Elliott Wave Pattern Recognition for Forecasting GBP/USD Foreign Exchange Market

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***Abstract*—This research presents an approach to the Elliott wave pattern implicates a forecast of future movements in foreign exchange (forex) rates of the previous movement inductive analysis. Elliott wave is defined that each individual wave has its own characteristic or pattern, which as expected reflects the psychology of the moment. The forex market is one of the utmost intricate markets through the characteristics of high volatility, nonlinearity and irregularity. Meantime, these characteristics also make it very difficult to forecast forex. The problem is contained pattern recognition, classification, and forecasting. The research objectives are to recognize the pattern using the Elliott wave pattern, to validate accuracy patterns classification using Linear Discriminant Analysis (LDA) and to forecast short-term forex market using Elliott wave method. LDA is employed to obtain in term of classification's accuracy between 2 classes of selected data. The result shows the accuracy selected data is equal to 99.43%. Among of three levels of Fibonacci retracement which are 38.2%, 50.0%, and 61.8% results, the 38.2% shows the best forecasting for GBP/USD currency by using Mean Absolute Error (MAE), Root Mean Square Error (RMSE) and Pearson Correlation Coefficient (r) as the statistical measurements.**

***Index Terms*—Elliott Wave; Fibonacci Ratios; Forex; Linear Discriminant Analysis.**

I. INTRODUCTION

Forex is a liberty market that states the prices of currencies based on the supply and demand of a certain exchange. Forex trading is created by buying or selling a quantity of exchange against another. As the Bretton Woods System collapsed in 1970's, the fluctuations in the forex market are more volatile than ever [1]. Additionally, some significant factors such as economic growth, political, trade development, psychological, interest rates and inflation rates have high impacts on the exchange rate fluctuation [2]. The collaboration of these factors is in a very intricate style. As a component of study in the forex markets, the risk is an inevitability countable as technical analysis instruments [3].

A. Definition of Technical Analysis

Technical analysis is a forex market analysis technique that explicitly finds to exploit trends in previous prices whether through graphical analysis or quantitative methods [4, 5]. The technical analysis method focuses on understanding the current market trends and attempt to identify any reversal of this trend and forecast by what method the forex market is probably to perform in the future. Forecasting demands past market actions with price movement. The exact technical analysis methods the more accurate forecasting. Technical analysis is apprehensive with what has actually occurred in the market relatively than what should occur and takes into account the price of instruments and the volume of trading and produces graphs from that data to employ as the primary instrument [6]. According to Yao & Tan [2], the forex market has its own trend, cycle, seasonality, and rules. Technical analysis is employed to identify patterns of market price actions that have extended been recognized as significant. For numerous given patterns there is a high probability that they will produce the expected results. Correspondingly, there are recognition patterns that repeat themselves on a steady foundation.

B. Elliott Wave Theory

The Elliott wave pattern is a comprehensive description of how sets of people act [7]. It reveals that mass psychology swings from pessimism to optimism and return to an expected sequence, generating specific and determinate patterns. The knowledge derives from Elliot waves that define psychological strength behind the act of prices. According to Kotyrba et al. [8], Elliott wave theory is employed to recognize wave pattern including their deformation in the graphs and assist to improve the forecasting of its trend. Elliott wave patterns are not exact, they are marginally different every time they appear [9]. They can have a different amplitude and different period, although graphically the same pattern can appear different even though actuality the same. Besides, these patterns do not cover every time point in the series, but are optimized so that the advanced classifier would be able to learn their key characteristics and accurately recognize them. One of the significant problem is to recognize the input pattern reliably. Elliott wave patterns can be classified into uptrend and downtrend pattern. Uptrend patterns indicate that the forex market price is going upward while downtrend patterns indicate that the market price will move to downward. Elliott wave pattern has basis with Fibonacci sequence numbers and the golden ratio stated that each market times fluctuations is confined evolution or reduce, but been controlled within a definite range, understanding the mathematical ratio between Elliott wave and grasp the swing high and swing low of the price action of securities market, it can be clear and effective [10]. Elliott wave patterns can be classified into two classes which are main pattern and opposite pattern [9]. Main pattern specify that the market price is going to downtrend while opposite patterns indicate that the market price action will move to uptrend. In the first method, investor psychology tends to created five waves in favour and three waves in contradiction of the trend. The second method creates a pattern of exchange rate trend reversal. Elliott wave theory stated that a forex

market tends to clarify with three impulsive waves and two correction waves connecting them.

