HOMOGENEOUS ENSEMBLE NEURAL COGNITION FOR CIMB STOCK PRICE PREDICTION

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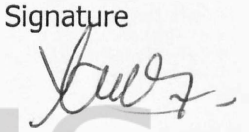

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ABSTRACT

Stock market forecasting has always been a topic of research interest due to the lucrative profit. However, stock market forecasting is a complicated task because of the not linear, volatile and random nature of the stock market. Literature reviews have shown that Artificial Neural Network (ANN) is an appropriate technique to be used in forecasting activities. However, there are certain limitation in single neural network. Therefore ensemble tecniques is introduced to overcome the limitation of single neural network. Ensemble techniques overcome the limitation of single learner by covering the different area of the problem search space aggregating multiple learner, consequently, reducing the error of estimation. Hence, this research investigates the performance of homogeneous ensemble neural network in closing price prediction. Ensemble Neural Network (ENN) has shown to be able to overcome the limitation of single neural network by covering the different area of the problem search space aggregating multiple single neural network, consequently, reducing the error of estimation. As the thesis title implies, the investigation will be focusing on homogeneous ensemble neural network which means multiple same architecture neural network will be used in the ensemble neural network. The two single neural network architectures as the building block for homogeneous ENN are used in this thesis which are FeedForward Neural Network (FFNN) and Recurrent Neural Network (RNN). These two architectures are among the ANN architectures that are widely adopted in ANN research. As shown in the literature review, both architectures shown to perform well in different studies which using different parameters and network configuration that have been conducted. Hence, it is also the interest of this thesis to the performance comparison of FFNN and RNN as well in this case study. The resulted single FFNN and RNN learner conducted in the experiment will then be used in experiment of homogeneous ENN. The results of these experiments are compared against each other to see how well the homogeneous ENN can perform better than single FFNN and RNN. The study case adopted in this thesis is CIMB stock listed in KLSE. CIMB is a well established financial bank company in Malaysia. The stock is selected due the volatile pattern trend that is suitable as the study case. In this study, a collection of input parameters which include technical data and economic variables are presented to the ANN to forecast the stock closing price of CIMB. The performance of the different ANN architectures are empirically evaluated based on Mean Square Error (MSE) and prediction accuracy.

