Stock Trend Prediction Using Simple Moving Average Supported by News Classification

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***Abstract*—The ability to predict stock trend is crucial for stock investors. Using daily time series data, one is able to predict the trend with the help of simple moving average technique. Unfortunately, stock trend is also affected by many factors, one of which is daily news. Daily news, particularly financial news have a great role in deciding stock trend. Each news has a sentiment value classified into positive, negative, and neutral sentiment that directly affects whether the trend goes up or down. It will be useful to combine simple moving average and news classification to predict stock trend more responsively. This paper uses machine learning using artificial neural network to combine the two aspects. The experiment in this paper uses approximately one year's worth of stock data and financial news. Artificial neural network is able to combine simple moving average technique and news classification, and the result indicates that financial news can improve the prediction responsiveness.**

Keywords—stock trend; simple moving average; news classification; sentiment value; artificial neural network

I. INTRODUCTION

Stock investment has been gradually growing popular lately. The increase on the number of stock investors is propelled by the numerous stock prediction techniques formulated today. Most of these techniques use time series data. The utilization of these techniques has mainly one objective, which is to maximize profit and minimize loss.

In the world of stock investment, there are two important factors that concern all investors. They are stock prices that indicates price per lot (unit for stock) and stock trends that indicate the movement of the stock. It is important to distinguish each approach. While [1], [2], [3], [7], and [8] focus on stock prices, this paper conducts experiments with the focus on stock trends.

[1] uses moving average technique and news classification based on word frequency. It is different form this paper which uses simple moving average technique and news classification based on dictionary and machine learning. Despite its simplicity, simple moving technique is more effective than other comparably more complex techniques [1].

Although stock trend prediction can be done only with prediction techniques, there are other factors which affect the stock trend. This results in the prediction not as responsive as it should be compared to the real world. Financial news, being one of the factors, have a great effect in stock trend movement due to the closely related information that they contain [3]. Each news contains information that can be converted into sentiment value. Positive sentiment value yields to the trend tend to go up while negative sentiment value does the opposite and thus affect the profit that can be made[2], [6].

Other than financial news, there are other approaches such as Twitter. [4] uses twitter sentiment to predict the stock market. However, it is stated that other financial factors such as financial news is still needed to make better performance. Similar to [4], [5] also uses twitter and concludes that when the twitter sentiments go high, the stock will go down and so does the opposite. In this paper, financial news is used to make sure that each news content has a contribution on stock trend prediction. Also, it is assumed that financial news is professionally written and reviewed.

In this paper, artificial neural network is used as a model to combine simple moving average and financial news' sentiment to predict stock trend more responsively. To achieve this, we need to retrieve, process, and classify daily financial news to get the sentiment value. Different from [7], which uses genetic algorithm to re-evaluate weights, this paper only use artificial network as it alone already gives good result compared to other methods [8]. We use both stock [12] and news [10] data from May 2013 to May 2014. The stock in this case is JKSE (Jakarta Composite Exchange) and the news are retrieved only on market & corporate category.

II. RELATED WORK

A. Simple Moving Average

Simple moving average is one of many time series analysis technique. Time series analysis is a method of timely structured data processing to find statistics or important characteristics for many reasons. Simple moving average shows stock trend by calculating the average value of stock prices on specific duration [11]. The prices that are used are closing prices at the end of the day. This technique can avoid noises and therefore smooth the trend movement. The formula is shown on (1).

Date	Open	High	Low	Close	Volume	Adj Close*
Jun 10, 2014	4,893.71	4,946.09	4,893.71	4,946.09	2,475,154,400	4,946.09
Jun 9, 2014	4,945.84	4,948.61	4,876.19	4,885.08	3,076,235,600	4,885.08
Jun 6, 2014	4,931.50	4,958.43	4,928.90	4,937.18	2,595,262,200	4,937.18
Jun 5, 2014	4,932.44	4,938.28	4,912.89	4,935.56	2,626,990,000	4,935.56
Jun 4, 2014	4,933.12	4,946.89	4,919.92	4,932.56	2,704,736,800	4,932.56

Figure 1. JKSE Historical Prices

$$SMA_n = \sum_{t=n-T}^{n-1} \frac{x_t}{T} \quad (1)$$

where SMA_n is simple moving average for n-th day, x_i is stock closing price at i-th, and T is duration for the simple moving average. Usually, the durations are 5, 10, 20, 50, 100, and 200 days [12]. Fig. 1 shows an example of stock prices retreived at [12]. Closing prices which are shown at 'Close' column are used to calculate simple moving average.