II. METHODOLOGY

Fibonacci ratios deliver the mathematical basis for the Elliott wave theory. Fibonacci ratios are mathematical relationships, stated as ratios, derived from the Fibonacci sequences. The main of Fibonacci ratios are 23.6%, 38.2%, 50% and 61.8%. The calculations as shown in below.

$$F_{61.8\%} = \left(\frac{1+\sqrt{5}}{2}\right)^{-1} \approx 0.6180$$

$$F_{50.0\%} = \frac{1}{2} = 0.5$$

$$F_{38.2\%} = \left(\frac{1+\sqrt{5}}{2}\right)^{-2} \approx 0.381966$$

$$F_{23.6\%} = \left(\frac{1+\sqrt{5}}{2}\right)^{-3} \approx 0.236068$$

Data were selected according to Elliott wave pattern. Figures 1 and 2 show the Elliott wave structure.

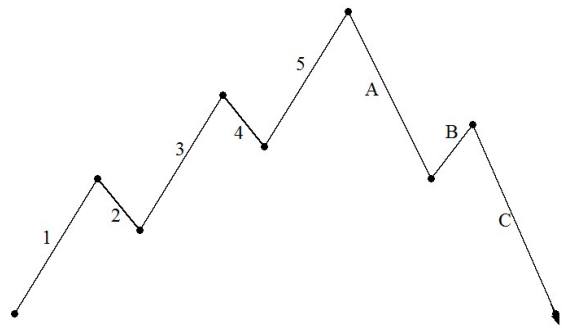

Figure 1: The basic pattern of Elliott wave (main wave)

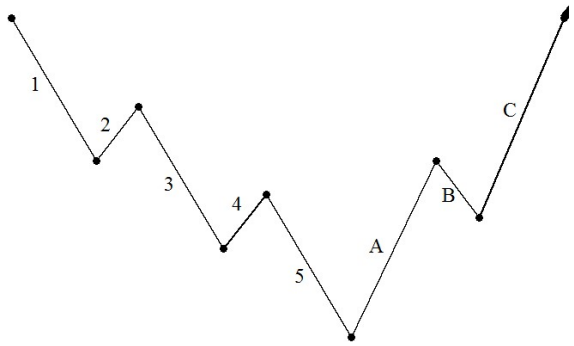

Figure 2: The basic pattern of Elliott wave (opposite wave)

III. DATA ANALYSIS

A. Linear Discriminant Analysis (LDA)

LDA algorithm is the general pattern recognition method for nonlinearly feature mining from high dimensional input Elliott wave patterns. Classification characteristically contains separating samples into training and testing categories. Pseudocode is defined as an item of consecutive phases for resolving a mathematical computational problematic of LDA. Pseudocode is employed to conceptually interpret with each calculation phase into a set of encoding commands relating numerous mathematical operations appropriate to solve an analytic problem. The LDA pseudocode was applied to acquire the classification's accuracy of the data. Following is a list of pseudocode for the LDA classification method. The input and output are $L, R, B_1, ..., B_n$.

Table 1
Notation

Notation	Description
n	number of samples
k	number of classes
A_i	i th samples in matrix
a_i	i th samples in vertorized
r	number of rows in A_i
c	number of columns in A_i
N	dimension of a_i(N = r * c)
Π_i	i th class in the dataset
L	transformation matrix (left)
R	transformation matrix (right)
I	number of iterations
B_i	reduced of A_i
l_1	number of rows in B_i
l_2	number of columns in B_i
S_w	within class matrix
S_b	between class matrix

i. Compute the mean, M_i of i th class in every i as

$$M_i = \frac{1}{n_i} \sum X \in \Pi_i \, X;$$

ii. Compute the global mean

$$M = \frac{1}{n} \sum_{i=1}^{k} \sum X \in \Pi_i \, X;$$

iii. $R_0 \leftarrow (I_{l_2}, 0)^T$;

iv. For j from **1** to I;

v. $S_w^R \leftarrow \sum_{i=1}^{k} \sum X \in \Pi_i \, (X - M_i) R_{j-1} R_{j-1}^T (X - M_i)^T$;

