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Development and implementation of a predictive method for the stock market analysis, using the long short-term memory machine learning method

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Abstract. In this work, the development and implementation of a computational tool based on the Long Short-Term Memory method were showed. The code was written in python, and consist of a recurrent neural network used in the field of deep learning. In the code, we implement artificial intelligence, which uses linear and logistic regression to make a predictive analysis based on historical data of each foreign exchange and the stock prices, with the target of predicting the next point of the future price (the price of closing of the futures trading candlestick). Cross-validation between linear and logistic regression is also performed to see which of the two has the highest success rate, that is, the accuracy of the method is evaluated using two validation alternatives. In addition, we make a matrix of pairs of different foreign exchanges to identify which are the most correlated or inverse, so that the program can open its range of operations (simultaneously with different foreign exchange), and with this, a greater number of operations can be made per time established (in the foreign exchange case it is from one minute to five minutes, operations strategy is called scalping). Finally, we present the results obtained, based on the behavior of foreign exchange and stock prices, using a statistical predictive to assess the accuracy of said sample statistical model taken in this study.

1. Introduction

A large part of stock market investors is always attentive to the behavior of the dollar, euro, oil, among others. For example, one of the major attentions that investors of the stock market have often consisted of calculating the correlation between different instruments, such as stocks and exchange-traded funds (ETF), or foreign exchange (Forex) currency pairs [1, 2].

It is of great importance to know if your portfolio is properly diversified, that is to say it is important to verify if the currencies are highly correlated in the portfolio or in the bag that you want to invest, in addition, it should be taken into account that you can tend to go up and down together compromising its diversification and investment strategy. Maintaining high attention on high correlations (positive or negative) is even more important for Forex traders, this is because currency pairs often exhibit high correlations, whether positive (both grow the same way) or negative (both decrease in the same way) due to market conditions or that have similar market factors. On the other hand also if this correlation factor tends to zero, this will



indicate that the two currencies that are being studied are not correlated (while the value of one grows, that of the other decreases) [3–5].

It's clear that the stronger a relationship is, both positive and negative, the more predictive value it will have in analysis. The longer periods used in technical analysis provide more accurate information. The correlations in periods of one minute are hardly worthwhile, while the information that is extracted from monthly or annual data is more reliable [6–8].

Another important factor in the study of investments is the behavior of the actions of the stock market, in addition to knowing the status of some companies in which you are interested in investing, in order to estimate and predict their behavior, we have implemented the long short-term memory (LSTM) method, with the purpose of forecasting the behavior of the stock exchange, for the next evaluation days, taking into account that this prediction; we will do it with help in the history of stored data, obtained previously as a basis for making this prediction and with this to be able to give a clue or guide to the investor to be able to reduce the error or failure in the investment [9–11].

Here, an algorithm based on the LSTM method to be used to predict the behavior of the stock market was developed. We also present the connection with an online platform, from which you can obtain the acquisition of updated data, in addition to being able to perform the method for a certain history of financial information of the stock market.

2. Methods

This method of data analysis has several memory cells, which consist mainly of a calculation unit that replaces traditional artificial neurons in the hidden layer of the network. With these memory cells, the networks can effectively associate the memories and the remote input in time, therefore, they are suitable to capture the data structure dynamically over time with high predictability. In Figure 1 is shown computational architecture of the LSTM method.