For example, we want to calculate 5 days simple moving average. Based on Fig. 1, we average 5 days closing price from June 4, 2014 to June 10, 2014 and the result is 4927.294. Stock trend can be determined by calculating two simple moving average with different durations, called short-term simple moving average and long-term simple moving average. If the value of short-term simple moving average is greater than long-term moving average, then it indicates the trend will go up. If the opposite happens, then the trend will go down [11].

B. *News Classification*

The main objective of financial news classification is to classify and calculate each news' sentiment value. Positive news are marked by sentiment value which is greater than 0, while negative news are marked by less than 0 sentiment value. If there are news having 0 sentiment value, they will be omitted as their neutralism does not affect the stock trend. The classification process can be explained step-by-step as follows [3]:

1) *Building Data Set*

A data set consists of some information related to a domain. An important property of a data set is that it is usable and can be manipulated by a computer.

2) *Feature Processing*

This is the most important step of news classification. It is a process to prepare readable information by machine. To achieve that, three smaller phases have to be done. They are Feature Extraction, Feature Selection, and Feature Representation. Feature Extraction is a phase to define and extract features based on the text. The next phase, Feature Selection, chooses the best features in order to get optimal subset relevant to the information. Feature Representation transform the features into a computer-readable format.

3) *Machine Learning*

Machine learning is a technique to analyze a great amount of data with computing algorithm. The result is a model that can identify pattern and eventually classify new text input. Out of many machine learning algorithm, one that is suitable for classifying news is artificial neural network.

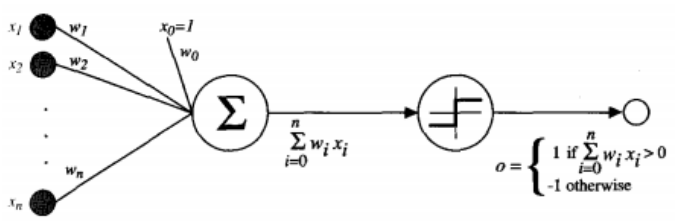

Figure 2. Artificial Neural Network's Perceptron

C. *Artificial Neural Network*

Artificial neural network is a good machine learning algorithm to estimate target function which has real, discrete, and vector value [13]. This algorithm has a basic unit called perceptron as shown on Fig. 2. A perceptron receives input, then calculate linear combination from the input and finally gives output that depends on activation function's threshold. One of many benefits of using this algorithm is that it is resistant to noisy environment.

III. IMPLEMENTATION

The implemented system design can be seen on Fig. 3. There are three main components required in order to predict stock trend more responsively. More explanation on those components are given as follows:

A. *Calculating Simple Moving Average*

Daily stocks data are retrieved online. Date and stock closing price are saved as attributes for simple moving average calculation. After that, simple moving averages are calculated with duration of 5, 10, 20, and 50 days. These durations are chosen for short-term stock trader. As stated before, in order to predict stock trend, we need two simple moving averages. Short-term simple moving averages are marked by 5 days and 10 days, while long-term simple moving averages are marked by 20 days and 50 days. Also, for each combination, a distance value is calculated by subtracting long-term value with short-term value.

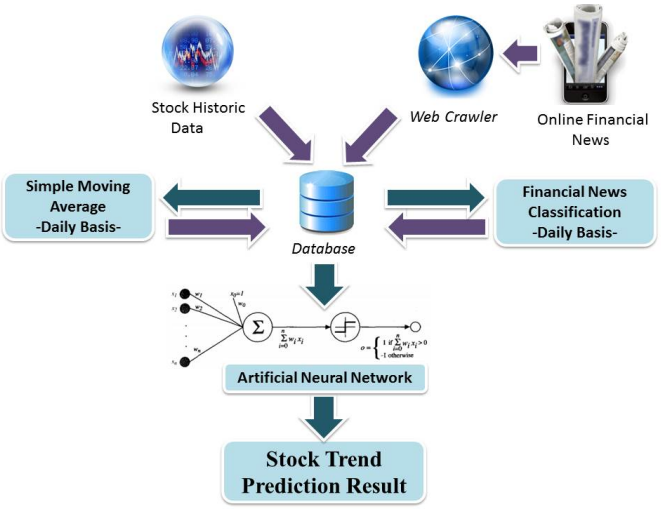

Figure 3. System Design

Jakarta Composite Index rose by 0.56% or 24.99 points to 4,477.49 in the today\'s closing session (1/22), while rupiah exchange rate fell by 0.07% to IDR12,143 per US$.

