A Comparison of Support Vector Machine and Fuzzy Type-2 Techniques in Weather Forecasting

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA
BORANG PENGESAHAN STATUS TESIS*

JUDUL: A Comparison of Support Vector Machine and Fuzzy Type-2 Techniques in Weather Forecasting

SESU PENGAJIAN: 2010/2011

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A Comparison of Support Vector Machine and Fuzzy Type-2 Techniques in Weather Forecasting

LIEW CHEW HONG

The report is submitted in partial fulfillment of the requirements for the Bachelor of Computer Science (Artificial Intelligence)

FACULTY OF INFORMATION AND COMMUNICATION TECHNOLOGY
UNIVERSITI TEKNIK AL MALAYSIA MELAKA
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I hereby declare that this project report entitled

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SUPERVISOR: [Signature] (DR. CHOO YUN HUOY) Date: 13/7/2011
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To my beloved parents, Mr. Liew Soon and Mrs. Florence, for their expression of love and full support...

To my supervisor, Dr. Choo Yun Huoy, for making it all worthwhile...
ACKNOWLEDGEMENT

This report would not have been possible without the guidance and help of several individuals who in one way or another contributed and extended their valuable assistance in the preparation and completion of this study.

First and foremost, my utmost gratitude to Dr. Choo Yun Huoy, who has been my inspiration by giving her assistance and guidance during the completion of this research work.

I am heartily thankful to Mr. Ahmad Shahi for the continuous support on this research study. I am sincere gratitude for his patience, motivation and guidance in all the time of the completion of work. Despite the distance, Mr. Ahmad had patiently e-mailed the information I needed.

I wish to extend my warmest thanks to all my course mates who are busy with undertaking their own work yet still willing to encourage all the time in continuing the research. The unity spirit had brought me confidence in the completion of works.

Last but not least, I would like to thank to my family for supporting me throughout my studies all the time. They are my motivation along the studies progress.
ABSTRACT

Weather forecasting is an important application by providing accurate weather prediction to saves lives, money and time in both local and global area. Type-2 Fuzzy Logic is one of the practiced automated techniques used to forecast weather. However, the research shows that Type-2 Fuzzy Logic does not obtain good performance when number of training data is small because of inadequate of rules to build a prediction system. Hence, this work had proposed Support Vector Machines (SVM) as the automated techniques for weather forecasting which can complement the weakness of Type-2 Fuzzy Logic and compared the performance of both techniques. The dataset which were recorded every half hour interval originally was subsample into weather dataset 1(3 hourly sample), weather dataset 2(2hourly sample) and weather dataset 3(daily average sample). The aim of the experiments was to investigate the performance of both techniques on the datasets with different size. The experiment environment is developed with C++ programming language in Matlab. The results of both techniques are compared in terms of Mean Squared Error (MSE) and validated using T-test. The experimental result shows that Support Vector Machine (SVM) had performed consistently better than Type-2 Fuzzy Logic due to its characteristic which is highly scalability on data with different dimensionality. Researchers are suggested to hybrid Type-2 Fuzzy Logic and Support Vector Machines (SVM) on the future work since Type-2 Fuzzy Logic had advanced in handling uncertainties of weather data.
ABSTRAK

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CHAPTER I

INTRODUCTION

1.1 Project Background

Weather forecasting is the application of science and technology to predict the state of atmosphere for a future time and a given location. Weather forecasts and warnings are the most important services provided by meteorological profession. Forecasts are used by government and industry to protect life and property and to improve the efficiency of operations. Besides, an individual can plan ahead a wide range of daily activities based on weather forecast since outdoor activities are severely curtailed by heavy rain or wind chilling.

A daily weather forecast involves the work of thousands of observers and meteorologists all over the world, and the work of thousands of machines. Modern computers make forecasts more accurate than ever, and weather satellites orbiting the earth take photographs of clouds from space. Forecasters use the observations from ground and space, along with formulas and rules based on experience of what has happened in the past, and then make their forecast. Weather forecasting today is a highly developed skill that is grounded in scientific principle and method and that make use of advanced technological tools. These had shown the importance of weather forecast for various places across the earth.
There has been much research into the incorporation of AI methods for weather forecasting. Support Vector Machines (SVM) algorithm will be used to forecast weather and comparison with Type-2 Fuzzy Logic will be done. Support Vector Machines is a set of related supervised learning methods used for classification and regression. It maps input vectors to a higher dimensional space where a maximal separating hyperplane is constructed. The performance of Support Vector Machines is compared with Type-II Fuzzy logic system in terms of forecasting accuracy, Mean Square Error (MSE) through this research.

