Journal of Computer and System Sciences 81 (2015) 966–980

Contents lists available at ScienceDirect

Journal of Computer and System Sciences

www.elsevier.com/locate/jcss

Dynamic grey platform for efficient forecasting management

Chen-Fang Tsai

Department of Industrial Management and Enterprise Information, Aletheia University, Taiwan, ROC

ARTICLE INFO

Article history:
Received 8 May 2014
Received in revised form 26 August 2014
Accepted 5 September 2014
Available online 18 December 2014

Keywords:
Forecasting model
Genetic algorithms
Grey theory

ABSTRACT

In this paper, we propose a dynamic grey platform to modify the traditional algorithms by applying two new prediction algorithms for forecasting management. The proposed platform integrates a grey model (GM) with an exponentially weighted moving average EWMA controller known as the EGM model. The EGM model attempts to improve the forecast accuracy and efficiency. The prediction error of the EGM model is minimized by applying a dynamic genetic algorithm (DGA). The contributions of the DGA are essentially from its two features: (1) the crossover and mutation rate controller of GA parameter optimization; and (2) the variable controller of EGM background value optimization. Six benchmarking data sets have been used in simulation to evaluate the effectiveness of our proposed model. The experimental results reveal that the better prediction accuracy reduces the cost of Taiwan's green gross domestic product (GDP).

1. Introduction

In uncertain environments, the suppliers need to provide a variety of short life-cycle products for uncertain market demands. Deng [1] noted that the characteristic of insufficient data has made accurate forecasting very difficult in such environments. Traditional forecasting techniques have been implemented by employing traditional prediction methods, such as: the Markov-chain method [2], linear regression model [3], exponential smoothing [4], and time series [5]. However, these algorithms have limitations as they require a large volume of sample data while sufficient availability of historical data is not always guaranteed. Many scholars have adopted the grey theory for analysis and decision making in situations where enough data is not available to be effectively used by traditional prediction approaches. The GM$(1,1)$ model of grey theory is commonly used for forecasting in several application fields such as pollution and energy [6], social management [7], industrial engineering [8], financial management [9,10] and logistic transportation [11].

Recently many scholars have attempted to propose new methods, for improving the accuracy of GM forecasts. The Markov chain dynamic system has been combined with the grey model to forecast the development of the system according to transition probabilities between states [2,4,12–14]. The Grey-Markov forecasting model not only provides simplicity of application but also a higher prediction accuracy than the traditional grey forecasting model. The artificial neural network (ANN) has been integrated the original GM$(1,1)$ model to improve the prediction accuracy of the original grey model [6,11,14,15]. A large volume of work has shown that fuzzy regression and fuzzy time series are powerful forecasting tools under limited information. Fuzzy tools have also been adopted in the grey forecasting model to deal with limited availability of the sample data [16–20]. Moreover, Hsu and Chen [6] applied a residual modification model which was first introduced by Deng [21] to improve the prediction accuracy of the original GM$(1,1)$ model. Lin et al. [22] modified the original GM$(1,1)$ model to improve prediction accuracy in green accounting in Taiwan.

E-mail address: au1204@mail.au.edu.tw.

