UNIVERSITI PUTRA MALAYSIA

RAINFALL TIME SERIES MODELING FOR A MOUNTAINOUS REGION IN WEST IRAN

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By

FATEMEH MEKANIK

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

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Dedicated to the author's beloved Father and Mother

Abstract of the thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirements for the degree of Master of Science

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By

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One of the major problems of water resources management is rainfall forecasting. Different linear and non-linear methods have been used in order to have an accurate forecast. Whilst there are some debates on whether the use of linear or non-linear techniques is better, it was found that rainfall modelling for the short term period is receiving more attention than those for long-term periods. This study gives attention to long-term rainfall modelling since long-term forecasting could provide better data for optimal management of a resource that is to be used over a substantial period of time. Hence, this study is to investigate the effect of linear and non-linear techniques on long-term rainfall forecasting. One of the non-linear techniques being widely used is the Artificial Neural Networks (ANN) approach which has the ability of mapping between

input and output patterns without a priori knowledge of the system being modelled. The more popular linear techniques include the Box-Jenkins family of models.

A feedforward Artificial Neural Network (ANN) rainfall model and a Seasonal Autoregressive Integrated Moving Average (SARIMA) rainfall model were developed to investigate their potentials in forecasting rainfall. The study area is the west mountainous region of Iran. Three meteorological stations among the several stations over the region were chosen as case study. The stations are the Hamedan Foroudgah, Nujeh, and Arak. Three different ANN models with three different input sets were trained. The first model investigated the effect of number of lags on the performance of the ANN. The number of lags varied from 1-12 previous months. The second model investigated the effect of adding monthly average to the inputs, and the third model considered seasonal average as an extra input in addition to the ones in the second model. The effect of the number of hidden nodes on ANN modeling was also examined. The preliminary inputs for SARIMA were found by examining the Autocorrelation and Partial Autocorrelation of the series. The 26 years monthly rainfall of 1977-2002 was used for training the models. The ANN models were trained and simulated using a program written in MATLAB environment (M-file). The SARIMA models were developed using SPSS syntax. The models were tested with one year monthly rainfall of 2003. It was proven that the larger lags outperform the lower ones in ANN modeling. Also, adding the extra monthly and seasonal average to the input set leads to better model performance. The number of hidden nodes was varied from 1-30. It was demonstrated that input nodes have more effect on performance criteria than the hidden nodes. The models were trained based on

the Levenberg-Marquardt algorithm with tansigmoid activation function for the hidden layer and purelin activation function for the output layer. Simulation results for the independent testing data series showed that the model can perform well in simulating one year monthly rainfall in advance .The SARIMA models were built using the same set of data as for the ANN. Model selection was done among multiplicative and additive models and the results revealed that additive SARIMA models have the best performance. The simulation results from the ANN and SARIMA model showed that the SARIMA model has a better performance both in training and testing. Thus, it is recommended for modeling rainfall in the region.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Master Sains

MODEL BERSIRI MASA HUJAN UNTUK SEBUAH KAWASAN BERGUNUNG-GANANG DI BARAT IRAN

Oleh

FATEMEH MEKANIK

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Faculty: Kejuruteraan

Satu daripada masalah berkaitan dengan pengurusan sumber air ialah ramalan hujan. Kaedah lelurus dan tak-lelurus berbeza telah diguna untuk menghasilkan ramalan tepat. Walaupun ujudnya debat manakah lebih baik diantara kegunaan teknik lelurus dan tak-lelurus, ianya didapati bahawa pemodelan hujan berdasarkan jangkamasa pendek menerima sambutan lebih hangat daripada yang berdasarkan jangkamasa panjang. Kajian ini bertujuan mengkaji kesan teknik lelurus dan tak-lelurus terhadap ramalan hujan berdasarkan jangkamasa panjang oleh kerana ramalan berjangkamasa panjang memberi data yang lebih baik untuk pengurusan optima terhadap satu sumber yang akan diguna untuk masa panjang. Satu daripada teknik yang digunai ramai ialah kaedah Rangkaian Saraf Buatan Suap Depan (ANN) yang boleh mengkaitkan corak masukan dan keluaran tanpa pengetahuan terlebih dahulu sistem yang dimodelkan. Teknik yang lebih disukai ramai termasuk kumpulan model Box-Jenkins.

Sebuah model hujan berasas kaedah Rangkaian Saraf Buatan Suap Depan (ANN) dan sebuah model hujan berasas kaedah Purata Bergerak Terkamir Autoregressi Bermusim (SARIMA) telah dibangunkan demi untuk menyiasat potensi model ramalan hujan berjangkamasa panjang. Tempat kajian ialah kawasan bergunung di Iran Barat. Tiga stesyen meterologi diantara beberapa stesyen di kawasan tersebut dipilih untuk kajian. Steysen terpilih ialah Hamedan Foroudgah, Nujeh dan Arak. Tiga buah model ANN berbeza dengan tiga set input berbeza telah dilatihkan. Model pertama mengkaji kesan nombor susulan keatas perlakuan/prestasi ANN. Numbor susulan berubah daripada 1 hingga 12 bulan terdahulu. Model kedua mengkaji kesan menambah purata bulanan kepada input dan model ketiga merangkumi tambahan purata bermusim sebagai input ekstra selain daripada input untuk model kedua. Kesan nombor nod terlindung juga diperiksakan untuk model ANN. Input permulaan untuk SARIMA didapati melalui Autosekaitan dan Autosekaitan Separa untuk siri siri. Hujan bulanan bagi dua puluh enam tahun daripada 1977 – 2002 telah diguna untuk melatih model. Model model ANN dilatih dan disimulasikan dengan sebuah program tertulis berasaskan MATLAB (M-file). Model model SARIMA dibangunkan dengan menggunakan nahu SPSS. Model diuji dengan hujan bulanan satu tahun iaitu 2003. Ianya dibuktikan bahawa model ANN yang bersusulan besar lebih berprestasi dibandingkan dengan yang bersusulan rendah. Tambahan pula sekiranya ditambah set input bulanan ekstra dan purata bermusim maka prestasi model lebih bererti. Nombor nod terlindung diubah diantara 1 – 30. Ianya ditunjuk bahawa kesan nod input keatas kriteria prestasi lebih bererti daripada nod terlindung. Model model terlatih berdasarkan algoritma Levenberg-Marquardt dengan

fungsi pengaktifan sigmoid untul lapisan terlindung dan fungsi pengaktifan paris tulin bagi lapisan output. Keputusan simulasi bagi siri data ujian tak bersandar menunjukkan bahawa model tersebut adalah sangat baik nutuk menyimulasikan hujan bulan satu tahun kedepan. Model SARIMA juga dibentukkan dengan set data yang sama diguna untuk membentukkan ANN. Pemilihan model dibuat daripada model yang berdaya tambah dan yang berpendaraban dan keputusan menghasilkan bahawa model SARIMA berdaya tambah berperstasi terbaik. Keputusan simulasi daripada model ANN dan SARIMA menhasilkan bahawa model SARIMA lebih berprestasi bagi kajian latihan dan ujian. Oleh demikian ianya disyorkan untuk memodelkan hujan dikawasan tersebut.

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I certify that a Thesis Examination Committee has met on (June 2010) to conduct the final examination of Fatemeh Mekanik on her Master of Science thesis "Rainfall Modeling for a Mountainous Region in Western Iran" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

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DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institutions.

FATEMEH MEKANIK

Date: 1 November 2010

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