Prediction of Multi Currency Exchange Rates Using Correlation Analysis and Backpropagation

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Abstract—In the rapid Development of information and the collecting data collection issue of information network is becoming one of the essential elements affecting many areas, such as foreign exchange (Forex). Forex consists of data having particular ordered values in terms of time history. These values have meaning and can be further predicted for the next value. It is a very important issue of making decision for foreign exchange player (trader) in foreign exchange market. Accurate prediction of forex will give benefit to forex player. But in reality, it is very hard to realize it due to the big piles of data that are necessarily to be processed. This study will develop a system implementing a method so called as Backpropagation (BP) with additional algorithm so called Levenberg Marquardt (LMA) that can predict foreign exchange value, especially for EUR or USD currency. Moreover, input parameter increase will also be developed on BP LMA using Pearson correlation coefficient analysis that will check the correlation between the two variables, but It did not still decrease the error value. The result obtained from conducting testing, forex prediction will be implemented using BP architecture and LMA with best MAPE tryout score of 0. 2208% and best MAPE testing by 0.2693% on scenario 1 (without correlation). In addition MAPE tryout score of 0.3905% MAPE practicing and MAPE testing score of 0.3816 % on scenario 2 (with correlation). Based on this study we can conclude that using BP LMA still generating better error value than using BP LMA added with correlation analysis on foreign exchange data pair. The margin of BP-LMA and BP-LMA added with correlation analysis is 0.1697 % for MAPE tryout and 0.1123 %. For MAPE testing.

Keywords— Information Network, Artificial Neural Network Backpropagation, Perason's Correlation Coefficient, Levenberg-Marquardt Algorithm,Foreign Exchange.

I. INTRODUCTION

Currency is a payment tool used in national economic transaction as a currency exchange tools. It gives significant impact on local and international economics market. At international trading, the value contained in currencies can be differents, hence it needs a base rule currencies that can use globally. It is foreign exchange or better known as forex. Forex can be reffered as a market where exchange traded [1]. A survey from Bank for International Settlements (BIS) conducted in April 2013, which acts as the world bank, mentioned that trade in forex market reached average value of 5.3 trillion dollars per day. It increased from 3.3 trillion in April 2007 to 4 trillion in April 2010 [2]. It put US Dollar (USD) as the most influential currency (achieved 87% in all trading in April 2013). It was followed by Euro (EUR), even though its market share dropped from 39% to 33% in April 2010 and Yen was placed in the third rank.

There are many things in forex market that must be considered. One of them is technology. Nowadays, use of technology does not merely affect the exchange rate in the market, but also variety of provider informartion media, such as Reuters and Bloomberg [3]. That is because technology embedded in network and computer calculation needs an adaptive and smart capabilities to predict an accurate forex value. Moreover, the implication is that trader can do mapping an appropriate analysis to penetrate how the condition of forex market move in certain momentum. In addition, a trader has to use this approach to decide, analyze, and controll market movement, either from the point of view of fundamental analysis or technical analysis.

One type of technical analysis that can be used is prediction technique. It is called time series prediction. Time series is a format of data preparation which is sorted by time. This technique aims to predict the forex movement and estimate the future conditions. Besides, in predictive algorithm, the implementation of time series is done by selecting the right candidate for forecasting process [4]. Processing of time series data requires a particular system that can predict forex price so it can determine the act of selling or buying forex. One method used to predict is Artificial Neural Network (ANN) or so called as Neural Network (NN).

NN has been used as a method for forecasting. It can predict the future events based on the pattern of events in the past. Moreover, NN has an advantage to remember and generalize data from what has already existed. Addition of backpropagation algorithm (BPA), in NN, also can support NN learning process. BPA is used because it is one training method that is able to deal with large scale of training. This is the most widely used and studied in training method [4]. But, there is

deficiency in NN training process optimization of weight and bias. Hence, levenberg-marquardt algorithm (LMA) is applied to speed up the training process. This method requires a less number of iteration than BPA in achieving minimum error. It occured because BPA method usually requires a small training rate to avoid oscillation. In other case, comparison at input analysis using correlation coefficient will be exerted. Using correlation coefficient will determine degree of relatedness of multi-currency data in the forex price. Hence, the forex currency pairs will be an additional input for BP LMA.

This research will develop a forex' information network predictive system using backpropagation with levenberg-marquardt (BP LMA) method. Besides that, additional comparison method using coefficient correlation analysis that use as reference for trader to determine the condition of the forex market is used so the advantageous use of technology can be directly benefitted.