Figure 4. Financial News Example

B. *Building News Classifier*

As stated before, news classification can be built with three steps. Following are more explanation on those steps implementation:

1) *Building Data Set*

The data set consists of daily financial news crawled and scraped from web-based newspaper. There are 5304 news from May, 17th 2013 until May, 9th 2014. Normally, around ten to fifteen news are crawled on working days and zero to ten are crawled on Sunday. Fig. 4 shows an example of news that is included in data set.

2) *Feature Processing*

There are three phases needed to process the features for the first time. First, feature extraction phase uses single discrete words approach. This approach processes the text in news one word at a time and does not process the word's semantic. Second, feature selection, uses dictionary [9] approach to select and apply the label for the feature. Finally, the features are represented as word vector of positive words, negative words, and neutral words. For the next iteration, when another news is processed, features are retreived by using machine learning to improve them.

Table 1 shows an example of mapping words from news in Fig. 4 to sentiment value using the dictionary. For each word classified as positive word, the sentiment value is added by 1. On the example, 'rose' is a positive word because in financial term, 'rose' often marks the increase on stock trend. On the contrary, each negative word is valued -1 (closing and fell) and neutral words give 0 value. For the result, that piece of news has a total sentiment of -1.

3) *Machine Learning*

The features are utilized in machine leaning using artificial neural network algorithm. Using backpropagation topology, sigmoid activation function on all nodes except output nodes which uses linear activation function, this step gives output in the form of a model. This model can be used repeatedly to classify new financial news into sentiment value.

TABLE 1. EXAMPLE OF MAPPING WORDS TO SENTIMENT VALUE

	Word List	Sentiment Value
Positive	rose	1
Negative	closing, fell	-2
Neutral	all other words	0

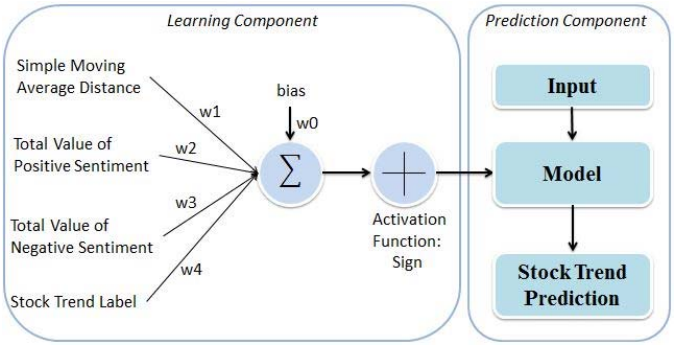

Figure 5. Artificial Neural Network for Predicting Stock Trend

C. *Predicting Stock Trend*

Machine learning using artificial neural network algorithm is used to predict stock trend. The artificial neural network uses three features along with one label. The three features are simple moving average distance which is a subtraction of long-term and short-term simple moving average, total value of positive sentiment value for one day news, and total value of negative sentiment value for one day news. Stock trend label is used and classified as uptrend and downtrend. Fig. 5 shows artificial neural network architecture for predicting stock trend supported by news classification. On one hand, learning component is done by background process. On the other hand, prediction component is foreground process which is seen and interact with the user.

IV. EXPERIMENTS

The experiments used one year's worth of both stock data and news. Three objectives of the experiments are:

1. Find the best parameters, which are the number of word vector, hidden layer type, and learning rate, for artificial neural network on news classification. The hidden layer types are 'a', 'o,o', 'i', and 't' with the detail for each type as follows:
    a. a: (attributes + classes) / 2
    b. o,o: dual layers of classes
    c. i: attributes
    d. t: attributes + classes
2. Find the best learning rate to predict stock trend and compare the result of stock trend prediction combining simple moving average and news classification with stock trend prediction using simple moving average only.
3. Find the best combination of short-term and long-term simple moving average that make prediction more responsive.

