Chaos, Solitons and Fractals 89 (2016) 518–526

Contents lists available at ScienceDirect

Chaos, Solitons and Fractals

Nonlinear Science, and Nonequilibrium and Complex Phenomena

journal homepage: www.elsevier.com/locate/chaos

A forecasting method for Chinese civil planes attendance rate based on vague sets

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ARTICLE INFO

Article history:
Received 30 January 2016
Revised 25 February 2016
Accepted 25 February 2016
Available online 30 March 2016

2010 MSC:
00-01
99-00

Keywords:
Civil planes attendance
Forecasting method
Vagye set

ABSTRACT

This paper investigates the feasibility and efficiency of Vague sets to forecast the attendance rate in civil airplanes. Firstly, an overview of the methods of using fuzzy theory for forecasting is made and some problems are pointed out; the concepts of vague sets is then reviewed; and then an improved vague forecasting method is presented to overcome the shortcoming of the previous studies; finally, an comparison between different methods is raised to verify its effectiveness.

1. Introduction

Time series is derived from the random processes theory called dynamic sequence, in accordance with a set of numerical sequence or dynamic series arranged in the time order, which will be a series of quantity changes of a certain phenomenon developed in time. Forecast refers to know the process and the results of things developed in accordance with certain methods and rules on the foundation of mastering some information. Time series forecasting is predicting (estimating) the value of its future or change trend based on the current and past observations of time series to acquire the later developments of things. The research about time series could be traced to AR model proposed by Yule in 1927 [1] and the analysis of time series has laid a solid foundation in the next 80 years. The traditional time series forecasting methods includes exponential smoothing, seasonal model and autoregressive and moving model. In the 1960s,exponential smoothing was appeared when Brown [2], Holt [3] and Winters [4] did some study about this. The classification method of additive model (linear) or multiplicative model (non-linear) which Pegels [5] put forward, the Muth's [6] demonstration that the way could be used to predict, that Box and Jenkins [7], Roberts [8], Abraham and Ledolter [9] et al., applied exponential smoothing into the framework of statistics are the history of exponential smoothing's developments. According to the previous research, Gardner [10] extended the definition of Pegels's classification and proposed the concept named damping trend; Snyder [11] proved that exponential smoothing was originated from a state space model of innovation. In 2003, Taylor et al. summarized the work of exponential smoothing and there were 15 different models, the most widely used ways were the simple exponential smoothing (no trend, no seasonal type), Holt's linear approach(increasing tendency, no seasonal type), Holt-Winters's increasing model (increasing tendency, increasing seasonal type) and multiplicative model (increasing tendency, multiplicative seasonal type). For seasonal model, people carried out vast re-

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http://dx.doi.org/10.1016/j.chaos.2016.02.037
0960-0779/

search around X-11 and X-12 [12,13], on which the follow-up study was based. In view of Yule's viewpoint that every time series could be seen as the realization of a random process, other scholars came up with many time series models. Slutsky, Walker, Yagolm and Yule [14] were the earliest who formulated the concept of autoregressive (AR) and moving model (MA). Box and Jenkins [1] integrated the results of previous studies, and presented a coherent, common three-step cycle time series forecasting methods including model identification, parameter estimation and model checking, which was important for modern time series analysis and forecast and promoted the widely use and development of ARIMA model. With the increasing complex issue to be solved, traditional time series forecasting models could not deal with fuzzy questions, and required more complete historical data, which in the real life was very harsh condition, so the traditional time series forecasting models didn't meet practical needs [15].

