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Financial forecasting using ANFIS networks with Quantum-behaved Particle Swarm Optimization

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ABSTRACT

To be successful in financial market trading it is necessary to correctly predict future market trends. Most professional traders use technical analysis to forecast future market prices. In this paper, we present a new hybrid intelligent method to forecast financial time series, especially for the Foreign Exchange Market (FX). To emulate the way real traders make predictions, this method uses both historical market data and chart patterns to forecast market trends. First, wavelet full decomposition of time series analysis was used as an Adaptive Network-based Fuzzy Inference System (ANFIS) input data for forecasting future market prices. Also, Quantum-behaved Particle Swarm Optimization (QPSO) for tuning the ANFIS membership functions has been used. The second part of this paper proposes a novel hybrid Dynamic Time Warping (DTW)-Wavelet Transform (WT) method for automatic pattern extraction. The results indicate that the presented hybrid method is a very useful and effective one for financial price forecasting and financial pattern extraction.

1. Introduction

The FX is the largest global market today. According to the September 2013 report of the Bank for International Settlements (2013), Global FX turnover reached $5.3 trillion a day in 2013. There are two main groups that trade on the FX market. The first group is companies and governments that use the FX market to convert domestic currency into a foreign currency for international business transactions. The second group consists of investors that trade in order to make a profit on the Forex market. Speculators on the FX market range from large banks to home-based operators (Archer, 2010).

As with other financial markets, the most important factor for being successful in FX trading is the ability to correctly predict future market fluctuations. If a speculator can "buy low and sell high", then he or she will make a profit. There are wild variations in exchange rates on the FX market, and it is difficult for traders to make the right decision to buy or sell. Forecasting future FX exchange rates is an intriguing subject for many speculators. They use artificial intelligent models to forecast future market values and look for complex chart patterns. The objective of this paper is to propose a hybrid artificial intelligence model as a trading advisory system. An ANFIS-QPSO hybrid system is used as a one-step-ahead forecasting method. Wavelet coefficients of time series are used as the ANFIS input parameters. The paper also presents a hybrid Dynamic Time Warping (DTW)-Wavelet Transform (WT) method for automatic pattern extraction from a financial time series. This study attempts to make correct trading signals based on forecasted market values and identified chart patterns. The proposed model can help traders to reduce trading risks and to increase their profit.

According to the efficient market theory, it is nearly impossible to accurately make long-term predictions based on historical market data. But in the short-term, there are some hidden repeating patterns that, if we can identify them, could help us make a profit from the market (Liu & Kwong, 2007). Professional traders use two major types of analysis to make accurate decisions in financial markets: fundamental and technical. Fundamental analysis is based on the overall state of the economy, the state of the industry and a company's overall financial situation. Technical analysis, on the other hand, relies on charts and historical data, and is based on the idea that history will repeat itself. Therefore, by analyzing

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past data, we can forecast future market trends. The two main methods used for technical analysis are statistical-based indicators and chart patterns. Statistical methods include the use of moving averages to find a mathematical relationship between past data that can be used for evaluating future market values. Finally, if a specific pattern appears in a chart, chart patterns analysis can be used to predict the future trends.

There are many papers dealing with financial market forecasting. Many of them employ soft computing techniques, such as genetic algorithms, neural networks, and neuro-fuzzy systems. Most previous works have presented methods to try to accurately predict the market. Obviously, based on the current human knowledge, it is impossible to correctly predict the exact market values. Therefore, researchers have used complicated methods to minimize forecasting error. To be successful in real market trading, professional traders place great value on predicting future market trends. Instead of trying to forecast an exact market value, the model proposed in this paper provides a trading advisory signal generated from predicted market trends.

The innovations of the presented method are as follows:

- The majority of earlier papers used just one of the technical indicators or chart patterns as a forecasting method. The proposed method uses wavelet decomposition of time series and extracted chart patterns as the system inputs.
- An ANFIS-QPSO hybrid method has rarely been used for financial forecasting. A novel method for tuning ANFIS membership functions by QPSO has been proposed. Experimental results have shown that this model is very accurate and highly efficient for forecasting in financial markets, especially in the Forex market.
- DTW has rarely been used for finding patterns in financial time series. In this paper a state-of-the-art hybrid algorithm, combining Dynamic Time Warping and Wavelet Transform, is presented to extract the shaped patterns in financial time series.
- The majority of earlier papers employed a single shape template or time series as a target pattern. These patterns are generally independent from the input time series. The presented method creates an adaptive pattern based on the main features of pattern and input time series to accurately predict the current data.

Section 2 of this paper provides the literature review, Section 3 reviews basic methods. The proposed method is described in Section 4. Section 5 describes the experiments and makes comparisons. Finally, Section 6 examines the conclusions of the study.

