Chapter VIII
Artificial Higher Order Pipeline Recurrent Neural Networks for Financial Time Series Prediction

Panos Liatsis
City University, London, UK

Abir Hussain
John Moores University, UK

Efstathios Milonidis
City University, London, UK

ABSTRACT

The research described in this chapter is concerned with the development of a novel artificial higher order neural networks architecture called the second-order pipeline recurrent neural network. The proposed artificial neural network consists of a linear and a nonlinear section, extracting relevant features from the input signal. The structuring unit of the proposed neural network is the second-order recurrent neural network. The architecture consists of a series of second-order recurrent neural networks, which are concatenated with each other. Simulation results in one-step ahead predictions of the foreign currency exchange rates demonstrate the superior performance of the proposed pipeline architecture as compared to other feed-forward and recurrent structures.

INTRODUCTION

The problem of predicting financial time-series data is an issue of a much interest to both economic and academic communities. Decisions regarding investments and trading by large companies and the economic policy of governments rely on computer modelling forecasts. The foreign currency exchange rates (or FX rates as they are more commonly known) are very important in this respect, with FX market worth an estimated daily trading volume of 1 trillion US Dollars (Huang et al., 2004).

Most financial data is non-stationary by default, this means that the statistical properties of the data change over time. These changes are caused as a result of various business and economic cycles (e.g. demand for air travel is higher in the summer months, this can have a knock-on effect of exchange rates, fuel prices, etc) (Magdon-Ismail et al., 1998). While this information should be taken into account in the current closing price of a stock, share or exchange rate it still means that long term study of the behaviour of a given variable is not always the best indicator of its future behaviour. An example of how this problem manifests itself is in the volatility (standard deviation) of stocks and shares. The probabilistic distribution of financial data can change greatly over time; during a period of time, it appears calm with only small changes, and during another period of time, it shows large changes (both positive and negative). It is for this reason that the volatility itself often becomes the central focus of financial time series prediction by the economic forecasting community, where it is assumed that a stable stock or exchange rate is a safer investment (Pham, 1995).

The Efficient Market Hypothesis states that a stock price at a given time reflects all the information available such as news events, other stock prices, and exchange rates at that time period. The hypothesis states that the future information is random and it is unknown in the present time. This indicates that it is impossible to produce above average returns based on historical share prices or other financial data. In reality, the markets reaction to new information is not always immediate due to various factors such as the psychological factors and reactions of various human actors. Therefore, the prediction of financial data is possible (Jensen, 1978).

There has been a considerable evidence to prove that markets are not fully efficient. Many researchers provide evidence showed that stock market returns are predictable by various means such as time-series data on financial and economic variables (Fama & Schwert, 1977; Fama & French, 1988)

There are two main approaches to financial time series forecasting, based on univariate, and multivariate analyses. In univariate approaches, the input variables are restricted to the signal being predicted. In multivariate approaches, any indication whether or not it is directly related to the output can be incorporated as the input variable (Cao & Tay, 2001). Financial time series have a number of properties, which make the prediction changeling, these include:

1. Nonstationary, since the statistical properties of the data change over time. The main cause of this is the effect of various business and economic cycles.
2. Nonlinearity, which makes linear parameter models information difficult to use.
3. High level of noise in the form of random day-to-day variations in financial time series.

Conventional statistical techniques such as autoregressive integrated moving average (ARIMA) and exponential smoothing (Brown, 1963; Hanke & Reitsch 1989) have been extensively used for financial forecasting as univariate models. However, since these models are linear, they fail to capture the nonlinear characteristics of financial time series signals.

There are lot of efforts and researches to explore the nonlinearity of the exchange rate time series and to develop nonlinear models which are capable of improving the forecasting of FX time series. These include the autoregressive random variance (ARV) (So, Lam, & Li, 1999), the autoregressive conditional heteroskedasticity (ARCH) (Hsieh, 1989), chaotic dynamic (Peel & Yadav, 1995) and self-exciting threshold autoregressive (Chappel, Padmore, Mistry & Ellis, 1996) models. These models may show good prediction for par-

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