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Hybridization of evolutionary Levenberg–Marquardt neural networks and data pre-processing for stock market prediction

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ABSTRACT

Artificial Intelligence models (AI) which computerize human reasoning has found a challenging test bed for various paradigms in many areas including financial time series prediction. Extensive researches have resulted in numerous financial applications using AI models. Since stock investment is a major investment activity, Lack of accurate information and comprehensive knowledge would result in some certain loss of investment. Hence, stock market prediction has always been a subject of interest for most investors and professional analysts. Stock market prediction is a challenging problem because uncertainties are always involved in the market movements. This paper proposes a hybrid intelligent model for stock exchange index prediction. The proposed model is a combination of data preprocessing methods, genetic algorithms and Levenberg–Marquardt (LM) algorithm for learning feed forward neural networks. Actually it evolves neural network initial weights for tuning with LM algorithm by using genetic algorithm. We also use data pre-processing methods such as data transformation and input variables selection for improving the accuracy of the model. The capability of the proposed method is tested by applying it for predicting some stock exchange indices used in the literature. The results show that the proposed approach is able to cope with the fluctuations of stock market values and also yields good prediction accuracy. So it can be used to model complex relationships between inputs and outputs or to find data patterns while performing financial prediction.

1. Introduction and literature review

Prediction is the process of making projection about future performance based on existing historical data. Accurate prediction aids in decision-making and planning for the future. Prediction empowers people to modify current variables to make a prediction of the future to result in favorable scenario. Selection and implementation of a proper prediction methodology has always been an important planning and control issue for firms and agencies. Financial stability of an organization depends on the accuracy of the predictions been made, since such information will most likely be used to make key decisions in important areas such as human resources, purchasing, marketing, advertising and capital financing. The complexity of the prediction process used for predicting a variable depends on various factors. Most importantly, the historical pattern of variable changes and the underlying input factors which affect a variable may increase the complexity of the prediction process.

There are two hypotheses to be considered while predicting stock price. First one is, The Efficient Market Hypothesis (EMH) stating that at any time, the price of a stock fully captures all known information about the stock. Since all known information is used optimally by market participants, price variations are random, as new information occurs randomly. Thus, stock prices perform a "random walk", meaning that all future prices do not follow any trends or patterns and are random departure from the previous prices and it is not possible for an investor to predict the market. This hypothesis interprets fluctuations as the result of delayed or incomplete information that influence stock market prices. External phenomena affect subsequent stock market prices. Accurate predictions are difficult because it is not possible to model, quantify, or even know a priori such external phenomena [54].

There has been a lot of debate about the validity of the EMH and random walk (RW) theory. However, with the advent of computational and intelligent finance, and behavioral finance, economists have tried to establish another hypothesis which may be collectively called as the Inefficient Market Hypothesis (IMH). IMH states that financial markets are at least not always efficient, the market

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is not always in a RW, and inefficiencies exists [47]. Many of these studies used intelligent systems such as neural networks to justify their claims. The fact that many market participants can consistently beat the market is an indication that the EMH may not be true in practice [22].

Predicting a change in market prices and making correct decisions based on that, is one of the most important requirements for anyone who has something to do with economical environments. For many years, how to make a prediction of stock market has been a prevalent research topic. Financial gain might be considered as the most basic issue in stock market prediction. If a system is able to consistently pick winners and losers in the dynamic market place, then it will be able to provide the owner of the system with more wealth. Thus, many individuals including researchers, investment professionals, and average investors are continually looking for this superior system which will yield them high returns.

There are several different approaches to time series modeling. Traditional statistical models including moving average, exponential smoothing, and ARIMA are linear in that predictions of the future values. These models use piecewise linear function as basic element of prediction model [24,26,8,37,7,20,49,46].The functional form for the problem has to be specified by the user. It could take a lot of time to experiment with different possible function relations and algorithms to obtain proper models. Moreover, many researchers claim that the stock market is a chaos system. Chaos is a non-linear deterministic system which only appears random because of its irregular fluctuations. So in finance theory, non-linear models are very important. For example, almost all of real business cycle models are highly non-linear. Superiority of non-linear models in finance is not supposed to be conflicting with the use of linear models by a practitioner. Linear models can be considered as the reasonable approximations of the non-linear phenomenon of interest and non-linear models can be applied in prediction. It is not surprising that non-linear models, from regime-switching models to neural networks and genetic algorithms are receiving a great deal of attention in the literature [16,48].