$S_b^R \leftarrow \sum_{i=1}^{k} n_i (M_i - M) R_{j-1} R_{j-1}^T (M_i - M)^T$;

vi. Compute the first l_1 eigenvectors

$\left\{\phi_l^L\right\}_{l=1}^{l_1}$ of $(S_w^R)^{-1} S_b^R$;

vii. $L_j \leftarrow \left[\phi_1^L, ..., \phi_{l_1}^L\right]$;

viii. $S_w^L \leftarrow \sum_{i=1}^{k} \sum X \in \Pi_i \, (X - M_i)^T L_j L_j^T (X - M_i)$;

$S_b^L \leftarrow \sum_{i=1}^{k} n_i (M_i - M)^T L_j L_j^T (M_i - M)$;

ix. Compute the first l_2 eigenvectors $\left\{\phi_l^R\right\}_{l=1}^{l_2}$ of $(S_w^L)^{-1} S_b^L$;

x. $R_j \leftarrow \left[\phi_1^R, ..., \phi_{l_2}^R\right]$;

xi. End *for* .

xii. $L \leftarrow L_I, R \leftarrow R_I$;

xiii. $B_l \leftarrow L^T A_l R$, for $l = 1, ..., n$;

xiv. Return $(L, R, B_1, ..., B_n)$.

where:

$$S_w^R = \sum_{i=1}^{k} \sum X \in \Pi (X - M_i) RR^T (X - M_i)^T \quad (1)$$

$$S_b^R = \sum_{i=1}^{k} n_i (M_i - M) RR^T (M_i - M)^T \quad (2)$$

B. Statistical Measurement

There are three statistical measurements namely Mean Absolute Error (MAE), Root Mean Square Error (RMSE) and Pearson Correlation Coefficient. MAE and RMSE are the indicators employed to determine differences between two parameters, namely observed and forecasted parameter. The smaller the number indicating the best result. This statistical measurement gives a forecasting accuracy. The Equations (3) and (4) show both of the statistical measurements for MAE and RMSE. Pearson Correlation Coefficient is employed to measures the strength and the direction of a linear relationship between two variables. The ideal number of is nearly value to 1. It indicates the strong relationship between two variables. The comparison between this statistical measurement as in (5) is used to determine the most appropriate retracement percentage level.

$$\text{Mean Absolute Error, } MAE = \frac{1}{N} \sum_{i=1}^{N} \left| F_i - O_i \right| \quad (3)$$

$$\text{Root Mean Square Error, } RMSE = \sqrt{\frac{1}{N} \sum_{i=1}^{N} (F_i - O_i)^2} \quad (4)$$

where: N = Number of values
F_i = Forecasting values
O_i = Observe values

Pearson Correlation Coefficient,

$$r = \left(\frac{\sum_{i=1}^{N} (O - O')(F - F')}{(\sum_{i=1}^{N} (O - O')^2)^{0.5} (\sum_{i=1}^{N} (F - F')^2)^{0.5}} \right) \quad (5)$$

where: N = Number of values
O = Observe values
O' = Mean observe values
F = Forecasting values
F' = Mean forecasting values

IV. MODELLING

Elliott five wave is concisely clarified as below:

i. Wave 2 is any 50 % or 61.8% retracement of wave 1.

ii. Fibonacci ratios relationship for wave 3 is
wave 3 is any 1.618 times the span of wave 1 or
wave 3 is 2.618 times the span of wave 1 or
wave 3 is 4.23 times the span of wave 1.

iii. Fibonacci retracement relationship for wave 4 is wave 4 is constantly related to wave 3.
wave 4 is any 23.6% retracement of wave 3 or
wave 4 is 38.2% retracement of wave 3 or
wave 4 is 50.0 % retracement of wave 3.

iv. The fibonacci relationship for wave 5 related to wave 1 indirectly.
(a) If wave 3 is more than 1.618 times the span of the wave then
wave 5 is any wave 1 or
wave 5 is 1.618 times the span of wave 1 or
wave 5 is 2.618 times the span of wave 1.

(b) Wave 5 is related to the whole span from lowest of wave 1 to the top of wave 3 and if wave 3 is less than 1.618 times the span of wave 1 then
wave 5 is any 1.618 times the whole span from lowest of wave 1 to the top of wave 3 or
wave 5 is 2.618 times the whole span from lowest of wave 1 to the top of wave 3.

v. Wave 4 is equal to or less than 61.8% retracement of wave 3.