II. METHOD AND MATERIAL

A. Foreign Exchange

Foreign exchange (forex) is one type of trade or transaction that trades a country's currency to others (currency pair) involving major currencies market for 24 hours continously [1]. The movement occurs throughout the world with level of liquidity and high price of acceleration and increace the Return of Investment (ROI).

B. Multi Currency

Multi-Currency is a term used to describe type of various currencies, such as USD, EUR, GBP, etc. The term of multi currency is reffered to multi currency pricing (MPC) which is a financial service enabling companies to set price of goods and services in various foreign currencies. Multi-Currency Pricing (MCP) technology is part of our payment processing platform that makes it simple and cost-effective to sell to global customers in their own familiar currency [5]. Thus, trader can expand business sustainably into new international markets, or enhance existing customer relationships, with zero investment or change in your business infrastructure.

C. Artificial Neural Network

Artificial Neural Network (ANN) or can be called Neural Network (NN) is a network architecture modelling the work of human nervous system (brain) when it is carrying out specific tasks. This model is based on the human brain's ability to organize its constituent cells (neurons) having ability to carry out certain tasks, especially with the effectiveness of the network pattern recognition which is very high [6]. Theere is a figure that shows non-linear mathematical model of a neuron in general [7].
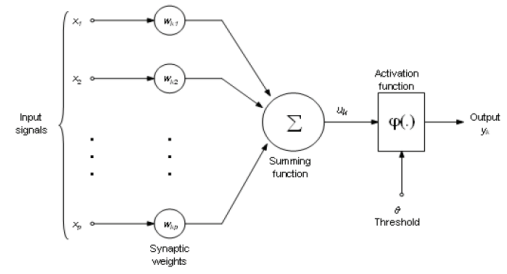

Figure 1. Non-linear mathematical model of a neuron in general [7]

NN has a widely distributed structure in parallel and ability to learn so It can make generalization, which means it produces correct output for an input that has not been trained. NN has a tendency to save experiential knowledge and make it ready to use. NN resembles a human brain in two ways, knowledge acquired through learning networks and strength of connection between nerve cells (neurons) known as synaptic weights are used to store knowledge [7].

NN is the most accurate forecasting models and mostly used in forecasting application, such as forecasting a social, economic, engineering, forex, stocks, and so on [x]. NN is a data-driven itself to adaptive method which is few a priori assumptions about the model' shape to a problem in learning. This unique function makes NN can resolve the learning problem. There is a learning process that is based on pattern of the existing training data to find out the weight of its synaptic. The components of NN are neuron, threshold, bias, layer, activation function, and the architecture model.

D. Backpropagation (BP)

Backpropagation (BP) is the most popular algorithm for training a multi layer perception (MLP). MLP is one type of NN architecture that contains of a lot of neuron pattern and linked closely with learning algorithm to train a network. It works to get an adequate learning pattern and minimum error value [8].

The BP' calculation has two stages. There are foward calculation that is used to calculate the error value between actual-taget output values and backward that propagates the error value to correct the synaptic weights in all neurons. This network model is widely used to be applied in completion of a problem related to the identification, prediction, pattern recognition and so on.
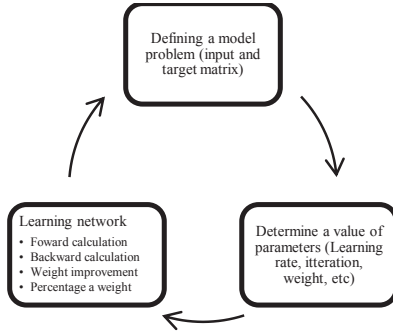
Figure 2. Illustration of the training process BP

E. Levenberg Marquardt Algorithm

LMA is an enlargement algorithm from general BPA. In BPA, process of updating a weight and bias apply a directly negative gradient descent. While LMA seize an approach that is Heasian matrix (H). LMA gives a better improvement than BPA and its result has an efficient algorithm [9] This was confirmed by B. M. Wilamowski dan Y. Chen in their research that LMA combines a speed from Newton algorithm with stability from the steepest decent [9].

