UNIVERSITI PUTRA MALAYSIA

COMPARATIVE EVALUATION OF THREE METHODS FOR PREDICTING TRAFFIC VOLUME

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By

SEYED ALI ZAMANI

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

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In dedication to:

My parents that dedicated whole their life to my progression

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in Partial fulfilment of the requirement for the Degree of Master of Science

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June 2008

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In many places the capacity of existing road traffic system is frequently exceeded by the traffic demand. Combinations of technologies and systems that are generally called as Intelligent Transportation Systems (ITS) have the potential to perform as an influential tool to battle against congestions by increasing the effectiveness of the present surface transportation network. One of the most important issues regarding the utilization of above system is the need to forecast the traffic volume. This research presents forecasting of short-term traffic volume utilizing Artificial Neural Networks (an intelligent advanced method), ARIMA (Auto Regressive Integrated Moving Average) time series method and Historical Average along the PLUS highway in Malaysia.

The study focuses on two stations at Sungai Besi and Nilai along Section 5 of the highway. Feedforward ANNs, ARIMA timeseries, and Historical Average methods are developed for these sections for single and multiple intervals in order to forecast traffic volume and compare the results. The data for this study consist of a three

months period of 2006 obtained from PLUS highway authority. Twelve various NNs models are developed including Univariate and Multivariate models with a wide range of inputs. This is done to find the most effective NNs model with the highest performance in terms of traffic volume forecasting. Models were developed for all week days as well as single day's model. Inputs of these models are mostly previous hours' traffic volume, upstream flow, and weather information. Four time series models and one historical average model were developed for forecasting traffic volume. Time series models are developed for weekdays and holidays separately.

This study proved that the architecture of ANNs model is suitable to be applied to the traffic volume forecasting problem. It also demonstrates that a successful neural network model requires considerable effort in defining the network's parameters. Generally NNs with previous hours' traffic volume, same hour traffic volume of same day of last weeks, and abnormal day distinguisher as input are more successful than others. The study revealed that NNs model brings the best results and consequently has the highest performance for forecasting short-term traffic volumes. NNs method also shows an acceptable level of accuracy for the case of multiple forecasting which had a low level of error raise. It can be concluded that NNs models are site specific and they perform better in sites with high level of traffic variation due to their adaptive nature.

Abstrak tesis yang dibentangkan kepada senat Universiti Putra Malaysia untuk memenuhi keperluan ijazah Master Sains

PENILAIAN SECARA BANDINGAN TIGA KAEDAH UNTUK RAMALAN ISIPADU TRAFIK

Oleh

SEYED ALI ZAMANI

June 2008

Pengerusi: Profesor Madya Ahmad Rodzi Mahmud, PhD

Fakulti: Kejuruteraan

Keperluan aliran trafik di kebanyakan tempat kerapkali melebihi dari keupayaan tersedia sistem trafik jalan. Gabungan teknologi dan sistem yang secara umumnya dikenali sebagai Sistem Pengangkutan Pakar mempunyai potensi untuk bertindak sebagai alat menghadapi kesesakan dengan meningkatkan keberkesanan kepada jaringan pengangkutan daratan. Salah satu isu penting dalam penggunaan sistem tersebut ialah keperluan prasyarat dalam meramal kepadatan trafik. Penyelidikan ini mempersembahkan ramalan jangka pendek kepadatan trafik menggunakan Jaringan Neural Buatan (kaedah kepakaran termaju), kaedah siri-masa ARIMA, dan Purata Sejarah di laluan lebuhraya PLUS di Malaysia.

Kajian ini di di tumpukan di dua setesen iaitu di Sungai Besi dan Nilai di sepanjang Seksyen 5 lebuhraya tersebut. Salurhadapan ANNs, sirimasa ARIMA, dan kaedah Purata Sejarah di bangunkan untuk seksyen ini bagi setiap selaan dan sela berulang bagi meramal kepadatan trafik dan seterusnya membuat perbandingan hasil. Data bagi kajian ini terdiri dari julat 3 bulan bagi tahun 2006 yang diperolehi dari pihak berkuasa PLUS. Dua belas model NNs dibangunkan termasuk model Univariat dan Multivariat dengan pelbagai julat kemasukan. Ini di laksanakan untuk mencari model NNs yang paling berkesan dengan prestasi tertinggi mengambil kira ramalan kepadatan trafik. Model di bangunkan untuk setiap sela mingguan dan harian.

Kemasukan kepada model ini kebanyakkannya dari kepadatan trafik bagi jam terdahulu, aliran kehadapan dan maklumat cuaca. Empat model siri-masa dan satu model purata sejarah telah dibangunkan untuk ramalan kepadatan trafik. Model-model siri-masa telah dibangunkan secara berasingan untuk setiap hari kerja dan cuti.