2. Literature review

Many previous studies used statistical technical indicators to predict the price variations. Some of the proposed methods used soft computing techniques as a forecasting system. Escobar, Moreno, and Munera (2013) presented a new technical indicator based on fuzzy logic. Current indicators used only mathematical models, but Escobar et al. incorporated some aspects of trader behavior, such as risk tendency. They used fuzzy logic to make decisions an ordinary investor.

Cheng, Wei, Liu, and Chen (2013) used ANFIS to forecast stock prices on the Taiwanese stock markets. They advocated that making forecasts based on several past periods of stock prices is much better than using a single previous period, and observed that it is difficult to find the best weight for each period. They incorporated high-order data into the values of single attributes by using the method of ordered weighted averaging (OWA). Wei (2013a, 2013b) proposed an ANFIS model that optimized an adaptive expectation genetic algorithm for predicting stock prices. Wei (2013a, 2013b) in another study used a novel genetic algorithm (GA) weighted ANFIS model to forecast the Taiwan stock index. Because of strong connections with the Taiwan economy and international trade, Wei (2013a, 2013b) used fluctuations in other stock markets as forecasting factors in his proposed model. Chang, Wei, and Cheng (2011) proposed a hybrid ANFIS model based on auto regression and volatility to forecast stock prices. (Vanstone & Finnie, 2006; Vanstone et al., 2004a, 2004b) used neural networks to forecast stock prices on the Australian stock markets.

Kazem, Sharifi, Hussain, Saberi, and Hussain (2013) used optimized support vector regression with a chaos-based firefly algorithm for stock price forecasting. Tan, Quek, and Cheng (2011) proposed an ANFIS model that was supplemented by reinforcement learning (RL) for identifying trend movement and making investment decisions. Atsalakis and Valavanis (2009) used fifteen different combinations of past stock prices to find the best ANFIS inputs for forecasting short-term trends in stock markets. Esfahanipour and Aghamiri (2010) used technical indices as the input variables for ANFIS on a Takagi Sugeno Kang (TSK) type fuzzy system and fuzzy C-mean clustering for stock price prediction. Boyacioglu and Avci (2010) used six macroeconomic variables and three indices as ANFIS input variables for predicting the Istanbul Stock Exchange index. For predicting stock prices, Atsalakis, Dimitrakakis, and Zopounidis (2011) presented the Wave Analysis Stock Prediction (WASP) system, an ANFIS system based on Elliot Wave Theory. Wei, Chen, and Ho (2011) separated past forecasting models into two main types: models based on artificial intelligence algorithms, and statistical models based on mathematical equations. They proposed an ANFIS model which used multi-technical indicators to predict stock price trends. Melin, Soto, Castillo, and Soria (2012) presented an ensemble of ANFIS for the prediction of chaotic time series. Svalina, Galzina, Lujic, and Šimunovic (2013) proposed an ANFIS to forecast the close prices for the next five days for the Zagreb Stock Exchange Crobex index. They used a separate ANFIS for each day. Ebrahimpour, Nikoo, Masoudnia, Yousefi, and Ghaemi (2011) combined three Multilayer Perceptron (MLP) neural networks and an ANFIS to forecast trends on the Tehran stock exchange. Vanstone, Finnie, and Hahn (2012) used a neural network to create a stock trading system based on fundamental variables. Chen (2013) used particle swarm optimization for tuning subtractive clustering parameters, and the ANFIS model for predicting business failures. Ansari, Kumar, Shukla, Dhar, and Tiwari (2010) proposed an uncertainties detection system to be used during a period of recession, an ANFIS based on economic and statistical analysis. Cheng, Wei, and Chen (2009) proposed a new fusion ANFIS based on multi-stock volatility causality for forecasting stock prices in Taiwan. (Liu, Leng, & Fang, 2014)(Chiang, 2013) and (Lin et al., 2012) used ANFIS with QPSO as a membership tuning function. Choudhry, McGroarty, Peng, and Wang (2012) used a neural network to forecast FX exchange rates based on past bid and ask prices. Marghescu, Sarlin, and Liu (2010) applied the fuzzy c-means method, Sarlin and Marghescu (2011b) used a self-organizing map (SOM). Sarlin and Marghescu (2011a) in another study used a neuro-genetic hybrid model for predicting currency crises. Trinkle (2005) proposed an ANFIS model for forecasting annual excess stock returns, and compared the results using the neural network and the Autoregressive Integrated Moving Average (ARIMA) model. Vojinovic, Kecman, and Seidel (2001) compared a radial basis function neural network model with a linear autoregressive model for forecasting the USD/NZD exchange rate. Albanis and Batchelor (2007) proposed a hybrid method based on neural network and recursive partitioning for combining heterogeneous classifiers in stock selection. Leung, Chen, and Mancha (2009) used two independent neural network