The corrective wave pattern is normally referred to as A, B and C. Wave A and C are the trend corrections, and wave B is a counter-trend interchange within the correction.

i. The fibonacci relationship for wave A is
wave A is any 23.6% retracement of wave 5 or
wave A is 38.2% retracement of wave 5.

ii. The fibonacci relationship for wave B is wave B is related to wave A.
wave B is either 50 % retracement of wave A or
wave B is 61.8 % retracement of wave A.

iii. The fibonacci relationship for wave C is
wave C is any 1.618 times the span of wave A or
wave C is 2.618 times the span of wave A.

V. RESULTS

Data was applied from the zone of forex market that is a set of data that mirrors the situation of the market. Data indicates the behavior of the GBP/ USD price.

A. Pattern Recognition

Uptrend pattern (see Figure 3) is begin by the movement high to low direction level of wave 1 and reverse to upward at wave A. Wave 2 is the reversal of wave 1. The high level

of wave 2 is above to high level of wave 1. Wave 3 is the reversal of wave 2 and similar movement direction to wave 1. The low level of wave 3 is below to low level of wave 2. Therefore, the low level of wave 2 is called as the support level and the high level of wave 2 is called as the resistance level. This resistance level is also called as the Fibonacci retracement level. Wave 4 is the reversal of wave 3. The high level of wave 4 is below to high level of wave 3. Wave 5 is the reversal of wave 4 and similar movement direction to wave 3. The low level of wave 5 is below to low level of wave 4. Therefore, the low level of wave 4 is called as the support level and the high level of wave 4 is called as the resistance level. This resistance level is also called as the Fibonacci retracement level. Wave A is the reversal of wave 5. The high level of wave A is above to high level of wave 4. Wave B is the reversal of wave A and similar movement direction to wave 5. The low level of wave B is above to low level of wave A. Therefore, the high level of wave A is called as the resistance level and the low level of wave B is called as the support level. This support level is also called as the Fibonacci retracement level. Wave C is the reversal of wave B but similar direction to wave A.

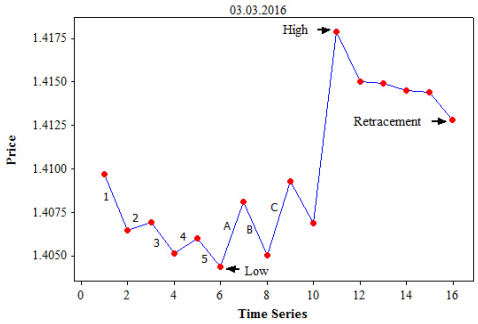

Figure 3: Elliott wave pattern recognition (uptrend)

Downtrend pattern (see Figure 4) is begin by the movement low to high direction level of wave 1 and reverse to downward at wave A. Wave 2 is the reversal of wave 1. The low level of wave 2 is above to low level of wave 1. Wave 3 is the reversal of wave 2 and similar movement direction to wave 1. The high level of wave 3 is above to high level of wave 2. Therefore, the high level of wave 2 is called as the resistance level and the low level of wave 2 is called as the support level. This support level is also called as the Fibonacci retracement level. Wave 4 is the reversal of wave 3. The low level of wave 4 is above to low level of wave 3. Wave 5 is the reversal of wave 4 and similar movement direction to wave 3. The high level of wave 5 is above to high level of wave 4. Therefore, the high level of wave 4 is called as the resistance level and the low level of wave 4 is called as the support level. This support level also is called as the Fibonacci retracement level. Wave A is the reversal of wave 5. The low level of wave A is below to low level of wave 4. Wave B is the reversal of wave A and similar movement direction to wave 5. The high level of wave B is below to high level of wave A. Therefore, the low level of wave A is called as the support level and the high level of wave B is called as the resistance level. This resistance level also is called as the Fibonacci retracement level. Wave C is the reversal of wave B but similar direction to wave A.

