

Deep learning for stock market prediction from financial news articles

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Abstract—This work uses deep learning methods for intraday directional movements prediction of Standard & Poor's 500 index using financial news titles and a set of technical indicators as input. Deep learning methods can detect and analyze complex patterns and interactions in the data automatically allowing speed up the trading process. This paper focus on architectures such as Convolutional Neural Networks (CNN) and Recurrent Neural Networks (RNN), which have had good results in traditional NLP tasks. Results has shown that CNN can be better than RNN on catching semantic from texts and RNN is better on catching the context information and modeling complex temporal characteristics for stock market forecasting. The proposed method shows some improvement when compared with similar previous studies.

Keywords: *Deep learning; Recurrent neural network; Convolutional neural network; intraday stock forecasting*

I. INTRODUCTION

The aspiration of any investor is to forecast the market behavior with the aim of making the best decision when he comes to buying or selling shares of stocks seeking to maximize his profits. This is a difficult task because market behavior is volatile and influenced by many factors such as global economy, politics, investor expectation and others.

The random walk theory [1] introduces a hypothesis that stocks prices are defined randomly and for these reasons they are impossible to forecast. However, advances in artificial intelligence and the growth of available data have made possible to forecast the stock price behavior with a better performance than a random process [2]-[8].

There are three approaches related to the information required to make a prediction. The first approach, technical analysis, is based on the premise that the future behavior of a financial time series is conditioned to its own past. The second approach, fundamental analysis, is based on external information as political and economic factors. This information is taken from unstructured data as news articles, financial reports or even publishing in microblogs by analysts. Nofsinger [9] shows that in some cases, investors tend to buy after positive news resulting in a stress of buying and higher stocks prices; and after negative news, they sell, resulting in a decrease of prices. Finally the third approach considers as

relevant all information coming from both, financial time series and textual data.

Prior works in this area focus on technical analysis. These works use different statistical techniques and artificial intelligence models to make a prediction based only in technical information [10][11]. This approach has a limitation since the market reacts to external information that is not contained in the historical data used to extract the technical information.

Inspired by fundamental analysis, many authors propose the use of text mining techniques and machine learning techniques to analyze textual data and take out information that can be relevant to the forecast process [12]-[15]. The most relevant works in the area are reviewed in [16][17]. Other works [3][18] use hybrid models by combining text mining techniques with the technical information. This approach outperforms other baseline strategies.

Recently, with more computational capabilities and the availability to handle massive databases, it is possible to use more complex machine learning models, such as deep learning models, which presents a superior performance in traditional Natural Language Processing (NLP) tasks. The outstanding deep learning models are: Convolutional Neural Network (CNN) [19]-[22], Recurrent Neural Network [23][24], specifically the Long Short Term Memory architecture (LSTM) [25][26], and Recurrent Convolutional Neural Network (RCNN) [27][28].

Some examples of deep learning models for financial time series forecasting are shown in [29][30]. Those authors apply a deep neural network model that use as input events taken from financial news articles to forecast the direction of prices of a set of stocks and the S&P 500 index. The main characteristics in the work described in [30] is the event representation method and the convolutional neural network which models the influence of these events on stock prices behavior in short-term, middle-term and long-term.

From the works cited above it is possible to identify three key points for the construction of deep learning models. The first one is the definition of the prediction horizon, the second one is the temporal effect of a news document and the third one is the representation type of the information. Regarding the first point, daily prediction (intra-day) is the most used.