Combining the Real-Time Wavelet Denoising and Long-Short-Term-Memory Neural Network for Predicting Stock Indexes

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***Abstract*— A stock market index can be a valuable indicator to describe the performance of a stock market in a particular region. Nevertheless, it is very difficult to forecast its future values or trends since the index data often demonstrate a high degree of fluctuations. Intrinsically, the wavelet denoising is a useful method to separate the signals from noise in many practical multi-media applications while the long-short-term-memory neural network (LSTM) is a powerful recurrent neutral network (RNN) architecture of learning and prediction models used in the field of computational intelligence. Nevertheless, few research studies have ever considered their combination for the prediction of stock or index movement. More importantly, some existing proposals trying to combine wavelet denoising with other artificial neural network architectures suffer from two major drawbacks. First, when applying the conventional one-time wavelet transform for denoising the stock data, this approach has made a serious logical flaw to include future stock data in its training phase, thus leading to impressive results in the back-testing yet actually impractical in real-world applications. In addition, the wavelet functions and decomposition levels are typically fixed in those studies for which they will not be able to produce optimal results in terms of the prediction accuracies. Hence, we propose in this paper a novel model to combine real-time wavelet denoising functions with the LSTM to predict the East Asian stock indexes in which the wavelet denoising adopts a sliding window mechanism to exclude the future data while its system configuration is flexibly optimized based on some predefined criteria. The empirical results reveal that the performance of our proposed prediction model shows significant improvements when compared to those of the original LSTM model without utilizing the wavelet denoising function. Furthermore, there are many interesting and possible directions including the integration with other deep learning networks for the future investigation of this work.**

Keywords—stock index forecasting; real-time wavelet denoising; wavelet transform; recurrent neural network; long short-term memory neural network.

I. INTRODUCTION

A stock market index is an important measurement to represent a stock market. The index is often used by the investors to manage their investment portfolios. Hence, the prediction of the stock market index movement has become important for the institutional investors as well as the general public. In addition to the north American and European markets, East Asian stock markets have been very active in these years. Thus, six East Asian stock market indexes are investigated to evaluate our proposed model in this paper, namely Hong Kong Hang Seng Index (HSI), Shanghai Stock Exchange Composite Index (SSE), Shenzhen Stock Exchange Composite Index (SZSE), Taiwan Capitalization Weighted Stock Index (TAIEX), Tokyo Nikkei Index (NIKKEI) and Korea Composite Stock Price Index (KOSPI).

As stock index data is very noisy, data denoising is one of effective ways to improve the prediction performance. The simplest way for denoising data is to use a moving average method [1]. However, the moving average method usually lags behind the real data trends. Another way is to adopt Fourier transform [2]. Nevertheless, Fourier transform cannot handle time information properly, and is not suitable to be applied to the non-stationary signals [3]. Unfortunately, stock index data is exactly time-varying and non-stationary. While wavelet transform has overcome the disadvantages of Fourier transform for expressing functions containing discontinuities and sharp peaks, and for deconstructing and reconstructing finite and non-stationary signals [4, 5]. Hence, the wavelet transform is used as a denoising technique to smooth the stock index data in this paper.

Long-short-term-memory neural network (LSTM), one of powerful architectures of Recurrent Neural Network (RNN), has been shown successful applications in many engineering domains [6-8]. Therefore, the LSTM is adopted as a prediction model in this paper.

Admittedly, there have been some research efforts on the combination of the wavelet transform and the LSTM. However, most are not aiming at financial market prediction problems, such as [9] for tourist arrivals prediction and [10] for audio onset detection. Furthermore, a few studies have attempted to apply wavelet denoising combined with other artificial neural network architectures to the stock market prediction according to [5, 11, 12].

However, there exists two major drawbacks. For one thing, in their approach, the stock data was denoised by the

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