ABSTRAK

HOMOGEN ENSEMBLE NEURAL KOGNISI UNTUK RAMALAN HARGA TUTUP SAHAM CIMB

Ramalan pasaran saham merupakan satu topik penting yang kerap diselidik dalam penyelidikan disebabkan keuntungan lumayan yang dapat diperolehi melalui pelaburan dalam pasaran saham. Walau bagaimanapun, pasaran saham adalah sukar untuk diramal. Sifat pasaran saham yang tidak linear, berubah-ubah dan rawak merumitkan lagi ramalan dalam pasaran saham. Kajian literatur menunjukkan bahawa rangkaian neural buatan (ANN) adalah salah teknik yang bagus dalam aktiviti ramalan. Walau bagaimanapun masih terdapat kelemahan dalam rangkaian neural buatan tunggal. Dengan ini teknik ensemble telah digunakan mengatasi kelemahan rangkaian neural buatan tunggal. Teknik ensemble mengatasi kelemahan rangkaian neural buatan tunggal dengan mengabung beberapa rangkaian buatan untuk menerokai ruangan carian yang berlainan, dengan itu, mengurangkan ralat dalam ramalan. Oleh itu, kajian ini adalah dijalankan untuk mengaji prestasi homegen ensemble rangkaian neural buatan (ENN) dalam membuat ramalan harga tutup saham. Ensemble rangkaian buatan (ENN) telah menunjukkan bahawa teknik ini dapat mengatasi kelemahan, rangkaian neural buatan tunggal dengan meliputi lain-lain ruangan carian bagi masalah yang dikaji dengan agregat beberapa neural network tunggal, dengan ini, dapat mengurangkan ralat ramalan. Tajuk tesis the menunjukkan bahawa pengajian ini menumpu dalam homogen ensemble rangkaian buatan neural iaitu beberapa topologi rangkaian neural buatan yang sama akan digunakan dalam ensemble rangkaian neural buatan. Dua topologi rangkaian buatan tunggal yang digunakan blok binaan untuk homogen ENN dalam tesis ini adalah FeedForward Neural Network (FFNN) and Recurrent Neural Network (RNN). Dua seni bina neural network ini paling luas digunakan dalam kajian ANN. Selain itu, kajian literatur telah menunjukkan bahawa kedua-dua seni bina neural network ini telah menunjukkan keputusan yang bagus dalam kajian yang berlainan dengan input parameter dan configurasi rangkaian yang berlainan. Oleh itu, tesis ini juga membandingkan prestasi FFNN dan RNN yang menggunakan input parameter dan configurasi rangkaian dalam kajian ini. FFNN dan RNN daripada eksperimen yang dijalankan akan digunakan dalam eksperimen homegen ENN. Keputusan daripada eksperimen yang dijalankan akan dibandingkan untuk mengetahui betapa baik ENN dibandingkan dengan FFNN dan RNN tungal. Kajian ini akan dijalan dengan mengunakan saham CIMB yang berdaftar di KLSE. CIMB adalah salah satu syarikat perbankan yang telah stabil diasahkan di Malaysia. Saham ini dipilih adalah kerana ciri tidak menentu yang ditunjukkan dalam harga saham. Dalam kajian ini, koleksi input parameter mengandungi teknikal data, pembolehubah ekonomic akan digunakan dalam kajian ramalan harga tutup saham CIMB. Prestasi topologi ANN yang dikaji akan dibandingkan dari segi MSE dan ketepatan ramalan.

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LIST OF ABBREVIATIONS

ANN	-	Artificial Neural Network
EMH	-	Efficient Market Hypothesis
ENN	-	Ensemble Neural Network
EUR	-	Euro
FFNN	-	Feedforwad Neural Network
FTSE 100	-	Financial Times Stock Exchange 100
KLCI	-	Kuala Lumpur Composite Index
KLSE	-	Kuala Lumpur Stock Exchange
IDE	-	Integrated Development Environment
IPO	-	Initial Public Offering
MLP	-	Multi-Layered Perceptron
MSE	-	Mean Squared Error
RNN	-	Recurrent Neural Network
S&P 500	-	Standard & Poor's 500
SGD	-	Singapore Dollar
USD	-	United States Dollar

LIST OF SYMBOLS

+ - Addition
= - Equal
> - Greater than
≥ - Greater than or equal to
∈ - Is a member of
⊂ - Is a subset of
≤ - Less than or equal to
∑ - Sum of

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Investment play an important role in today's society for generating extra income due to the shrinking monetary of dollar because of inflation and other economic factors. One of the investment channels would be stock trading. Stock trading is the activities of buying and selling of stocks in the stock market. Stock is a kind of financial securities that is commonly known and traded by public (Bodie, Kane and Marcus, 2014). Stock owner is the stakeholder of the company. There are two kinds of stock which are traded; shares and stocks. Share is issued by a company through Initial Public Offering (IPO) when the company is first listed in stock market. Stock can be further divided into two types, namely common stock and preferred stock. Common stock is where the stakeholder have voting right towards the corporate decision whereas for preferred stock, the owners of the stock are only entitled to dividend payments quarterly or annually by the company according to their revenue. Stock is one of the channels for the corporates to collect capital for expanding business. This is done by listing the company stock in the stock market to be traded. This initial process is called IPO. After listing the stock, investors which include public and company can gain profit through stock trading. Stock exchange (formerly securities exchange) is a corporation or mutual organization which provides "trading" facilities for stock brokers and traders to trade stocks and other securities, thus, providing either a virtual or real marketplace (Soni, 2011; Agrawal, Chourasia and Mittra, 2013).

