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Multiobjective optimization based adaptive models with fuzzy decision making for stock market forecasting

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ABSTRACT

Stock market forecasting is an important and challenging task. Conventional single objective optimization based adaptive prediction models reported in the literature do not satisfy many cost functions simultaneously. Very few reported materials are available on the development of multiobjective optimization based stock market prediction models. In this paper multiobjective particle swarm optimization (MOPSO) and nondominated sorting genetic algorithm version-II (NSGA-II) have been introduced to effectively train the adaptive stock market prediction models which simultaneously optimize four performance measures. The model developed is an adaptive one with nonlinearity introduced at the input end by Legendre polynomial expansion scheme. The stepwise algorithms are provided to develop the model and simulation study is carried to evaluate the performance. To arrive at the best possible solutions from these models, fuzzy logic based decision making strategy is suggested. Close examination of simulation results reveals that in terms of directional accuracy (DA) and computation time MOPSO based model is better where as in terms of average relative variance (ARV) and I-metric the NSGA-II model is superior. However, with regard to mean average percentage of error (MAPE) and Theli's U, MOPSO is better above one month ahead prediction. But for below one month ahead prediction, the NSGA-II model is preferable. To facilitate comparison two single objective optimization based models (PSO and GA based) are also developed and the performance has been obtained through simulation study. Comparison of the results demonstrate that in terms of MAPE and DA the performance of multiobjective is better where as the single objective optimization model exhibit superior performance in terms of Theli's U and the ARV.

1. Introduction

The stock market being a random walk, time varying and complex process [1,2], is difficult to predict in real life situation. During the last decade, the trading decisions have been made [3] by employing various intelligent models. Many real world stock forecasting problems have to fulfil multiple, conflicting criteria or objectives, rather than a single objective. Therefore, there is a requirement to develop adaptive forecasting models satisfying multiple objectives simultaneously. In financial sector very few work has been reported in the literature which makes multiobjective formulation of financial optimization problems and solve those using multiobjective evolutionary tools. In the past, most multiobjective optimization problems have been formulated and solved as a single objective optimization techniques [4]. The conventional approach is to transform the multiobjective optimization problem to a single objective by taking the weighted sum of each objective and then optimize this objective by conventional evolutionary computing based optimization methods. The disadvantages in using this approach are fixing up appropriate weights of each objective through exhaustive search process and the possibility of missing some important solutions during the search process.

Due to various advantages of evolutionary algorithms (EA) [5–10], they have been successfully applied to many optimization problems associated with financial sector such as currency exchange rate, stock market forecasting and portfolio optimizations [11]. In recent past multiobjective evolutionary algorithms (MOEAs) such as the NSGA-II and Pareto archive evolution strategy (PAES) [12,13] have been used for optimizing four different objectives related to stock market forecasting. Hybrid models using of hidden Markov model, fuzzy logic and MOEA [14] have been suggested to predict nonlinear time series such as the stock data. The MOEA is used to find a range of trade-off solutions between the number of fuzzy rules and the prediction accuracy. A stock trading system using multiobjective PSO (MOPSO) has been reported in [15]. Using market data at the end of the day, the system updates the weights of several technical indicators by optimizing the percentage profit and the sharpe ratio.

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During the training phase the conventional forecasting models adaptively minimise a single objective cost function, the most conventional being the mean square error using a derivative based least mean square (LMS) [16] or recursive least square (RLS) [16] algorithm. Such algorithms do not have the potentiality to train a model which simultaneously satisfies many objectives. But in real life situation, a stock market forecasting model requires more than one objective to be simultaneously satisfied which are not met by conventional prediction methods explained before. This specific requirements can only be fulfilled by the evolutionary computing based weight updating scheme. Further, the evolutionary computing techniques can be applied in two ways. In the first approach the multiobjective optimization problem can be viewed as a single objective problem taking the weighted sum of many objectives and then minimising the resultant cost function by using the conventional genetic algorithm (GA), particle swarm optimization (PSO) or any one of the evolutionary computing family. Such a formulation, however, does not provide, all possible solutions and the process is tedious and time consuming. Further, the fixing up of appropriate weight for each objective is a difficult task. Hence the second approach based on multiobjective optimization is a promising as well as convenient alternative tool for developing efficient prediction models. Accordingly, in this paper a multiobjective optimization based forecasting model for stock market has been developed considering simultaneous optimization of four different objectives. For performing this task the popular nondominated sorting genetic algorithm-II (NSGA-II) and multiobjective particle swarm optimization (MOPSO) are chosen considering their potentiality and simplicity. The second issue which needs attention is the proper selection of model architecture. The forecasting of financial time series such as stock indices are related to its contributing factors in a nonlinear manner. Therefore, the adaptive nonlinear models such as multilayer artificial neural network [17], functional link single layer artificial neural network [18], neurofuzzy neural network [19] and radial basis function neural network [20] have been used. These structures contain both the linear and nonlinear elements and hence are more suitable for prediction of nonlinear time series. In the present case a single layer nonlinear adaptive model using Legendre polynomial expansion [21] in the front end is chosen to provide effective prediction performance. The use of such expansion scheme transforms the input features of the data into nonlinear manner and then the associated weights of the model are updated through multiobjective optimization strategy, such as NSGA-II as well as MOPSO.

