Forecasting Model Based on LSSVM and ABC for Natural Resource Commodity

Yuhanis Yusof, Siti Sakira Kamaruddin, Husniza Husni, Ku Ruhana Ku-Mahamud, and Zuriani Mustaffa

Abstract—**Reliable forecasts of the price of natural resource commodity is of interest for a wide range of applications. This includes generating macroeconomic projections and in assessing macroeconomic risks. Various approaches have been introduced in developing the required forecasting models. In this paper, a forecasting model based on an optimized Least Squares Support Vector Machine is proposed. The determination of hyper-parameters is performed using a nature inspired algorithm, Artificial Bee Colony. The proposed forecasting model is realized in gold price forecasting. The undertaken experiments showed that the prediction accuracy and Mean Absolute Percentage Error produced by the proposed model is better compared to the one produced using Least Squares Support Vector Machine as an individual.**

Index Terms—**Artificial bee colony, least squares support vector machine, swarm computing, forecasting, optimization.**

I. Introduction

The importance of price forecasting model for commodity, particularly for nonrenewable natural resource commodity, namely energy fuels and metals is undeniable. This situation has resulted to a large and growing body of literature. In price forecasting, numerous models have been presented, ranging from statistical to Computational Intelligence (CI) models. A major shortfall of statistical techniques [1]-[8] have led researchers to suggest Computer Intelligence (CI) based forecasting tool, which is Artificial Neural Networks (ANN) [9], to overcome the complexity in choosing an appropriate forecasting approach. Application of ANN in the area of finance range from financial crisis to commodity price [10]. In prediction of commodity prices, particularly in energy fuels [11] and metal prices [3], [12], the application of ANN proved its effectiveness against statistical methods. Nevertheless, existing work [11], [13] also suggest that ANN is weak in generalization. On the other hand, there are various successful work reported on Least Support Vector Machine (LSSVM) which is a variant of Support Vector Machine (SVM).

Support Vector Machines are particular classifiers that are based on the margin-maximization principle. They perform structural risk minimization, which was introduced to machine learning by Vapnik [14], and which have yielded excellent generalization performance. LSSVM reformulates the original SVM algorithm and is reported to consume less computational effort in a huge-scale problem compared to standard SVM's [15]. For LSSVM, the regularization and kernel(s) parameters are known as hyper-parameters. The hyper-parameter tuning is important to the performance of LSSVM. Hence, in this paper, the values of LSSVM hyper-parameters is optimized based on Artificial Bee Colony (ABC), which is a nature inspired algorithm. Existing research suggested that ABC possess the advantages on memory, local search and the ability of self-enhancement in finding solution. Hence it generates promising results in optimization problem.

This paper is organized as follows: Section II presents a review on LSSVM, ABC and also research undertaken in the area of time series forecasting. Section III includes on how the experiments was performed while the results is presented in Section IV. Finally, conclusion of the work is presented in section V.

II. Literature Review

A. Least Squares Support Vector Machine

Least squares support vector machine (LSSVM) is a variant of standard SVM. Least Squares Support Vector Machines (LSSVM) reformulates the original SVM algorithm. It has been proposed by Suykens and Vandewalle [15] for the purpose to solve short term load prediction problems. LSSVM is reported to consume less computational effort in the huge-scale problem compared to standard SVM's. As a modified version of a standard SVM, LSSVM applies equality constraint instead of inequality constraint that has been used in SVM to obtain a linear set of equations [16], which it simplify the complex calculation and easy to train [17]. In addition, in several real-cases demonstration, LSSVM has been reported to produce outstanding generalization performance with low cost in computational [18].

Usually, the training of the LSSVM model involves an optimal selection of regularization parameter γ and kernel parameter σ^2. Several kernel functions, viz. Gaussian Radial Basis Function (RBF) Kernel, linear Kernel and quadratic Kernel are available. In this paper, the employed RBF Kernel is expressed as:

$$K(x, x_i) = e^{-\frac{\|x-x_i\|^2}{2\sigma^2}} \tag{1}$$

where, σ^2 is a tuning parameter which associated with RBF function.

B. Artificial Bee Colony

Recently, another nature inspired algorithm, Artificial Bee Colony (ABC), has been proposed by Karaboga and it is

Manuscript received January 13, 2013; revised April 15, 2013. This work was supported by MOHE under Exploratory Research Grant.

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DOI: 10.7763/IJCTE.2013.V5.820

proven to be strong in global optimistic result [19]. It is a new meta-heuristic population-based optimization technique motivated by the intelligent foraging behavior of honey bee swarms. ABC posses the advantages on memory, local search and the ability of self-enhancement in finding solution [20] where it leads to yield outstanding results in solving optimization issues. The ease of use [21] and capability in avoiding local minimum reinforce the advantage of ABC algorithm [22], [23]. In addition, ABC also appear to be faster in searching optimal solution [22].