This research uses LMA as a training algorithm in BP to get an accurate prediction and minimize error. LMA is applied in second phase in BP (backward calculation) [10]. In the phase of backward propagation, Jacobian matrix that contains the first derivative weight in the network is conducted.
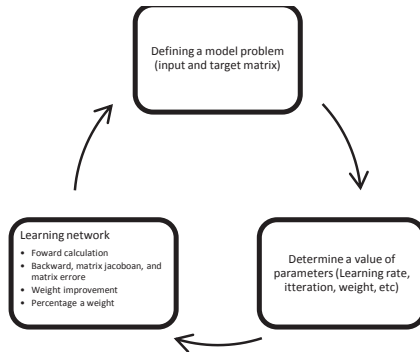

Figure 3. Illustration Learning BP LMA

F. Correlation Coefficient

Correlation coefficient is a number of single overview that gives scheme about how one variable relates to other variables. In world of trading, Relation of currencies is critical to measure the level of correlation of currencies. Correlation in finance is a statistical measure of relationship between two effects [11]. The correlation coefficient ranges between -1 and +1. -1 which means a perfect relation of negative correlation, +1 means a perfect relation of positive correlation, and zero means that there is no relation between the two variables. Some currencies tend to move in the same direction and on the other hand, that is opposite. This is a robust knowledge for someone who trades with more than one currency pair. Hence, the result helps the trader to take action, hedge, diversity or double position advantage. This research will apply correlation technique to measure the relation of two currencies.

G. Time Series Prediction

Time series prediction is a type of forecasting that uses a format of data preparation so called as time series. It can be daily, weekly, or yearly depend on the purpose of data' functioning to observe [12]. Time series data used is based on historical data of a particular observation [13]. Since the research data in the present study is quantitative, forecasting with time series will be conducted. Time series prediction methods assume that data or events of the past tends to re-occur in the future. The focus of prediction in time series is what will happen, not why it happens. [13].

H. Data

The data used to predict action of purchasing or selling forex are daily data of closing of November 2011 to November 2013 period. The available data is in the form of foreign currency in the form of real number containing EURO (EUR) and US Dollar (USD) as well as use an intermediate currencies such as Yen, Swiss Franc (CHF), Pound sterling (GBP), Canadian Dollar (CAD), and New Zealand Dollar (NZD). Data is obtained from metatrader with 515 total data from two years' data. It is split into two parts of data: training and testing data. Afterwards, various composition data will be observed. It aims to control an amount of data' composition which uses as training and testing data. We divide it into data proportion of 70-30% and 50%-50%. In our experiment, 70%-30% gives better performance than 50%-50%, so we choose 70%-30 as data' reference.

III. DESING SYSTEM

A. General Description

This research will make model of EUR/USD forex' prices and implementing an intelligent algorithm that is BP LMA. Additional method to analyze the model currency is using another currencies pairs, for example the value of EUR/USD will be obtained by using EUR/GBP and GBP/USD currencies, but previously it has been analyzed using correlation coefficient. Therefore, it can be an additional input and comparable analyze in BP LMA using the closing price of the forex.
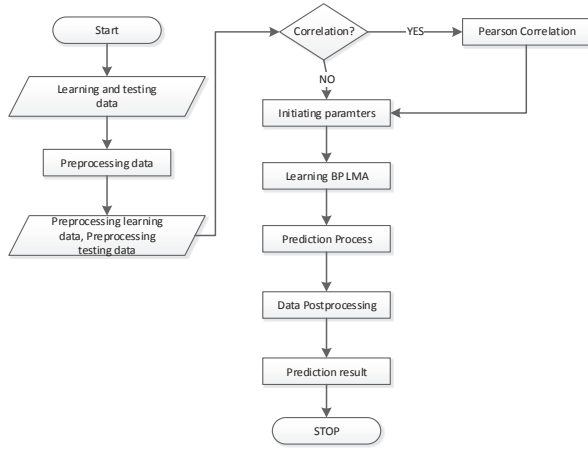
Figure 4. General Description BP LMA with correlation and without correlation.

B. Preprocessing dan Postprocessing Process

Preprocessing is processing process of original data to certain scale before the data are used. Afterwards, the data will be scaled and determined into input values and the aimed target, so it can be included in a reliable scale or so called as normalization. The availability of data doesn't use at once as system input. That is because data have various ranges. The preprocessing is used to plot it in a same range through scaling process into the range of [0 1]. Scaling process aims to make an ease of calculation process. In this research, scaling of [0 1] will be changed the minimum and maximum limit become [0.1 0.9]. This value is used to avoid an outlier's data when a data prediction has a minimum or maximum values. The preprocessing process is calculated by using eq. 3.1.

$$x' = \frac{(0.9-0.1)(x-a)}{b-a} + 0.1 \qquad (3.1)$$

If the data want to be returned to actual value. Data post processing process is done using eq. 3.2.

$$x = \frac{(x'-0.1)(b-a)}{0.9-0.1} + a \qquad (3.2)$$

Where a is minimum value of overall data, b is maximum value of overall data, x is actual data, and x' is normalized data.