In the following, the results of each experiments are given with some analysis:

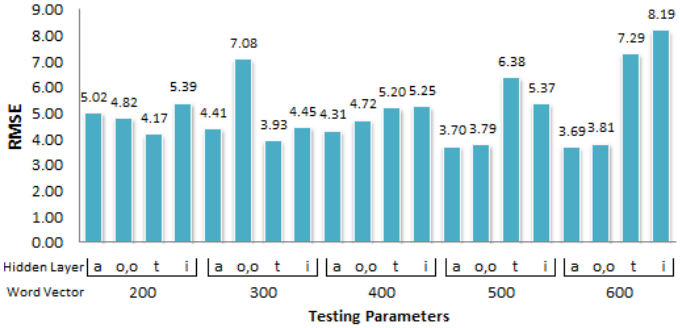

Figure 6. First Part Result

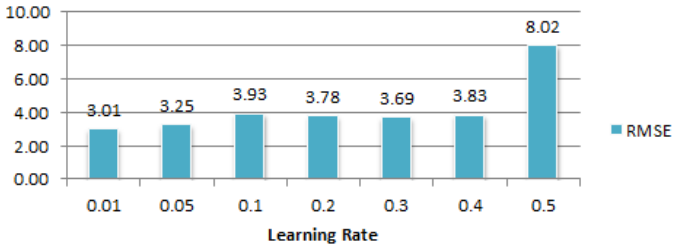

Figure 7. Second Part Result

A. *Parameters of News Classification*

The experiment was divided into two parts. The first part of this experiment tested the number of word vector and hidden layer type. Fig. 6 shows the result for the first part in the form of a table. The data set consists of 5304 daily financial news and data test consists of 1305 daily financial news taken from different period.

The lowest error (RMSE) was given by combination of hidden layer type 'a' and 600 word vectors. The next part of this experiment tested learning rate with the same data set and data test. The experiment used hidden layer type 'a' and 600 word vectors as that combination gave the best result on the first part of the experiment. Fig. 7 shows the result of the second part of the experiment.

The lowest error (RMSE) was given by learning rate 0.01. In conclusion, this experiment gives three best parameters resulting in lowest error and therefore the least overfitting parameters. The parameters are hidden layer type 'a', 600 word vectors, and learning rate 0.01.

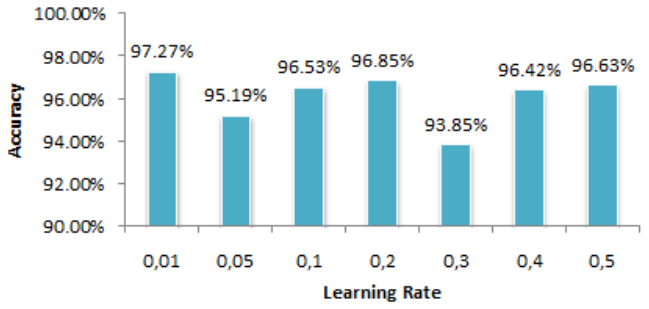

Figure 8. Learning Rate Testing Result on Stock Trend Prediction

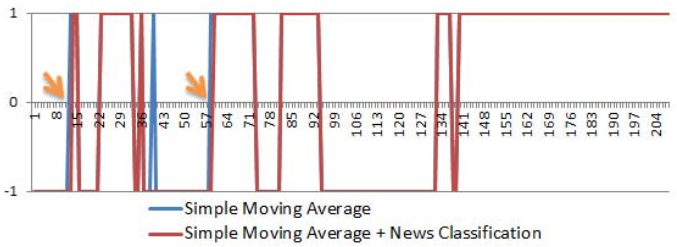

Figure 9. Comparison for Learning Rate 0.01

Figure 10. Comparison for Learning Rate 0.3

B. *Stock Trend Prediction*

The parameter that was tested in this experiment was learning rate. Fig. 8 shows the result for this experiment. The accuracy was calculated by using cross validation testing with k = 10. The highest accuracy was given by learning rate 0.01 and the lowest was given by learning rate 0.3. In order to analyze the result further, both learning rate were used to compare stock trend prediction supported with news classification result with simple moving average only. Fig. 9 and Fig. 10 show the comparison for each learning rate with 1 as uptrend and -1 as downtrend.

For learning rate 0.01, interesting responses are marked by orange arrows. On those cases, stock trend will change from downtrend to uptrend and use only simple moving average technique gives better respond. On both cases, stock trend prediction supported with news classification gives trend switch signal slower and it is a disadvantage for stock traders as they receive buy signal slower; resulting in higher stock price when they buy.