A stock market is a public market for a company to list their stock and to gather financial resources by trading their company stock with an agreed price. In return, the stock holder will receive a yearly dividend or bonus from the company's

profit. Besides that, stock holders can also trade the stock with an agreed price if they want to earn from the price difference of buy and sell activities. The turnover in the world stock market involves huge financial transaction. For example, in year 2008, the estimated size of the stock market is around $36.6 trillion[1]. Some of the popular stock markets where the investor can trade includes New York Stock Exchange, National Association of Securities Dealers Automated Quotations (NASDAQ), Toronto Stock Exchange, Amsterdam Stock Exchange, London Stock Exchange, Paris Bourse, Philippine Stock Exchange, the Singapore Exchange, Kuala Lumpur Stock Exchange, the Tokyo Stock Exchange, the Hong Kong Stock Exchange, the Shanghai Stock Exchange and the Bombay Stock Exchange, amongst others. The trading of the stock market reflects the national economies of that particular country through stock index.

An index is a statistical composite measure of the movement in the overall market or industry. Basically, indexes allow measuring the performance of a group of companies over a period of time. Companies are organized in an index according to two main methods or weighting as it is commonly termed. The movements of the prices in a market or section of a market are captured in price indices called stock market indices, e.g. the Standard & Poor's 500 (S&P 500), the Financial Times Stock Exchange 100 (FTSE 100), and the Euro next indices (Soni, 2011; Mingyue, Cheng, and Yu, 2016). This particular index values reflect the health of stocks in the trading market. There are also specific index values that reflect the health of the particular domain market.

Investor can gain huge profit through stock trading activities by gaining profit through the difference of prices. However, techniques from various disciplines such as econometric, statistic and computation approaches are required in order to predict and forecast the high and low price of a stock. Thus, if one is able to forecast the closing price of a particular stock, he or she can make a fortune out of it. This process is known as stock market forecasting. Stock market forecasting is a complicated task due to the nonlinear, uncertainty and volatile nature of the stock market. Furthermore, the task of forecasting is getting more and more complicated

[1]http://seekingalpha.com/article/99256-world-equity-market-declines-25-9-trillion

due to the influences from different external parameters such as interest rate, inflation rate and currency exchange, amongst others, toward the stock price. To date, stock market forecasting remains as a hot research topic that numerous folks, investors particularly, are trying to grasp.

Stock market forecasting is a challenging task, as a result many methods has been used to forecast the stock market. The next section will briefly discuss some of these methods.

1.2 Stock Market Forecasting

Many traditional methods have been applied to predict both the stock market moving price and stock market closing price. There are two imperative theories used in conventional approach for stock market prediction namely, Efficient Market Hypothesis (EMH) (Fama, 1964) and the random walk theory (Fama, 1965). The EMH is introduced by Fama in 1964 (Fama, 1964). According to EMH hypotheses, the future stock price is unpredictable based on the stock historical data. The EMH exists in three forms, namely weak EMH, semi-strong EMH and strong EMH (Fama, 1964). On the other hand, the random walk hypothesis states that stock prices do not depend on past stocks (Fama, 1965) and thus, there is no pattern to be exploited since the historical data do not reflect the pattern of the current stock price.

Two conventional approaches used for stock market prediction are technical analysis and fundamental analysis (Falinouss, 2007). Technical analysis is a numerical time series approach used to predict stock markets based on historical data by using charts as the primary tool (Pring, 1991). This approach tries to mine information from the historical data to recognize the pattern, which sometimes also referred to as mining the time series. Fundamental analysis is the study on the factors that affect supply and demand (Thomas, 1998). These conventional approaches have now become inferior due to the rise in the computational power where computer can now analyse larger data set more accurately within a shorter time period.