The RW model says that not only all historical information are summarized in the current value but also those increments—positive or negative—that are uncorrelated and balanced with an expected value equal to zero. In other words, the positive fluctuations are as many as negatives in long term. The random nature of this model makes it difficult to perform accurate predictions. Hence, prediction of the stock market seems to be a daunting task. Mainly, since stock time series have a close to random-walk behavior due to the fact that stock markets have numerous underlying factors which most of them are currently not fully understood, therefore a non-linear model can be beneficent. A large set of interacting input series are often required to explain a specific stock. If we are able to predict stock market time series more accurately, we can allocate society resources to the right place so that national resources will not be wasted. The Intelligent Systems are capable of learning such non-linear chaotic systems because they make very few assumptions about the functional form of the underlying dynamic dependencies and their initial conditions. This may eventually put a question on the traditional financial theory of efficient market. Intelligent Systems are those which learn from their past experiences and use this knowledge in current and future decision making [22].

Artificial Intelligence (AI) is one of the intelligent systems that computerizes human reasoning has found a challenging test bed for various paradigms in many areas including financial time series prediction. Extensive research has resulted in numerous prediction applications using artificial neural networks (ANN), fuzzy logic and genetic algorithms (GA) and other techniques [12,39,58,44,56,32,33,53,34,25]. Most progress to date in AI has been made in the areas of problem solving; concepts and methods for building programs that reason about problems rather than calculate a solution.

A number of studies have compared the capability of AI techniques over conventional techniques such as ARIMA, Regression etc. in prediction problems, and they have found that AI-based systems result in more accurate outputs than conventional approaches such as ARIMA and Regression [30,31,28]).

Nowadays, increasing number of efforts have been focused on AI models for stock market prediction, while using AI models or a combining of several models has become a common practice to improve prediction accuracy. Hence, the literature on this topic has expanded dramatically [1].

Hadavandi et al. [30] presented an integrated approach based on genetic fuzzy systems (GFS) and artificial neural networks for constructing a stock price prediction expert system. They used stepwise regression analysis to determine factors which have most impact on stock prices, then divided the raw data into k clusters using self-organizing map (SOM) neural networks. Finally, all clusters fed into independent GFS models with the ability of rule base extraction and data base tuning. Results showed that their approach outperforms other methods such as ANN and ARIMA.

Chang and Liu [11] used a Takagi–Sugeno–Kang (TSK) type Fuzzy Rule Based System (FRBS) for stock price prediction. They used simulated annealing (SA) for training the best parameters of fuzzy systems. They found that the forecasted results from TSK fuzzy rulebased model were much better than those of back propagation network (BPNN) or multiple regressions.

Esfahanipour and Aghamiri [21] used Neuro-Fuzzy Inference System adopted on a TSK type Fuzzy Rule Based System for stock price prediction. The TSK fuzzy model applies the technical index as the input variables and uses Fuzzy C-Mean clustering for identifying number of rules. They tested the proposed model on Tehran Stock Exchange Indices (TEPIX) and Taiwan stock Exchange index (TSE) data (the same data set that used by Chang and Liu [11]. Results showed that the proposed model can effectively improve the prediction performance and outperforms other models.

Shen et al. [53] introduced the artificial fish swarm algorithm to optimize RBF. In this paper, to improve prediction efficiency, a K-means clustering algorithm is optimized by artificial fish swarm algorithm during the learning process of RBF. To confirm the usefulness of their algorithm, they compared the prediction results of RBF optimized by three methods: artificial fish swarm algorithm, genetic algorithms, and particle swarm optimization as well as prediction results of ARIMA, BP, and support vector machine. Results demonstrated that the proposed model performs better than other models.

De and Araújo [18] introduced a class of hybrid morphological perceptrons, called dilation–erosion perceptron to overcome the RW dilemma in the time series forecasting problem. A gradient steepest descent method was presented to design the proposed dilation–erosion perceptron, using the back propagation (BP) algorithm and a systematic approach to overcome the problem of non-differentiability of morphological operators.

Cho [15] used a new architecture for financial information systems. The developed prototype was entitled as the Multi-level and Interactive Stock Market Investment System. It is specially designed for investors to build their financial models to forecast stock price and index.

Chang Chien and Chen [14] focused on stock trading data with many numerical technical indicators, and the classification problem is finding sell and buy signals from the technical indicators. This study proposed a GA-based algorithm to build an associative classifier that can discover trading rules from these numerical indicators. The experiment results revealed that the proposed approach is an effective classification technique with high prediction accuracy. It is also is highly competitive when compared with the data distribution method.