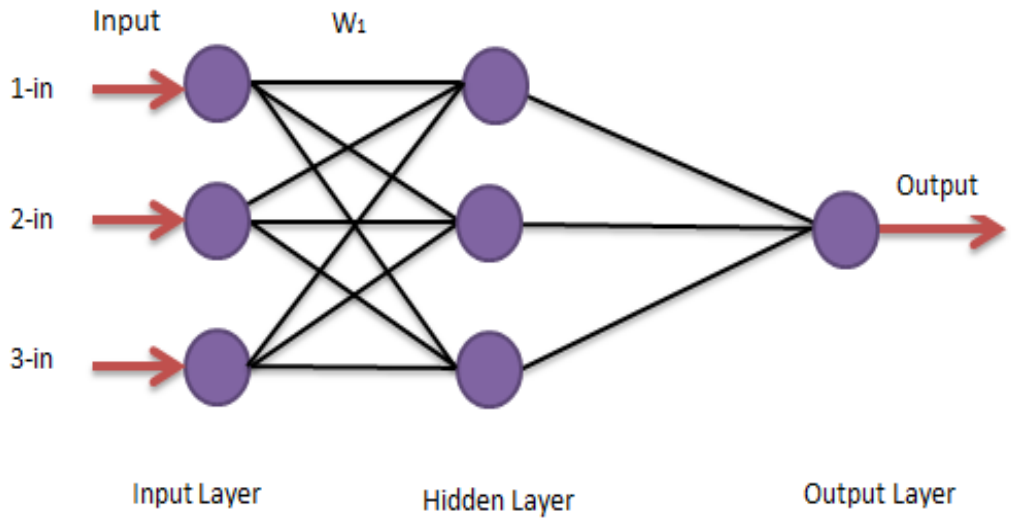

Figure 3.2 : ANN Model with 3 Input 1 Output