1.2 Problem Statement

Type-II Fuzzy logic system is one of the practiced AI techniques in weather forecasting. However, it still has concealed weakness which will affect the performance or accuracy in forecasting. Type-II fuzzy logic system is a time-consuming method due to its complexity of implementation. Besides that, Type-2 fuzzy logic system does not obtain good performance when the number of training data is small (performs better when the number of training prototypes is large) because there are lesser rules can be obtained through small training data and hence accuracy will degraded.

1.3 Objective

The objectives of the project are detailed as follow:

- To proposed a forecasting technique in handling small sample data for weather forecasting
- To compare and analyze the result of proposed technique with type-II fuzzy logic system.
1.4 Scope

The scope of the project is listed as follow:

- The forecasting system is based on the Support Vector Machines (SVM) method.
- The output of the forecasting system will be in terms of Mean Square Error (MSE) to shown the accuracy of SVM.
- Weather dataset that collect on previous year had used in training and testing phase.
- The testing environment is developed with C++ programming language in Matlab.
- 10-fold cross validation been run on the experiment to evaluate the performance of both methods.
- Validation testing, T-test had been done to assess whether the result of both method are statistically different from each other.

1.5 Project Significance

Weather forecasting that built in artificial intelligent method had performed well by giving high accuracy. In this project, the experimental result will show the strength of Support Vector Machines (SVM) against Type-2 Fuzzy Logic System. The comparison of result in terms of Mean Square Error (MSE) between Support Vector Machines and Type-II Fuzzy Logic System will be provided in the report in research area.
1.6 Expected Output

The output of the research will come out with the performance comparison between Type-2 Fuzzy Logic and Support Vector Machines (SVM) on weather forecasting through the simulation result on Matlab platform. The performance of both techniques will be compared in term of Mean Square Error (MSE) and Support Vector Machines (SVM) is expected to be perform better than Type-2 Fuzzy Logic.

1.7 Conclusion

As a conclusion, forecasting system that built by AI techniques, which is Support Vector Machines (SVM) will providing promising result in terms of accuracy.

Chapter I has briefly described the weather forecasting system on the project background, problem statement, objective, scope, project significance and expected output. It is important to clearly list out all the important points before start develop the system. Next, chapter II is going to describe about the literature review in order to establish the importance of the topic by finding facts and comparing the existing systems.
CHAPTER II

LITERATURE REVIEW

2.1 Introduction

In this chapter, the literature part of this research study will be presented and discussed. This includes the studies on the methods of weather forecasting. Some of the forecasting algorithms are discussed and compared in order to justify the choice of method.

2.2 Weather Forecasting

Weather forecasting is the application of science and technology to predict the state of the atmosphere for a given location. Weather forecasting can have many different forms, depending on required applications. For example in airport it is far more important to know about the cloud visibility a few hours ahead rather than temperature. Also in building, weather prediction can play an important role in saving the energy. This can be done by controlling the heat and cool factors of buildings (A. Mountis and G. Levermore, 2005). Besides that, there is necessary to do forecasting on natural disaster such as earthquake.

Thousands of years ago, people had tried to do weather forecast and study on
meteorological. The Greek philosophers were found to be actively in forecast weather in millennia ago. Chinese weather prediction and ancient Indian astronomers also started to study on meteorology years BC (before Christ). Ancient astronomers forecast weather based on the observation on the patterns of events. For example, it said to be fair weather on the next day if the sunset was particularly red. However, the predictions prove to be inaccurate since the prediction made without rigorous statistical testing, but some of which is supported by the science. In mid-17th century, the scientific studies of meteorology develop the measure instruments such as mercury barometer and thermometer which resulted accurately and effectively (John J. Cahir).

The second half of the 20th century saw unprecedented growth of commercial weather forecasting firms in the United States and elsewhere. There are varieties of issues even some of business are seeking consultant on weather forecasting. Nowadays, modern weather forecasting involves a combination of computer models, observation, and knowledge of trends and patterns. Reasonably accurate forecasts can be made up to about five days in advance by using these methods. Emerging information technologies and artificial intelligent (AI) techniques are being used to improve the accuracy of forecasts. The automated weather forecasting techniques that popular used in weather forecasting will be further discuss in the next section.