The rest of the paper is organized into various sections as detailed in sequel. Section 1 deals with literature review, problem formulation and the motivation behind the problem under investigation. The Legendre polynomial based adaptive nonlinear (LPBAN) prediction model with conventional derivative based training scheme is dealt in Section 2. Different cost functions obtained from the prediction models need to be optimized simultaneously. These cost functions are defined in Section 3 Multiobjective optimization algorithms such as NSGA-II and MOPSO which have been used in the present investigation are outlined in this section. The development of forecasting model using the Legendre expansion and NSGA-II and MOPSO based training scheme and fuzzy decision making rule are dealt in Section 4. Simulation study of the proposed multiobjective optimization based models using three real life stock indices has been carried out and a comprehensive discussion on the results obtained from this study is presented in Section 5. To compare the prediction performance of the two proposed multiobjective based models (MOPSO and NSGA-II), corresponding two single objective prediction models are also developed and the performance has been evaluated under identical conditions. An in depth analysis of the results of four prediction models has been made and the findings have been listed in tabular forms in the simulation section of this paper. Finally, the conclusion of the paper is drawn in Section 6.

2. Legendre polynomial based adaptive nonlinear (LPBAN) forecasting model with derivative free training scheme

A detailed diagram of an adaptive hybrid model using Legendre polynomial expansion with MOEA based training scheme is shown in Fig. 1. From the known stock data, few key factors which comprises of both statistical and technical features are extracted for each day and are used as inputs to the forecasting model. Let N

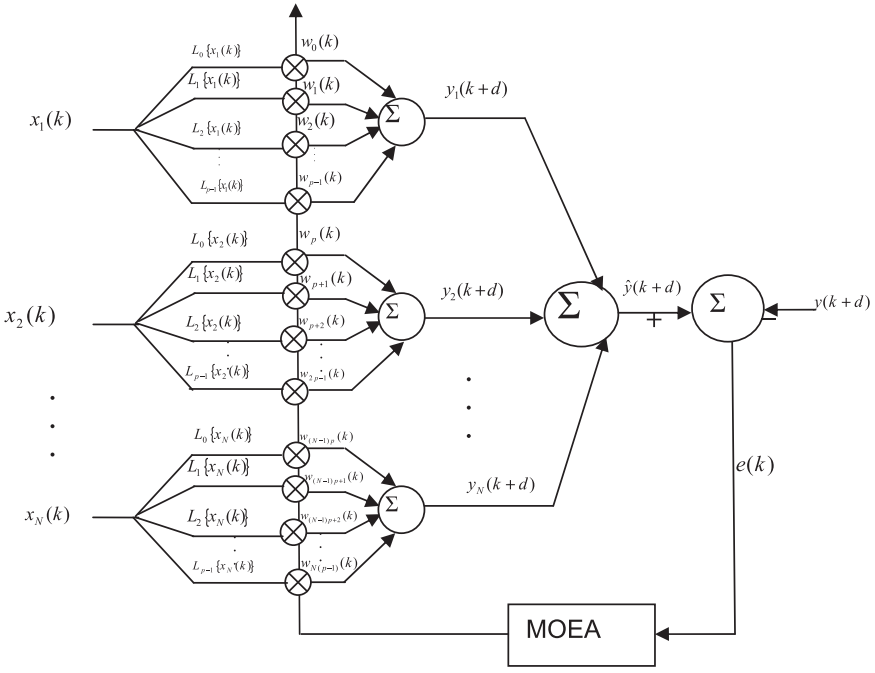

Fig. 1. Stock indices forecasting using Legendre polynomial and MOEA based adaptive hybrid model.