Table 1. Normalization Process

Closing	EUR/USD (x)	EUR/USD (x')
11/1/2013	1.3671	0.10
10/31/2013	1.3748	0.57
10/30/2013	1.3771	0.71
10/29/2013	1.38	0.89
10/28/2013	1.3801	0.89
10/27/2013	1.3801	0.89
10/26/2013	1.3802	0.90
10/25/2013	1.3794	0.85
10/24/2013	1.3774	0.73
10/23/2013	1.3707	0.32

C. BP LMA

Forex prediction system will be implemented by using learning process from BP LMA. LMA is used to optimized an updating weight and bias. Here is a flowchart of training process that is conducted.
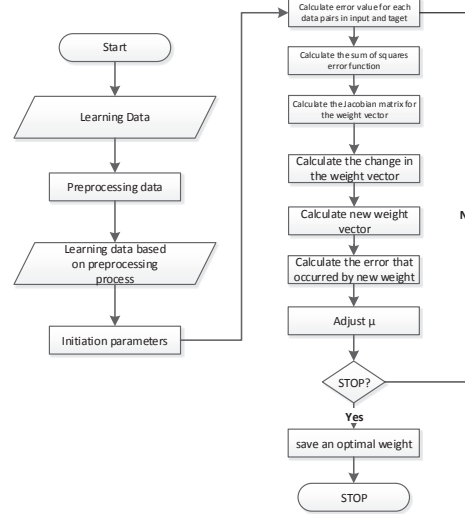

Figure 5. Flowchart training process of BP LMA

D. Development of Input Data Based on Correlation Coefficient Process Analysis.

This process calculates correlation between the currencies pairs. The equation 3.3 will use Pearson correlation (r) and the best data are retrieved by diagonal matrix Table 2.

$$r = \frac{\sum XY - \frac{(\sum X)(\sum Y)}{n}}{\sqrt{\left(\sum X^2 - \frac{(\sum X)^2}{n_x}\right)\left(\sum Y^2 - \frac{(\sum Y)^2}{n_y}\right)}} \qquad (3.3)$$

Where: X is closing price of variable 1, Y is closing price of variable 2, and n is amount of data pairs.

Table 2. The Correlation Coefficient Matrix

	AUD/USD	CAD/USD	CHF/USD	GBP/USD	JPY/USD	NZD/USD
EUR/AUD						
EUR/CAD						
EUR/CHF						
EUR/GBP						
EUR/JPY						
EUR/NZD						

E. System Comparison

After the overall process finished, the calculation process get a complete parameter of each data' model. The first experiment was performed by general BP LMA, so called as

scenario 1. second experiment, model input of BP LMA will be modified using another currencies that based on calculation of correlation coefficient of the minimum error, so called as scenario 2.
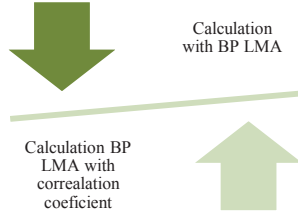

Figure 6. Comparison between BP LMA and BP LMA Using Coefficient Correlation

F. System Performance Measurement

The performance measurement is used to know how much closeness forecasting result with the original data. In this research, measurement of system performance was evaluated through prediction of accuracy in all pattern. Performance measures was used by Mean Square Error (MSE) to calculate the error that occurred in the system. MSE can be calculated using following formula:

$$MSE = \frac{\sum_{i=1}^{n}(E_i{}^2)}{n} \qquad (3.4)$$

Where n is amount of error in matrix error, E_i is sum of errors in error's matrix; E is error to-i.

Besides, Mean Absolute Percentage Error (MAPE) is used as performance measurement to generate error value and value comparison.

$$MAPE = \frac{1}{n}\sum_{i=1}^{n}\frac{|x_i - y_i|}{x_i} x100\% \quad (3.5)$$

Where n is number of input pattern; x_i is actual value made as targeted from I, y_i is an output data prediction from i. The calculation of MSE and MAPE is calculated when the learning process is done in preprocessing data.

IV. RESULTS

A. Testing Scenario Analysis Results

As explained in the previous experiment, the combination of scenario parameters is a combination of BP LMA that consist of scenario 1 and scenario 2. They produce an error value that is MAPE learning and testing. The result of both experiment express that scenario 1 yields better percentage error than scenario 2. The difference between both of them is not that significant, it differs only numbers behind the comma. It can be analyzed that the value of intermediary currency has bias or noise within correlation process and it cause a greater percentage error value than scenario 1. It was tested with ten attempts and using each of parameters combination of BP LMA to produce the best parameter. The best parameter combination are four historical data, eight hidden neuron in

hidden layer in amount of 0.4 levenberg-marquardt parameter, 2 beta parameters, and 400 epochs.