Traditional time series forecasting is another approach that is used to predict stock market closing price. It utilises the linear prediction models of the historical to forecast the output. There are two categories of traditional time series which are the univariate and multivariate regression models (Maddala and Lahiri, 1992). The traditional time series used a set of factors known as explanatory variables to predict the stock market closing price. As the name implies, univariate means single explanatory variable and multivariate means more than one explanatory variable.

Machine learning utilises set of samples to trace the patterns of the stock market (Krollner, Vanstone and Finnie, 2010). This method tries to approximate the function of the stock market pattern through learning the process by mapping the input to the desired output. The level of success for this method varies upon different datasets and machine learning methods used. Artificial neural network (ANN) is one of the machine learning methods which is commonly used to predict the closing price of the stock market (Dase and Pawar, 2010; Li and Ma, 2010). The ability of ANN to learn and generalize from the non-linear data trend is well suited to problem domain such as stock market prediction. Multi-layered perceptron (MLP) is the common ANN that is used to estimate the closing price of the stock market (McNelis, 2005). MLP is a type of feedForward Neural Network that use backpropagation as training algorithm. The universal approximation ability of MLP allows it to approximate the function by mapping the input to the desired output (Zhang 2003). Vaisla and Bhatt (2010) and Ahangar, Yahyazadehfar, and Pournaghshband (2010) shows that ANN outperforms classical autoregressive linear models in stock forecasting. Autoregressive linear models is a sequence of values where the next stochastic value is depend on previous value linearly. A more detail review studies will be carried out in the next chapter on the role of ANN in stock market forecasting.

1.3 Artificial Neural Networks

Artificial neural network is a bio-inspired machine learning algorithm that mimics the architecture of a human brain (Engelbrecht, 2007). ANN is built from a massive parallel simple processing unit known as artificial neuron mimicking the function of

neuron in human brain (Haykin, 2004). These artificial neurons receive input and propagate this input through weighted link which act as synapses that connect others artificial neurons. The incoming input is excited or inhibited by the weight value. The artificial neurons then perform simple calculation by accumulating the incoming input through summing the product of input value, weight and feed to a transfer function which is nonlinear in nature to produce the output (Kröse and Smagt, 1993).

ANN is organized in layer consists of input, output and one or more hidden layers. The organization of different layout of ANN layers is referred to as topology/architecture and some of these architectures are feedforwad neural network (FFNN), recurrent neural network (RNN) and ensemble neural network (ENN), amongst others (Haykin, 2009). Each of these ANN architectures has its own characteristics that might affect the output result that is being produced. For example, feedforward neural network has data flow in one direction and no feedback the network whereas recurrent neural network has feedback in the network where the data is flowed back to input layer in a cycle. However, there is limitation in single neural network such as FFNN and RNN. Hence, ensemble technique is introduced to overcome the limitation of single neural network. Ensemble technique overcome single neural network limitation by aggregating multiple single neural network to cover different exploration of search space in the problem domain, as a result, the error of estimation is reduced. In this research, homogeneous ENN is adopted which means the multiple same architecture neural network will combine together to produce output.

Each of these architectures has shown to be performing well in many of the forecasting tasks. FFNN (Park *et al.*, 1991; Tkacz, 2001), RNN (Barbounis, Theocharis, Alexiadis, and Dokopoulos, 2006; Kermanshahi, 1998) and ENN (Taylor and Buizza, 2002, Yu, Wang, and Lai, 2008) have all been proven to be well-performed and demonstrated satisfactory results in researches cited. In light of the supporting literatures on these architectures, the FFNN, RNN and ENN are chosen to be adopted in the prediction of stock closing price of CIMB stock closing price and the performances of different ANN architectures in forecasting are investigated

also in this research study. CIMB is a financial bank company which is listed in Kuala Lumpur Stock Exchange. This financial institution in Malaysia has grown to become one of the banking powerhouses in ASEAN countries. CIMB stock is selected as the study due the volatile and nonlinear of the price trend which is suitable for the study case. Nevertheless, literature review shown that the performance of FFNN and RNN varies in different study cases. Hence, one of investigation in this thesis is to carry out the experiment to compare the performance of FFNN and RNN in this study case. Besides that, the homogeneous ENN experiment is using multiple FFNN and RNN which are selected from the single FFNN and RNN. The experimental result is then compared to check on performance.