Kajian ini telah mengesahkan model binaan ANNs adalah sesuai di gunapakai dalam permasalahan ramalan kepadatan trafik. Ia juga telah menunjukkan faktor kejayaan model jaringan neural memerlukan usaha yang berpatutan untuk mendefinasikan parameter jaringan. Secara umumnya NNs dengan kepadatan jam trafik terdahulu, trafik jam semasa pada hari yang sama untuk minggu terdahulu dan kemasukkan pembeda harian adalah lebih berjaya dari yang lain. Model NNs juga menunjukkan tahap ketepatan yang boleh di terima untuk kes ramalan berulang yang mempunyai peningkatan kesalahan pada tahap rendah. Ianya boleh disimpulkan bahawa model NNs adalah lebih bergantung kepada tapak tertentu dan ianya akan lebih baik di tapak-tapak yang yang mempunyai tahap julat trafik yang tinggi disebabkan sifat-dasar penyesuaiannya.

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All the praise to Allah the Al-Mighty for his blessing and benevolence

I wish to express my sincere gratitude and appreciation to the numerous individuals who have contributed towards the completion of this thesis:

I certify that an Examination Committee has met on 5th of June 2008 to conduct the final examination of Seyed Ali Zamani on his degree thesis entitled "Comparative Evaluation of Three Methods for Predicting Traffic Volume" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as partial fulfillment of the requirements for the degree of Masters of Science. The members of the Supervisory Committee were as follows:

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Date: **14 August 2008**

DECLARATION

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

SEYED ALI ZAMANI

Date:

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AADT	Average Annual Daily Traffic
ACF	Auto Correlation Function
ADT	Average Daily Traffic
ARIMA	Auto Regressive Integrated Moving Avenge
ATC	Annual Traffic Census
ATIS	Advanced Traveler Information Systems
ATMIS	Advanced Traffic Management Information Systems (ATMIS)
DHV	Design Hourly Volume
ESM	Exponential Smoothing Method
GML	Gaussian Maximum likelihood
ITS	Intelligent Transportation Systems
MAE	Mean Absolute Error
MSE	Mean Square Error
MSE	Mean Square Error
NNs	Neural Networks
PACF	Partial Autocorrelation Function
PTCs	Permanent Traffic Counters
RMSE	Root Mean Square Error
STARIMA	Space-Time ARIMA
TLRN	Time-Lag Recurrent Network
TMS	Traffic Management System
UTCS	Urban Traffic Control System

VARIMA	Vector Auto Regressive Moving Average
VLSI	Very Large Scale Integrated
VMT	Vehicle Miles Traveled

CHAPTER 1

INTRODUCTION

1. 1 General Introduction

Nowadays in global societies transportation plays an outstanding role. Not only transportation does support human being mobility, but it also provides the platform for economic intensification. Unfortunately, the rising populace in the urban areas, mainly resulting in low density urban sprawl, has caused severe congestion in many of the major metropolitan districts.

Road traffic overcrowding is now a global matter. In many places the capacity of road traffic system is frequently exceeded by the traffic demand. This produces delays of commuters, a falling reliability of the traffic system, and a worsening in access of important economic centers complexes with environmental damage.

Combinations of technologies and systems that are generally called as Intelligent Transportation Systems (ITS) have the potential to perform as an influential tool to battle against congestions by increasing the effectiveness of the present surface transportation network. The development of ITS, and smart cars and highways, is in

progress currently in an accelerated manner in the United States, as well as in Europe and Japan. It seems that ITS will act as an important part of surface transportation in the coming years.

It is noticeable that new technologies such as ITS will achieve an important position in improving the traffic congestion problem which is faced in today's highway systems. ITS, through its various sub branches like Advanced Traffic Management Information Systems (ATMIS) and Advanced Traveler Information Systems (ATIS) provides opportunities to traffic engineers and decision makers to fight against problems related to highways traffic and congestion management. Precise estimation of current and short-term traffic will result in successful utilization of these ITS systems.

One of the most important issues regarding the utilization of above system that is a prerequisite for most of them is forecasting the traffic volume in advance as a compulsory need for these systems.

1.2 Problem Statement

Different techniques and methodologies have been utilized to forecast traffic volume in short-term. The traffic forecasting models are generally based on time series analysis, which means that they used past data for forecasting of future values of variables. Considering the relationship between time series data, the time series models distinguish the pattern in the past data and extrapolate that pattern into the future. Advanced

modeling techniques like neural networks (NNs) are also utilized in designing short-term traffic forecasting models.