B. Input Data Correlation Analysis in Forex

The process of correlation analysis will use correlation matrix. That process calculation is conducted by currency pair of forex. Pearson correlation (r) will be used for calculation process to figure out the correlation between the two currency pair and the best data obtained can be seen in table 4.

Table 3. The Correlation Results

	AUD/ USD	CAD/ USD	CHF/ USD	GBP/ USD	JPY/ USD	NZD/ USD
EUR/ AUD	0.913 45					
EUR/ CAD		0.672 43				
EUR/ CHF			0.155 51			
EUR/ GBP				0.521 914		
EUR/ JPY					0.981 64	
EUR/ NZD						0.691 74

Based on the result, it can be concluded that EUR/GBP-GBP/USD has the biggest value among others, 0.521914. It means that to predict EUR/USD, BP LMA can apply another input, that is EUR/GBP-GBP/USD. The correlation value is generated on EUR/GBP and GBP/USD is 0.521914 which includes a great value. Due to the positive value which is also the best value among other correlation values.

C. Scenario Learning and Testing System

As explained in the previous section, there are two models in JST-BP LMA that will be performed to demonstrate the validation of forex value model for EUR/USD. In addition, the additional input from correlation coefficient will be used as a comparison. In this research, experiment will be conducted in two scenarios. There are BP LMA without correlation (scenario 1) and with correlation (scenario 2). Using daily data curency as a learning method, it can desired one prediction between input and target of historical data. Each scenario is applying one input layer, one hidden layer, and one output layer with various number of neuron of each.

The combination result of each best parameter will be used to result a minimum error value. Ten experiments were conducted continually to find out whether the values resulted are constant. Measurement of system performance by using MAPE (Mean Absolute Percentage Error) is used to calculate the system performance. Figure 7 and 8 show the comparison of prediction value resulted by the system. The original value and prediction value have the same pattern and quite similar.
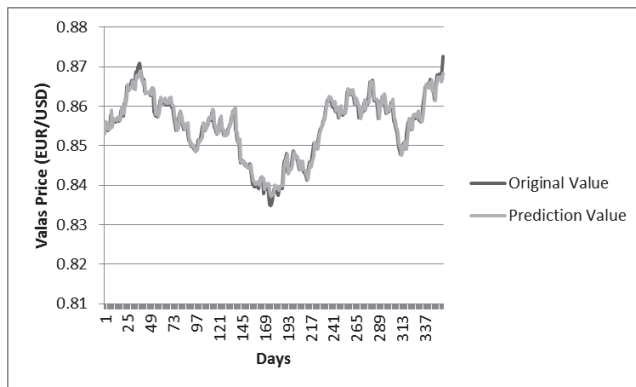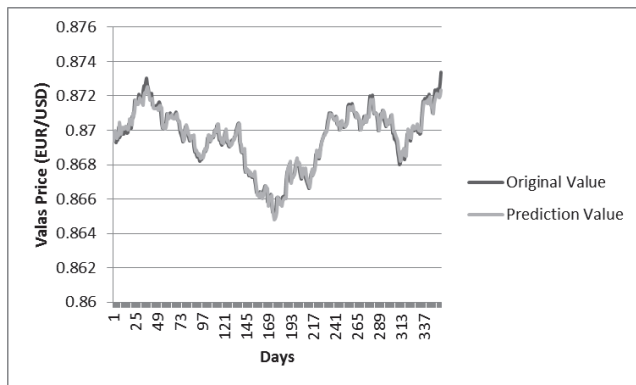
Figure 7. Trend of Scenario 1

Figure 8. Trend of Scenario 2

V. CONCLUSION

Backpropagation benefitting LMA as a training method can be implemented in the system being built to predict price of EUR/USD forex. Another development method was used as a comparison product that is correlation method. Correlation method was used to find out the impact of relatedness of two variables, value of currency pair. The finding resulted is that the more minimum error is resulted by model without using correlation. This means that trader only necessarily to concentrate on analyzing single value forex. The best combination in this case is scenario 1 with number of history data of 4, hidden neuron in hidden layer is 8, levenberg-marquardt parameter is 0.4, number of beta parameter is 2 and epoch is 400. In addition, system performance reached in BP-LMA system is that best MAPE value of 0.2208 was obtained and best MAPE test of 0.2693$.

FUTURE RESEARCH

The most important thing, it is suggested in this study not to add the biggest currency pair from correlation coefficient. This is to validate a better system performance like using another currency and does not depend on the biggest correlation value. Besides, to determining optimal parameters in BP LMA, an additional algorithm can be used, such as genetic algorithm, fuzzy and so on.

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