On the other hand, the comparison graph with learning rate 0.3 gives more interesting responses. The disadvantage on learning rate 0.01 becomes an advantage on learning rate 0.3. Stock trend prediction supported by news classification gives better response and faster buy signal to stock traders. On the contrary, there is still a disadvantage when the stock trend change from uptrend to downtrend that is marked by green arrows. On those cases, stock trend prediction supported by news classification gives slower response and therefore slower sell signal to stock trader. This results in smaller chance to get maximum gain.

The last response is marked by orange circles when there are highly dynamic changes on stock trend. In these cases, the algorithm predicts the stock trend to be constant whereas the fact was that it is fluctuating rapidly. Further analysis showed that in these cases, simple moving average distances as one of the three features have unexpectedly very small values. In conclusion, learning rate 0.3 is better than learning rate 0.01

although it has smaller accuracy. It gives more positive responses to stock traders to gain more benefit.

C. Simple Moving Average Combination

There are four combinations for this experiment. Here, short-term simple moving average is marked by 5 and 10 days duration and long-term simple moving average is marked by 20 and 50 days duration. The experiment used cross validation testing with k = 10. Fig. 11 to Fig. 14 show comparisons for each combination between stock trend prediction supported by news classification and prediction with simple moving average only.

Fig. 11 shows 5 and 20 days combination whose explanation is already given at section IV.B. For 10 and 20 days combination, the result shows that it is not responsive to the stock trend change and gives many slower responses. On 5 and 50 days combination, news classification has no effect on stock trend prediction. This can happen because of the simple moving average distance value is relatively big as duration of 5 and 50 days give minimum and maximum simple moving average value respectively.

The last combination, 10 and 50 days, gives constant stock trend prediction for a long duration and does not respond to the trend change well. In conclusion, 5 and 20 days combination gives the best response among the others. More positive responses are given from this combination and therefore gives higher chance for stock trader to gain profit.

Figure 11. 5 and 20 Days Combination

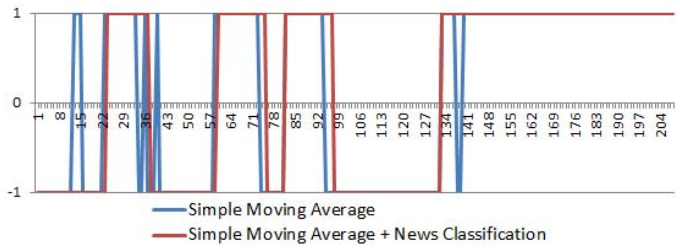

Figure 12. 10 and 20 Days Combination

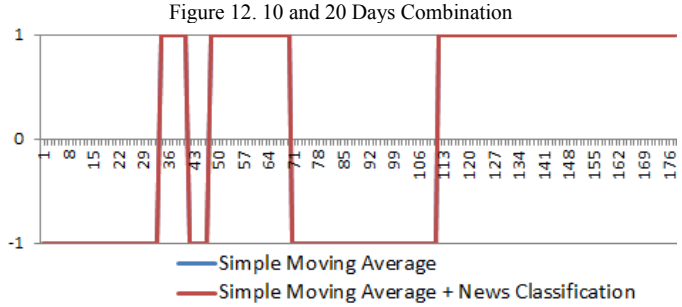

Figure 13. 5 and 50 Days Combination

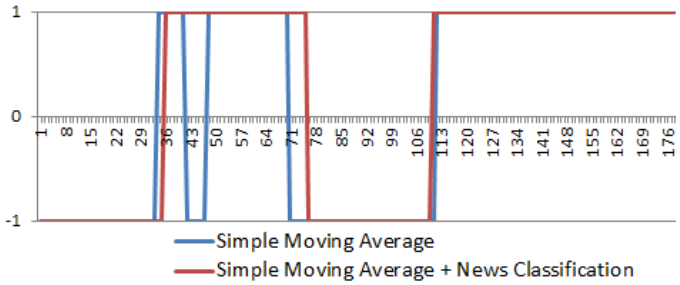

Figure 14. 10 and 50 Days Combination

V. CONCLUSIONS

In this paper, we want to verify financial news influence on stock trend prediction. To achieve that, simple moving average technique and news classification along with artificial neural network to combine the two are made and tested. Experimental results on one year's worth of JKSE stock data and financial news show that financial news can positively affect stock trend prediction. Artificial neural network does the combination of both components very well. However, only several parameters on stock trend prediction and simple moving average combination give the best result and thus improve stock trend prediction to be more responsive. Because of this, we can try other stock prediction techniques, news classification features, and simple moving average combination in the hope of better performance in predicting stock trend.

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