Fuzzy time series. To solve the question above, American Control Professor Zadeh [16] in 1965 proposed the fuzzy theory and the concept about fuzzy logic, and firstly established the model that could deal with uncertain and fuzzy language variables. Later in 1993, vague sets is raised by Gau and Buehrer [17] which can describe the rate for favor, against and abstentions in the vote model at the meantime and obviously provides more information for decision. Fuzzy forecasting is a way to predict and evaluate that bases on fuzzy mathematics, whose feature is similar to our normal thinking pattern and is suited to solve practical problems, that have vague and non-quantitative definition. Fuzzy forecasting [18] needs to establish the evaluation factors, weight sets about each factor, the evaluation consisting of a variety of evaluation results, and uses synthetic operators to do a comprehensive operation. Fuzzy evaluation generally includes selecting the index system, determining the standard value and the target set, standardization of raw data, the weight distribution of each factor, selection of composite operator, calculation of indicators values and degree of membership etc. In 1993, Song and Chissom [19] applied fuzzy sets to time series, then they found that it worked better in predicting practical things than traditional time series and after solving the students enrollment at the university of Alabama between 1971 and 1992, they formally put forward vague time series model. After that, weighted average forecast [20], multi-attribute FTS of a second order [21], K-means based FTS [22] and other methods are presented to improve the FTS model and later, Li [23] proposes a vague forecasting method based on the previous FTS. By now, the FTS has been successfully applied to many fields such as enrollments forecasting, temperature prediction [24], stock index forecasting [25] and so forth. Fuzzy interval is the foundation of fuzzy time series model which has great effects on the calculation process and the forecasting accuracy, so it's the emphasis of model theoretical research. When using fuzzy time series forecasting model, we need to pay attention to their own characteristics, select the appropriate method to determine the fuzzy interval so that the best application results are obtained. Different fuzzy time series models need to set up different fuzzy relation matrix and distinguishing forecasting rules. Then, Song and Chissom put forward fuzzy time series based on time varying to predict dynamic things. Hwang [26] et al. constructed time varying fuzzy time series forecasting. Sullivan [27] describes comprehensively first-order time varying model and first-order time-invariant model, and compared these models with first-order Markov model based on linguistic scale. The development of fuzzy time series was from low-level to high-level, to settle the shortcoming of low-level. Lee [28] et al. constructed high-level two-factor fuzzy logic relation to improve forecast accuracy, and applied to practical prediction problems. Sah [29] proposed a new way of time-invariant to deal with forecasting which changed available historical data to the input of fuzzy time series. In fact, later research about fuzzy time series is the improvement of the model proposed by Song et al. Furthermore, vague sets theory has been utilized in many applications, such as satisfaction-based web service discovery and selection [30], approximation set in rough approximation space [31], risk analysis of compressor system [32,33], and Uncertain Query Processing [34,35].

But in previous studies, there are some points that have been neglected.

Firstly, when dealing with the upper limit and the lower limit of prediction bound, they inclined to set them artificially according to the historical data which will result in the limitation of the value predicted in the future and some smaller or bigger value cannot even appear in the model which does not consist with the fact.

Secondly, the predication subintervals are equally divided in previous studies which will lead to the densely distributed values and thus the fuzzy transfer membership is relatively simple which is not appropriate for the prediction.

Thirdly, some characteristics of the data are not taken into consideration such as periodicity which may make negative impact on the forecasting accuracy.

Fourthly, it's impertinent for them to deal with date used to verify model validity: in the past ways, what they adopted to validate the data model was the data in transferring relation, which led that the distribution of forecast data could only change back and forth between several values after determining the transferring relationship. This meant transferring relationship was static not dynamic, which could be found in other paper.

In this paper, we try to get the natural limitations of the predicted indexes as the upper and lower limitations of the prediction bound and divide the subintervals nonequally by referring to the evaluation scale raised by Dai. et al. [36]. And then, the characteristics of the index including trend and periodicity are identified and a comprehensive method is raised to forecast the index. Particularly, main innovations of this paper lie in that where we introduce an improved vague forecasting method to solve the issue of Chinese civil planes attendance rate prediction.

2. Vague sets and vague time series

2.1. Basic definitions

Definition 1. Roughly, we have some basic definition of the vague sets [17]. Vague set is a set of objects, each of