The 2004 Indian Ocean Tsunami had occurred on December 26, 2004 with an epicenter off west coast of Sumatra, Indonesia due to an undersea megathrust earthquake. The earthquake was caused by subduction and triggered a series of devastating tsunamis along the coast of most landmasses bordering the Indian Ocean, killing over 230,000 people in fourteen countries, and inundating coastal communities with waves up to 30 meters (100 feet) high. It was one of the deadliest natural disasters in recorded history. Indonesia was the hardest hit, followed by Sri Lanka, India, and Thailand (National Geographic News, 2005). Therefore, a prediction system is important to protect all lives in the world. In the aftermath of the disaster, there is now an awareness of the need for a tsunami warning system for the Indian Ocean.

More recent news, there is great earthquake disaster happen at the coast of
Japan which occurred on 11th March 2011. This was caused by a 9.0-magnitude undersea megathrust earthquake. The degree and extent of damage caused by the earthquake and resulting tsunami were enormous, with most of the damage being caused by the tsunami. The earthquake and tsunami caused extensive and severe structural damage in Japan, including heavy damage to roads and railways as well as fires in many areas, and a dam collapse (FoxNews.com, 2011). All these disasters had proved the importance of development an intelligent forecasting system in order to decrease the risk of environment damaging by the power of natural.

2.3 Automated Weather Forecasting Techniques

The artificial intelligence (AI) techniques that applied by other researchers on weather forecasting had been discussed in this section. Besides, comparison will be made among the artificial intelligence (AI) techniques.

2.3.1 Type-II Fuzzy Logic System

Type-2 fuzzy sets and systems generalize (type-1) fuzzy sets and systems so that more uncertainty can be handled. From the very beginning of fuzzy sets, criticism was made about the fact that the membership function of a type-1 fuzzy set has no uncertainty associated with it, something that seems to contradict the word fuzzy, since that word has the connotation of lots of uncertainty. Prof. Lotfi A. Zadeh proposed more sophisticated kinds of fuzzy sets, the first of which he called a type-2 fuzzy set (Zadeh, 1975). A type-2 fuzzy set lets us incorporate uncertainty about the membership function into fuzzy set theory, and is a way to address the above criticism of type-1 fuzzy sets head-on. And, if there is no uncertainty, then a type-2 fuzzy set reduces to a type-1 fuzzy set, which is analogous to probability reducing to determinism when unpredictability vanishes.
Researcher A. Mencattini et al. (2005), used Type-2 Fuzzy Systems to do local level forecasting. In this research, they used frequency signal decomposition in order to extract chaotic and deterministic component with the aimed to be independently predicted. Type-2 Fuzzy System been applied in this research due to its capability in handling small sensitivity to measurements uncertainty and noise.

Meteorological data are uncertain (fuzzy) in nature and information on weather is vaguely defined [1]. Type-II fuzzy logic system performs well by removing the noise and uncertainty in dataset. The result in forecasting will be true when quality of the dataset had improved. However, there still having some weaknesses on this method:

i. Large time consuming when processing a large amount of data and needs very powerful computer by using type-2 fuzzy logic system. (A. Mencattini et al., 2005)

ii. Type-2 fuzzy logic system does not obtain good performance when the number of training data is small (performs better when the number of training prototypes is large). (Mendel, 2003)

2.3.2 Artificial Neural Network

Artificial neural network (ANN), usually called neural network (NN), is a mathematical model or computational model that is inspired by the structure and/or functional aspects of biological neural networks. A neural network consists of an interconnected group of artificial neurons, and it processes information using a connectionist approach to computation.
Figure 2.1 Architecture of Neural Network

In most cases an ANN is an adaptive system that changes its structure based on external or internal information that flows through the network during the learning phase. Modern neural networks are non-linear statistical data modeling tools. They are usually used to model complex relationships between inputs and outputs or to find patterns in data.

In Malaysia, meteorological department commonly used numerical method that involves a complex mathematical computing to forecast weather. According to (Abdul Manan Ahmad et al., 2002), the weather forecast system used artificial neural network to do forecasting which have capable to learn the pattern of rainfall in order to produce a precise forecasting results. But the reliability issue of a trained network is still in doubt. (Abdul Manan Ahmad et al., 2002)

1. Developing the network architecture for a specific task is complicated because there are no standard patterns and it is necessary to construct the architecture starting from zero in each specific case. (Petar Haichev, 2010)

2. Interpretation of the obtained results is difficult in some cases. (Petar Haichev, 2010)