1.4 Problem Statements

As mentioned in the earlier section, it is noted that the nature of the stock market is non-linear, uncertain and volatile. The non-linearity characteristic of stock market cannot be model by using statistical linear regression model. Linear model is normally a straight line pattern, thus, anything that cannot be presented using a straight line pattern is nonlinear. Stock closing price trend is normally fluctuating due to the price increment and decrement over time, hence, stock closing price pattern belongs to the nonlinear type. Therefore, a nonlinear model is needed in order to capture this characteristic of stock market. The uncertainty of the stock market also caused difficulty in identifying some priori knowledge for certain mathematical model. Furthermore, the difficulty would increase with the influences by other external parameters such as macroeconomic parameters. ANN is a non-linear modelling machine learning that is able to approximate a non-linear function without any prior knowledge. Thus, this research is aimed to investigate the efficiency of different neural network architecture which is able to forecast the stock market closing price by taking into account some of the macroeconomic parameters. The objective and scope of the research are described in detail in the next section.

1.5 Research Objectives

The research's main objective is to investigate whether homogeneous ensemble neural network in stock market forecasting by taking into account some

macroeconomic parameters in compare to single ANN by utilizing the benefit of different learner may covering different area of search space and hence reducing the prediction error. The sub objectives are:

1. To conduct a review study on stock market forecasting by using NN and different macroeconomic parameters in forecasting.
2. To investigate, analyze and compare the performance of the stock market prediction using feedforward neural network (FFNN) and recurrent neural network (RNN) in this study case due to different studies has shown different result on FFNN and RNN prediction.
3. To investigate, design and implement homogeneous ensemble neural architecture for stock market prediction and compare the result empirically against single ANN (FFNN and RNN).

The contribution of thesis is to investigate performance of homogeneous ENN compare to single neural network (FFNN, RNN) in forecasting the CIMB stock closing price utilizing the advantages of ensemble technique which have been mentioned. Besides that, the review of the FFNN and RNN stock market forecasting have shown that under different input parameters, different network configuration and different topology, some of the studies result shown that both the FFNN and RNN has outperform the other. Hence, is the interest of this study to investigate the performance of FFNN and RNN within the defined input parameters, network configuration and architectures. Besides that, the homogenous ENN is then compared to the performance FFNN and RNN in terms of MSE and prediction accuracy.

1.6 Thesis Structure

The remainder of this thesis is structured in the following way:

Chapter 2 describes the state of the art of neural network in stock market forecasting. The basic models of neural network are reviewed and described as well. The different neural network architectures which are used in the stock market forecasting model are discussed whereas different macroeconomic parameters used

in the stock market forecasting are reviewed. Finally, a discussion of the stock market forecasting is presented as the motivation to conduct the work in this thesis.

Chapter 3 describes the neural network model that serves as a platform to test and run the stock market forecasting that has been developed. The characteristics of each of the neural network architecture used in the stock market forecasting platform are described in this chapter. This includes the data, neural network configuration such as the number of input neurons, the number of hidden neurons, the error functions and the activation function, amongst others.

Chapter 4 described the experimental setup for the experimental works. It explained a predictions system developed to carry out the experiments allow the flexible configuration for the experiments.

Chapter 5 gives details on the experimental setup of the stock market forecasting experiment by using three different ANN architectures. Each of the experiment of the respective ANN architectures is described and the results of the experiments are discussed. Results comparison between the three different ANN architectures are discussed to select best ANN architecture as the predictor for the CIMB stock.

Chapter 6 presents the main conclusions of this thesis and the discussion of future works.