A Self-Organized Neuro-Fuzzy System for Air Cargo and Airline Passenger Dynamics Modeling and Forecasting

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ABSTRACT

A self-organized, five-layer neuro-fuzzy model is developed to model the dynamics and to forecast air cargo and airline passenger by using the input of previous years' consumer price index, exchange rate, gross national product, and number of cargo volume/passenger traffic. Simulation results show that the neuro-fuzzy model is more effective than neural network in prediction and accurate in forecasting. The effectiveness in modeling, prediction and forecasting is validated, and the input error from the series-parallel identification method is attenuated by the neuro-fuzzy model to yield better forecasting results.

Keywords: Air Cargo, Airline Passenger, Forecasting, Neural Network, Neuro-fuzzy System

INTRODUCTION

Knowing air cargo and airline passenger demands are important in planning and operation of airline industry. The arrangement of an air route, the purchasing of planes, the assignment of flight crew, the dispatch of flights, and the operation of revenue management all require reliable information to support right decisions. Pitfield et al. (2010) presented the airline strategies for aircraft size and airline frequency with changing demand and competition by a simultaneous-equations approach. Pai (2010) assessed the determinants of aircraft size and frequency of flights on airline routes by market demographics, airport characteristics, airline characteristics and route characteristics. Wei and Hansen (2006) proposed an aggregate demand model for air passenger traffic by airline service variables such as service frequency, aircraft size, ticket price, flight distance, and number of spokes in the network.

Many recent works have recognized the necessity of accurate forecasts for air cargo or airline passenger demand. State forecasting of a dynamical system requires the current and previous condition to forecast the system’s future states. Forecasting entails gathering historical data, analyzing patterns, and acquiring results that facilitate the prediction of future events. It is believed that past information can be modeled...
into a system that explains the current behavior. Classical approaches are mainly based on stochastic models, using time series analysis techniques such as autoregressive moving average (ARMA) and multiple regression models; however, the accuracy of state forecasting may be vulnerable to qualitative factors from macroeconomic and political effects.

Many have focused on applying recurrent or feedforward neural network (NN) to state forecasting. NN is effective in realizing the input-output mapping and is useful as a state forecaster, but its performance is constrained by large amount of training required and by the “black box” nature opaque to the dataset. Rob and Norman (1999) developed a neural network model to forecast Japanese demand traveling to Hong Kong. Lim and McAleer (2002) proposed an integration analysis of annual tourism demand by Malaysia for Australia. Vincent (2003) also compared three different approaches: exponential smoothing, autoregressive integrated moving average and artificial neural networks to tourist arrival forecasting. Recently, there have been significant developments in neuro-fuzzy, fuzzy-neural and neural-fuzzy model integrating the advantages of neural network and fuzzy system (Chen, 2008, 2009, 2011; Chen & Lin, 2008; Hsiao et al., 2008; Chen, Wang, & Tsai, 2009; Chen, Wang, & Wu, 2009; Chen, Wu, & Wang, 2009; Chen & Wang, 2010). The neural network has the learning ability of mimicking biological neural network to deal with complex problems, while the fuzzy logic is to tune the membership functions of knowledge-based system operating in linguistic, rule-based structure. It is known that a neuro-fuzzy model is effective to system modeling and control in engineering. Yang et al. (2007) and Chen et al. (2009a, 2009b) proposed a self-organized neuro-fuzzy model for system identification, in which the five-layer network adaptively adjusts the membership functions and dynamically optimizes the fuzzy rules. Recent interests have also been in applying neuro-fuzzy model to system dynamics modeling and forecasting. Paz and Peeta (2009) proposed a fuzzy control to estimate driver response behavior in transportation system. Ang and Quek (2006) suggested a neuro-fuzzy approach in stock trading. Keles et al. (2008) presented a neuro-fuzzy model for predicting domestic debt. Lin et al. (2008) also proposed an early warning system for currency crisis by neuro-fuzzy model. Atsalakis and Valavanis (2009) applied a neuro-fuzzy inference system to forecast stock market short-term trends. All of the above works were limited to training and validation of their models, yet there is no forecasting at all. Tobias et al. (2007) proposed a gravity model including general economic activity and geographical characteristics for airline passenger volume estimation, but it is limited to city-pair model. In this paper, a self-organized neuro-fuzzy model is applied to system modeling and forecasting of air cargo and airline passenger in Taoyuan and Kaohsiung International Airport.

The rest of this paper is organized as follows. The structure of neuro-fuzzy system and the learning algorithm are introduced. A practical example is used to demonstrate the application of the neuro-fuzzy system. The performance of the neuro-fuzzy model is evaluated and compared with a neural network approach. Based on the analysis results, some points are made. Finally, the indications of summary and conclusion about the results of simulation and analysis are given.

**NEURO-FUZZY MODEL**

Artificial neural networks inspired by biological neural networks can learn complex functional relations by generalizing from a limited training data. Neural networks can thus serve as a black-box for nonlinear dynamic systems by using input/output training data. Two of most commonly used fuzzy inference systems are Mamdani fuzzy model and Sugeno fuzzy model (Chen et al., 2009b). The former describes a system by using the natural language that makes it more intuitive and easy to realize, while the latter specifies a system by mathematical relation that makes it suitable to opti-
Routing in Opportunistic Networks
Hoang Anh Nguyen and Silvia Giordano (2011). *Ubiquitous Developments in Ambient Computing and Intelligence: Human-Centered Applications* (pp. 179-193).
www.igi-global.com/chapter/routing-opportunistic-networks/53338?camid=4v1a