http://dx.doi.org/10.1016/j.jcss.2014.12.011
0022-0000/

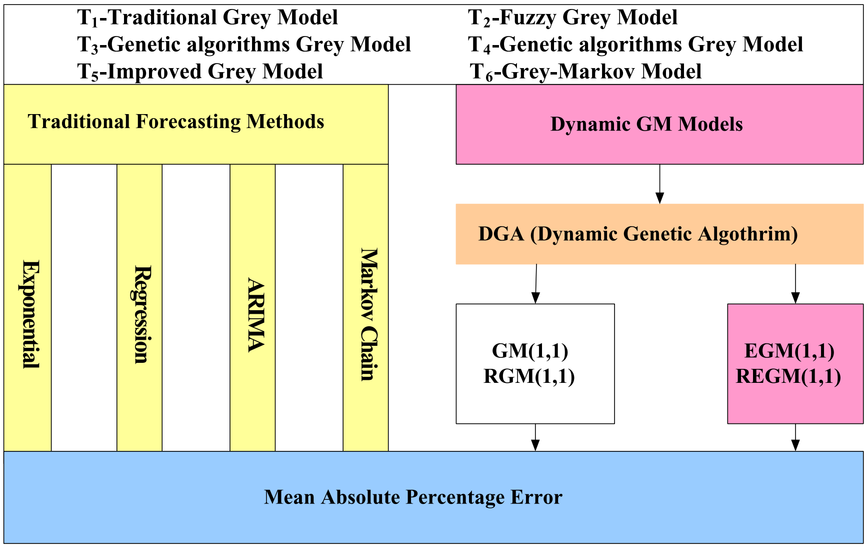

Fig. 1. Traditional forecasting and dynamic GM models architecture.

Grey theory adopts an accumulation technique, called the accumulated generating operation (AGO) to obtain systematic regularity and effectively reduces noise in discrete time series data. Hung et al. [23] pointed out that differences in the generating coefficient of background value in the GM(1, 1) model will affect in the error levels of forecast precision. Adaptive modification in generating coefficient value improves prediction accuracy of the GM(1, 1) model. In recent years, many researchers utilized the genetic algorithm (GA) to seek a generation of optimal coefficient value to improve the grey forecasting model [23–25]. Following this strand of research we modify the accumulation technique using the exponentially weighted moving average (EWMA) method. Optimal generating coefficient value has been achieved by applying GA procedures. A forecasting model known as EGM(1, 1) combined with residual modification known as REGM(1, 1) has been proposed in this study to improve the forecast precision.

To assess the effectiveness of the EGM(1, 1) and REGM(1, 1) models, we select the previous 6 research case studies [6,13,18,24–26] for evaluation and verification purposes. These proposed models have shown significant improvement in the predicting precisions of GM(1, 1) models with limited data. The novel EGM(1, 1) models have been found feasible and effective in improving performance efficiencies of the traditional GM(1, 1). The paper is organized as follows. Section 2 provides the design and architecture of GM(1, 1) models. Section 3 proposes the GA search methodology. Section 4 presents methodologies and the experimental results of theoretic and empirical test-beds. Finally we draw some general conclusions in Section 5.

2. Architecture and design of GM models

Traditional prediction methods such as: time series [5], linear regression model [3], exponential smoothing [4] and Markov method [2] have been widely applied to various applications in industrial and commercial domains. Nevertheless, these forecast models have limitations as they need sufficient samples for effective prediction and gathering data is not always easy in various industrial environments. It is a challenging task in short life-cycle consumption products to collect enough data to satisfy data demand of the traditional prediction methods. The research often encounters unclear situations with incomplete information and data for their prediction studies.

In cases where there is less data available for analysis and decision-making, the GM(1, 1) model of grey theory is commonly used for forecasting. Deng [1] established the residual modification the GM(1, 1) model, known as the RGM(1, 1) model and proved that it enhances the accuracy of GM(1, 1) effectively. We propose a new forecasting model (Exponentially Weighted Moving Average grey forecasting) known as EGM(1, 1) model. To improve the EGM(1, 1) model we use the residual errors of EGM(1, 1) which is known as the REGM(1, 1) model.

Fig. 1 illustrates the technical platform architecture of traditional prediction models and dynamic GM models. It integrates artificial intelligence controller and EWMA technique to reduce the forecasting error of GM(1, 1) models. The theoretical experiments chosen to be most appropriate for this study are described in different research efforts [6,13,18,24–26]. Six benchmarking data provided by the previous works have been adopted to verify the effectiveness of our proposed EGM(1, 1) and REGM(1, 1) models. On the other hand practical experiments have been conducted to illustrate comparison of the prediction accuracy of GM(1, 1), RGM(1, 1), EGM(1, 1) and REGM(1, 1) models.

Our experimental test-beds use the benchmarking data (T_1–T_6) (see Table 3) shown below to verify effectiveness of the novel EGM(1, 1) and REGM(1, 1) models.