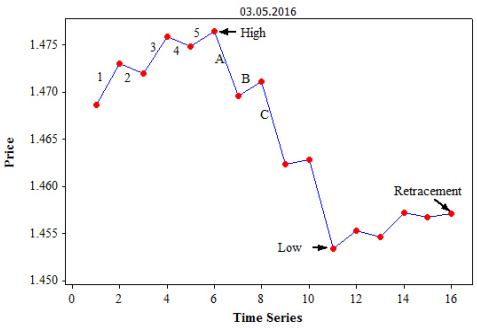

Figure 4: Elliott wave pattern recognition (downtrend)

B. Classification's Accuracy

The LDA classifier is employed to evaluate the classification's accuracy. The results are summarized in Table 2. There are 50 samples set of data. 40 training data sets and 10 testing data sets are derived. The dataset is generated with 2 different classes which are uptrend and downtrend. Each trial has 5 times of iteration. The maximum and minimum accuracy values for LDA are 100.0% and 98.9%. Distance within the maximum and minimum percentage values for LDA are close (see Figure 5) therefore it indicates consistent accuracy.

Table 2
Classification's Accuracy

Trial	LDA (%)					
	1	2	3	4	5	Average
1	98.67	98.67	100.00	100.00	98.67	99.20
2	100.00	100.00	100.00	100.00	98.67	99.73
3	100.00	96.67	100.00	100.00	100.00	99.33
4	97.33	100.00	100.00	98.67	100.00	99.20
5	100.00	100.00	100.00	100.00	100.00	100.00
6	100.00	100.00	100.00	100.00	98.00	98.63
7	98.67	98.00	100.00	100.00	98.00	98.93
8	98.67	100.00	98.00	100.00	98.67	99.07
9	97.33	100.00	100.00	100.00	100.00	99.47
10	98.67	100.00	100.00	100.00	100.00	99.73
					Mean	99.43

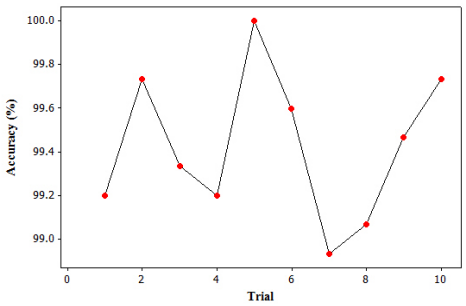

Figure 5: LDA accuracy

C. Retracement Levels of Forecasting

The comparison is between retracement levels of Fibonacci ratios at 38.2%, 50.0% and 61.8% for forecasting. Moreover, Mean Absolute Error (MAE), Root Mean Square Error (RMSE) and Pearson Correlation are the estimator between observed and forecasted data and also to measure of how close observe and forecast are to eventual outcomes. Result for MAE, RMSE and Pearson Correlation as shown in Tables 3 and 4.

Table 3
Statistical Measurement (uptrend)

Retracement Level (%)	Statistical Measures			
	MAE	RMSE	Pearson Correlation	*P*-value
38.2	0.001884	0.000019	0.992253	< 0.05
50.0	0.002493	0.000051	0.990843	< 0.05
61.8	0.003297	0.000091	0.988842	< 0.05

Table 4
Statistical Measurement (downtrend)

Retracement Level (%)	Statistical Measures			
	MAE	RMSE	Pearson Correlation	*P*-value
38.2	0.001685	0.000019	0.998806	< 0.05
50.0	0.001758	0.000029	0.998284	< 0.05
61.8	0.002648	0.000063	0.997322	< 0.05

In this research, the values of MAE and RMSE at level 38.2% is close to 0 compared to 50.0% and 61.8%. The values of Pearson Correlation at level 38.2% is close to 1 compared to 50.0% and 61.8% level with P- value is less than 0.05.

VI. CONCLUSION

The goal of this research is to show the validity of technical analysis in the GBP/ USD forex market through the research of Elliott wave pattern identified within the 4 months observation period. The research describes the details of the Elliott wave and their principles. The basic classification outlined in this research is utilized to show the past pattern of the forex market and how the market uptrend and downtrend can be explained by Elliott wave pattern. According to the results, it can be stated that Elliot wave patterns were successfully extracted in given time series and had been recognized and the method in which numerous patterns are repeated. The LDA's results show the consistent classification's accuracy in every Elliott wave patterns recognition. The research also provides an analysis of findings in describing the use of Elliott wave pattern to forecast future price movements. Fibonacci ratios level are useful to determine the accurate forecasting short term of forex market price. They can also be used to identify confirmation levels for forecasting. From the analyses, 38.2% level show the best forecasted of MAE, RMSE and Pearson Correlation for uptrend and downtrend.

In spite of many advantages deriving from the computational tools for creating automated trading systems, there are also limits that should be inspected such as the appropriate mathematical model and the applicability of the outcomes.

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