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Minimal variability OWA operator combining ANFIS and fuzzy c-means for forecasting BSE index

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Abstract

Stock data sets usually consist of many varied components or multiple periods of stock prices, resulting in a tedious stock market prediction using such high dimensional data. To reduce data dimensions, it is crucial to fuse high dimensional data into a useful forecasting factor without losing information contained in the original variables. Decision makers may desire low variability associated with a chosen weighting vector, further complicating proper weight assignment for past stock prices. In this paper a new time series algorithm is proposed to overcome above mentioned shortcomings, which employs a minimal variation order weighted average (OWA) operator to aggregate values of high dimensional data into a single attribute. Based on the proposed model a hybrid network based fuzzy inference system combined with fuzzy c-means clustering is used to forecast Bombay Stock Exchange Index (BSE30).

Keywords: OWA; Forecasting; Fuzzy logic; Neural network

1. Introduction

The stock market in recent years has become an integral part of the global economy. Any fluctuation in the stock market influences our personal and corporate finances as well as the economic health of a country. The stock markets have always been one of the most popular investment destinations due to their high returns. However, there is always some inherent risk to invest in the stock market due to its unpredictable nature. An intelligent prediction model for stock market forecasting would be highly desirable and of wider investment interest. Tremendous research work has been published in recent times and continues to find an optimal prediction model for the stock market. Most of the forecasting research work has employed statistical time series analysis techniques, such as autoregressive (AR) model [9], the Autoregressive Moving Average Model (ARMA) [3], and the autoregressive integrated moving average Model (ARIMA) [7]. These linear models are not very adequate in stock market prediction. Later on non-linear techniques, such as Autoregressive Conditional Heteroskedasticity (ARCH) [16] and Generalized Autoregressive

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Conditional Heteroskedasticity (GARCH) [6] were proposed to surmount their shortcomings. Also Random walk (RW) has been widely used in financial literature, but there are still many controversies on RW [21,30,33].

In recent years artificial intelligence (AI) techniques such as artificial neural networks (ANNs), fuzzy logic, and genetic algorithms (GAs) became popular research topics, since they can deal with complex problems which are difficult to solve by classical methods [10]. These techniques have been successfully used to replace complex mathematical systems which are used to forecast stock markets [2,10,27,31,34,37].

Each of the AI-based techniques has advantages and disadvantages. One approach to deal with complex real-world problems is to integrate several AI technologies. Combining their strengths to generate hybrid models that provide better results than the ones achieved with the use of each of these isolated techniques. Using hybrid models or combining several models have become a common practice to improve forecasting accuracy [1,8,28]. Development in forecast modeling may promise attractive benefits to investors. Adaptive Neural Fuzzy Inference System (ANFIS) is one among several hybrid models for forecasting, risk and uncertainty in the financial environment. Jang [24] utters that ANFIS is a fuzzy inference system implemented in the framework of adaptive networks. ANFIS can be used with more than one variable and does not rely on assumptions. The rules mined from ANFIS are also easily understandable. ANFIS has been successfully used in fields as diverse as engineering, education, medicine and financial investment [31].

Rajasekarana et al. [32] used a sequential orthogonal approach to build and train a single hidden layer fuzzy neural network. Sequential learning artificial neural network model proposed by Zhang and Morris [39] tackles fuzzy inputs and crisp outputs. This model can tackle common problems such as the determination of network structure in numerous of hidden layers and the number of hidden neurons in each layer; encountered by conventional fuzzy back propagation neural networks. Chen and Chen [12] proposed a fuzzy time series model combining granular computing approach with binning-based partitioning and entropy-based discretization methods for the prediction of stock market prices.

To build a statistical model, ARMA [7], ARCH [16] and GARCH [6], some assumptions are necessary. In the stock market, the relationship between past and future data sets is not necessarily linear. So these statistical models are inefficient with either linear or non-linear relationships [26]. Secondly, past forecasting models cannot process data base with higher dimensions easily, because complexity will increase multi-fold with the growth of data dimensions. Moreover the rules laid out by the time series models using AI techniques, such as ANN and GA are quite complex to understand [20]. To overcome these disadvantages of existing models this study incorporates OWA and ANFIS technique. OWA is used to reduce computational complexity of high dimensional data and ANFIS with the fuzzy c-means clustering is used to produce understandable rules for investors. The proposed model is verified through an empirical analysis of the stock data sets, collected from Bombay stock market (BSE30) and the results are compared with some existing models in literature. Results have shown that proposed model gives relatively better forecast than comparable models.

The rest of the paper is summarized as follows: Section 2 provides basic terminology and tools. The proposed modeling concept is discussed in Section 3. Finally, experimental results are given in Section 4 followed by conclusion in Section 5.

2. Basic terminology and tools

2.1. Order weighted averaging

The OWA first introduced by Yagar [35], has gained much interest among researchers. In recent years, many related studies have been conducted. Fuller and Majlender [17] use Lagrange multipliers to solve constrained optimization problem and determine the optimal weighing vector. Fuller and Majlender [18], employ the Kuhn–Tucker second order sufficiency conditions to optimize and derive OWA weights.

2.1.1. Yagar's OWA

Yagar [35], proposes an OWA to get optimal weights of the attributes based on the rank of these weighting vectors after processing aggregation.

An OWA operator of dimension n is a mapping $f : R^n \rightarrow R$ that has an associated weighting vector $W = [w_1, w_2, \ldots, w_n]^T$ with the following properties: