

# Chapter 78

## An Efficient Time Series Forecasting Method Exploiting Fuzziness and Turbulences in Data

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### ABSTRACT

*In recent years, there has been a growing interest in Time Series forecasting. A number of time series forecasting methods have been proposed by various researchers. However, a common trend found in these methods is that they all underperform on a data set that exhibit uneven ups and downs (turbulences). In this paper, a new method based on fuzzy time-series (henceforth FTS) to forecast on the fundament of turbulences in the data set is proposed. The results show that the turbulence based fuzzy time series forecasting is effective, especially, when the available data indicate a high degree of instability. A few benchmark FTS methods are identified from the literature, their limitations and gaps are discussed and it is observed that the proposed method successfully overcome their deficiencies to produce better results. In order to validate the proposed model, a performance comparison with various conventional time series models is also presented.*

### 1. INTRODUCTION

The aim of forecasting is to predict a future value of a variable such as amount of rainfall, temperature, demand for a product, air quality index, interest rate, etc. (Jain & Kumar, 2015). Forecasts drive a wide variety of business decisions, from sentiment analysis to long term forecasting (Jain & Kumar, 2016). The objective of forecasting is to determine what forecasting technique is the most suitable for what is

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being forecasted, and to maintain a strict regulation of reviewing forecasts (Jain & Kumar, 2017). Various models are being used for time series forecasting like moving averages, integrated moving averages, regression analysis, autoregressive moving averages (Singh, 2008), but not all methods produce acceptable results, especially, when the data under consideration show significant turbulences. Turbulence, in this context, refers to sudden rises and dips in the time series data under consideration, for example, data set comprises of students' enrollment in a university tends to be much less turbulent than a data set consists of stock exchange indices. To demonstrate the effectiveness of the proposed method, sales data of Tata Nano car in India from Jul-09 to Jan-12 are used. Pandey et al. (2013b) stated that various political, socio-political, technical, and promotional series of events might be the reason behind a turbulent sales pattern of the Tata Nano.

Zadeh (1965) introduced fuzzy set theory and fuzzy logic that offers a systematic method for handling ambiguities and uncertainties in data in linguistic terms. Fuzzy set theory is being used extensively in every area of engineering and sciences to tackle the problems caused by ambiguities in data. Time series forecasting is no exception; when fuzziness is incorporated in time series data to determine appropriate forecasts, it is called Fuzzy Time Series (FTS) forecasting.

The first recognized work in the area of FTS is attributed to Song and Chissom (1993, 1994) who developed FTS model to forecast the enrollment of the University of Alabama. Later, Chen (1996) contributed to the field of FTS forecasting by improving the work of Song and Chissom (1993, 1994), where simple arithmetic operations were used in place of complex max-min operations discussed in Song and Chissom (1993, 1994). Huarng (2001a) considered heuristic functions as a supplement to the knowledge base in FTS forecasting. Huarng (2001b) presented an approach based on interval length selection and assumed interval selection as a considerable parameter in FTS forecasting. Chen (2002) considered forecasting with high-order fuzzy time series models as a solution to non-deterministic states that arise during FTS forecasting. Other contributions to FTS forecasting are made by Singh (2007a), Singh (2007b) and Singh (2008) where a variety of time-variant difference parameters are used over the current state to forecast the next state. A number of modern researchers used advanced optimization techniques in fuzzy time series forecasting like the use of particle swarm optimization to get the optimal intervals in the universe of discourse (Chen & Kao, 2013) and membership values in the fuzzy relationships (Aladag et al., 2012).

In Table 1, we present a chronological survey of different FTS methods introduced over time with their authors, data set, method used and major focus. This survey is inherited and adapted from Pandey et al. (2013b).

The versatility of the FTS approach has always been a matter of concern as the data set used in most of the previous research works has been the enrolment data of the University of Alabama (see Table 1). Pandey et al. (2013a, 2013b) tried to subside this contention by applying and comparing the performances of benchmark FTS methods over data from agriculture and automobile sectors. Pandey et al. (2013b) also tried to establish FTS forecasting as an alternative to predict the diffusion of an innovation.

The proposed method overcomes the deficiencies and limitations identified in a few benchmark methods, pointed out in Pandey et al. (2013a, 2013b), viz. Chen (1996), Chen (2002), Huarng (2001a) and Singh (2007b, 2008).

The proposed method is computationally efficient in a way that it utilizes, simple first order fuzzy time series relations, but it considers previous  $n$  years' turbulence for computations; therefore, the behaviour of the proposed method is at par with higher order fuzzy time series models without the need to work on complex higher order relations. Another advantage offered by the proposed method over higher order

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