Even though there are currently a number of traffic management systems in service throughout the world, major advancements are necessary in order to improve current systems, comprising more accurate and trustworthy field equipment and highly developed data analysis capabilities.

An influential improved highway control is an important part of intelligent transportation systems (ITS). Generally, control and managing are consisted of forecasting of demand, optimization of network, and direct control. The preliminary principle about this case is that according to demand forecasting, optimal control strategies will be found out over a short-term time. Due to the discrepancies between real traffic volume and forecasted demand, the real-time direct control provides further adaptation to the implemented strategies. However, traffic engineers have been forced to employ reactive control methods because of the lack of reliable algorithms for forecasting highway demand in real-time. Therefore, developing trustable real-time forecasting is a critical step of optimizing highway control and its neighboring arterial streets. Regarding this issue and according to literature review in this research two of most promising and potential methods in the case of forecasting traffic volume in anticipation- FFBPNNs and ARIMA time series- are going to be compared while weighing against the old Historical Average method.

To avoid or decrease traffic congestion, the traffic control must be optimized in arterial streets which cause the correct distribution of the coming traffic flow. Forecasting results of traffic volume on exit ramps will affect the traffic control elements such as signal timing. Consequently, traffic volume forecasting and traffic distribution play critical roles in solving number of issues like traffic congestion problem, increasing construction costs, rising land prices, deteriorating air quality and declining commuters troubles for finding best existing sort of transport. For managing the transportation means, nowadays most efforts are for employing new information systems instead of widening the roads or building more of them.

Traffic volume forecasting, the ability to estimate true traffic volume (measured in units of vehicles/hour), is mainly important action in converting raw data into information. With no forecasting ability, ITS will offer services in a feedback mode where there will be a lag between the gathering of data and the execution of a traffic control policy. Consequently, the system will be managed based on old data. On the other words in feedback control error will be compensated after they occurs. Therefore the tendency is on “anticipation” instead of compensation. In controlling the system in a proactive way, ITS must have a forecasting capability. It should be able to make and continuously update forecasted traffic volumes values and connect them for several minutes into the future. Utilizing real-time data is a major requirement for providing dynamic traffic control.

Forecasting of traffic volume is applied not only to highway control, but also to other traffic platforms such as tunnels, intersections, etc. Obviously, the accomplishment of

ITS is reliant upon the expansion of traffic forecasting ability. Therefore, particular attention should be given to the capability of making short-term traffic forecasting.

To sum up, the reason for undertaking research can be stated as an elaboration in filling the gap and improving the performance of two potential methods- ANNs and ARIMA time series- in short term forecasting of traffic volume, which plays a critical role in control and managing the traffic in Intelligent Transportation systems.

1.3 Objectives of the Study

The aim of this research is to characterize and compare forecasting models for traffic volume. The specific objectives for the study are set as follow:

i) To explore the patterns of traffic volume considering their graphs and investigating their trends and variations,
ii) To identify and determine appropriate models in terms of performance and their parameters for the problem of traffic volume forecasting,
iii) To compare the results between Feed forward Backpropagation Artificial Neural Networks forecasting methods, autoregressive integrated moving average (ARIMA) time series methods, and Historical Average method according to their errors.

1.4 Scope of the Study

The scope of the study under consideration is limited to the Section 5 of North-South Highway in Malaysia. The study focuses on two stations at Sungei-Besi and Nilai stations along this corridor. The study scope is limited to the development of ANN, ARIMA timeseries, and Historical Average models for these sections in order to forecast traffic volume. It is expected that the study provides a detailed insight to the short-term traffic volume forecasting. The research investigates forecasting of traffic volume (veh/hr) for preparation of information for real-time control. The position of forecasting step is illustrated in figure1.1.

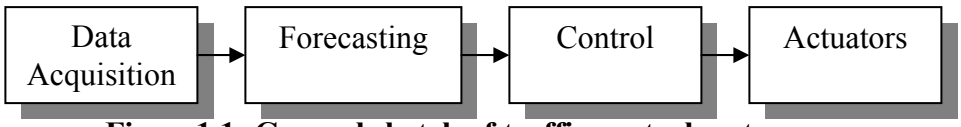

Figure1.1: General sketch of traffic control systems

1.5 Organization of the thesis

This thesis is made up of five chapters, the first chapter deals with general introduction, identifying problems and objectives. Chapter two is the critical review of related literature works like traffic volume definition and measurements, Neural Networks, time series, and historical average methods where the theoretical aspects of these methods are detailed out besides their application in traffic volume forecasting. Chapters 3 lists traffic characteristics of investigated Highway sections, process of building models for