In ABC, the colony of artificial bees incorporated of three groups of bees: employed, onlooker and scout bees. Half of the colony is composed of employed bees and the rest are of the onlooker bees. The number of food sources/nectar sources is equal with the employed bees, which means that one employed bee is responsible for a single nectar source. The aim of the whole colony is to maximize the amount of nectar. The duty of employed bees is to search for food sources (solutions). Later, the amount of nectars (solutions' qualities/fitness value) is calculated. Then, the information obtained is shared with the onlooker bees which are waiting in the hive (dance area). The onlooker bees decide to exploit a nectar source depending on the information shared by the employed bees. The onlooker bees also determine the source to be abandoned and allocate its employed bee as scout bees. For the scout bees, their task is to find the new valuable food sources. They search the space near the hive randomly.

C. Time Series Forecasting

Research on energy fuels and metal's behavior, including the price, have long occupied the interests of academia and this have resulted in the large volume of published studies describing the importance role of these commodities to the world. A great deal of attention have been paid to their price volatility and can be seen in the emerging various prediction model [24], ranging from econometrics model to computational model. The emergences of various techniques underscore the significance of these commodities in human life. Nevertheless, there are yet to be reported on the work that explores nature inspired computing in predicting prices of such resources.

In the study that has been conducted by Malliaris and Malliaris [13], the asymmetric results produced in predicting the highly correlated data sets of metals indicated that the proposed prediction model is still dubious. This is due the incapability of ANN to outperform statistical method (i.e regression) in all price prediction process. From the final result of the study, even though ANN excel in predicting crude oil, heating oil and gasoline, nevertheless in predicting propane, the result is contrary.

Wang and Li [25] highlight the importance of primary energy consumption prediction by presenting a prediction model utilizing LSSVM. By using Cross Validation in determining optimal value of LSSVM hyper parameters, the proposed method achieved the predetermined condition where the accepted error range is within 5%. In addition, it concluded that LSSVM is capable in dealing with small samples data sets as compared to ANN which frequently need more data for training purposes [26].

Prediction utilizing LSSVM in nonlinear water quality time series data has been presented by Tan, Yan, Gao and Yang [27]. The purpose of the study is to predict the total phosphorus. The comparisons were made between two ANN based approach, namely the Backpropogation (BPNN) and Radial Basis Function (RBF) network. Parameters of LSSVM were empirically derived in obtaining the ideal value. Upon completing the simulation processes, LSSVM excel by producing lowest average relative value, which is 0.064% as compared to BPNN and RBF network which is 0.529% and 0.552% respectively. As now many researchers are enthusiastic in proposing various optimization techniques for LSSVM, man-made approach which was applied in the undertaken work may be beneficial.

III. Experiments

A. Data Preparation

In this study, gold price time series data were employed. The time series data covered is from January 31, 2012 to June 18, 2012 and is obtained from Barchart [28]. From the dataset, the first 70% is used for training while the balance of 30% is for testing. Data tabulated in Table I indicates the variables assigned to the features involved. The daily spot price (output) will help the model to fix current price while the derivation input is beneficial for the model in learning the underlying relationship that is constant over time [13].

TABLE I: Input and Output Variables

Input	Variable	Output
Gold daily closing price	GC	
Percent change in gold daily closing spot price from the previous day	%Chg	
Standard deviation over the previous 5 days of trading	Stdev5	Gold daily spot price from day 21 onwards (GC21)
Standard deviation over the previous 21 days of trading	Stdev21	

B. Data Normalization

Prior to training, all input and output were normalized using Min Max Normalization [29]. The objective is to independently normalize each feature component to the specified range. If the input values are in extremely at different ranges, the training of prediction model will become difficult. In addition, normalization technique may improve the prediction accuracy and data mining algorithm [29]

C. Evaluation Metrics

For the purpose of evaluating the proposed technique, two quantitative evaluation metrics are utilized, namely Mean Absolute Percentage Error (MAPE), and Prediction Accuracy (PA), which are defined as follows:

$$obj.Func = MAPE = \frac{1}{N}\left[\sum_{n=1}^{N}\left|\frac{y_n - p_n}{y_n}\right|\right] \quad (2)$$

$$PA = 100\% - (MAPE \times 100) \quad (3)$$

where $n = 1, 2, ..., x$; y_n = actual values; p_n = predicted values; N =Number of test data.

IV. Results

The empirical results of performance comparison between ABC-LSSVM and LSSVM on two metrics, namely MAPE and PA are reported in Table II. From the table, the best prediction performance of the ABC-LSSVM is obtained at γ= 462.6987 and σ2= 11.3653, with error rate of 4.5024%. With that, the prediction accuracy achieved was 95.497%, which is higher compared to the one obtained using LSSVM. The single LSSVM was able to produce 95.078% accuracy, which is 0.4188% differs from ABC-LSSVM.

TABLE II: Gold Price Prediction

	γ	σ^2	MAPE Training (%)	MAPE Testing (%)	PA (%)
ABC-LSSVM	462.698	1	0.786	4.502	95.497
LSSVM	1000	1	0.600	4.921	95.078

V. Conclusion

In this paper, we proposed an optimization of LSSVM, which is a variant of the popular SVM, using a nature-inspired algorithm. The ABC algorithm that mimics the behavior of honey bee is proved to be able to optimize the hyper-parameter values of LSSVM. Such an approach is applied on time series forecasting of gold prices. Comparing with a non-hybrid LSSVM, the ABC-LSSVM presented a higher accuracy. Hence, such an approach is believed to become an interesting competitor in the area of forecasting.

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