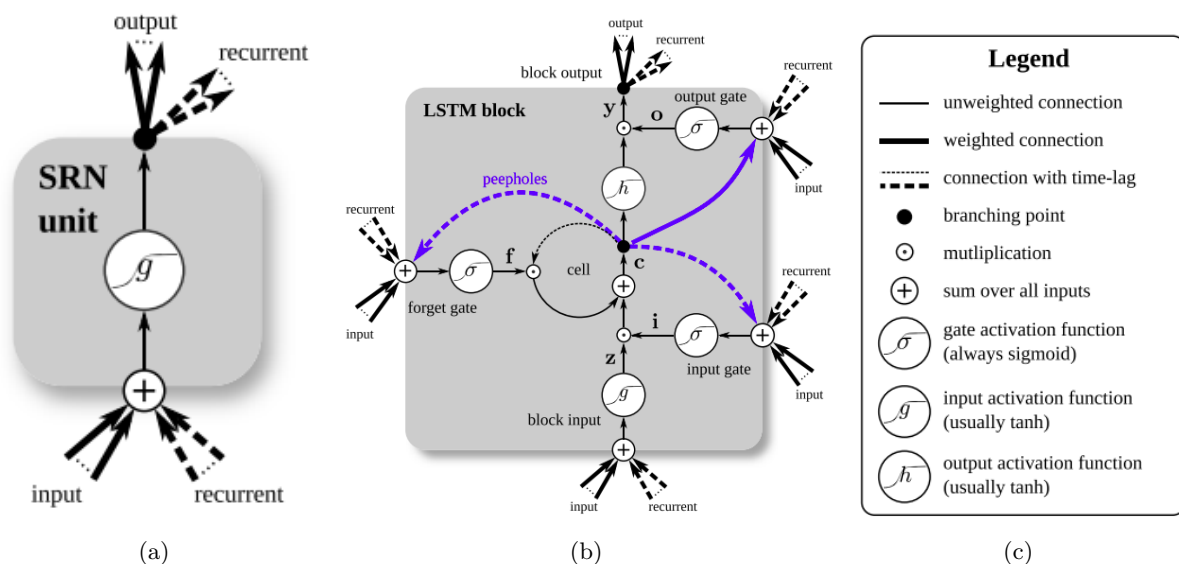


Figure 1. (a) Detailed schematic of the simple recurrent network (SRN) unit. (b) The architecture of a long short-term memory block as used in the hidden layers of a recurrent neural network. (c) Nomenclature used for each symbol of the schematic diagram [12].

The first step of the LSTM method, It consists in deciding what information is to be placed in the cell state, this decision is made by the forgotten door layer, so that h_{t-1} and $x(t)$, give us numbers of output between 0 and 1 for function f_t , where the value of zero indicates that

it is completely forgotten and the 1 that is kept completely in memory (see Figure 1). In this way, if we have a new input variable, which is very relevant or characteristic for the prediction, what the method does is that it will save this value, but otherwise, the method will forget this information by being irrelevant to say prediction value (see Equation (1)).

$$f_t = \sigma(W_f \cdot [h_{t-1}, x_t] + b_f). \quad (1)$$

The next step consists to decide what new data is saved in the cell state [13]. This has two parts, a layer called input “gate” decides which values that updated. After a layer called “tanh” has the function of creating a vector with new candidate values $\tilde{C}_t$, that could be added to the state, in the second part, we combine these two states to update (see Equation (2)).

$$i_t = (W_i \cdot [h_{t-1}, x_t] + b_i), \quad \tilde{C}_t = \tanh(W_c \cdot [h_{t-1}, x_t] + b_c). \quad (2)$$

Now, we are preparing to realize the product of the oldest (short-term) state of memory, to this expression, we also add one more term to the product of the new possible candidate values to be able to take (see Equation (3)) [14].

$$C_t = f_t \cdot C_{t-1} + i_t \cdot \tilde{C}_t \quad (3)$$

Finally, the value that is within the argument of the tanh function, which must be in a range of values between -1 and 1, after obtaining this value, we must multiply it by the value thrown by the exit door, resulting in only the part we have decided to take from the previous step (see Equation (4)) [13].

$$O_t = \sigma(W_o \cdot [h_{t-1}, x_t] + b_o), \quad h_t = o_t \cdot \tanh(C_t) \quad (4)$$

The steps followed in our research work were:

- (i) Data acquisition: In this step, the historical data stored in the database of the behavior of the stock market for a certain year was used.
- (ii) Data Preprocessing: At this stage, the following aspects must be taken into account: discretization, reduction of the data to work more easily with them, cleaning of the data, implying filling in some possible gaps (loss of information) in the data and finally We perform an integration and cleaning of some defective data, taken by machine error.
- (iii) Feature Extraction: At this stage, it's important must very careful to choose which are the variables that will feed the neural network.
- (iv) Neural network training: At this stage, the data is sent to the neural network using the LSTM prediction method, wherein this case three dense layers of activation and finally a dense layer of the linear activation function were used.

3. Results

In this section, we will show the most relevant results, which were obtained in our statistical study, about the behavior of the stock market and the correlation between the different international currencies.

Let's start by analyzing the correlation we obtained regarding international currencies that were taken into account in this study, where the colors closest to the green range, we want to indicate that there is a very good relationship (they are correlated) between this currency exchange pair, in addition to the pictures that have a color closer to the red range, shows us that they are foreign exchange currencies that are inversely related (not correlated), as shown in Figure 2. For example, the ratio of the EURUSD currency pair (consisting of the Euro (EUR) and the US dollar (USD)) to the USCHF currency pair (consisting of the US dollar (USD)

and the Swiss franc (CHF)), shows a very bad relationship between their behavior, as can be seen in the upper left of Figure 2.

The p-value and the t-statistic were 4.44×10^{-4} and -4.90 respectively, they give a good parameter in the chosen currency. In this case, it was the pound-dollar, but it could be any other as long as we meet this requirement between 2 and -2 means that 95% of the historical data for this currency is in that interval, then it is suitable for prediction (see Figure 3).

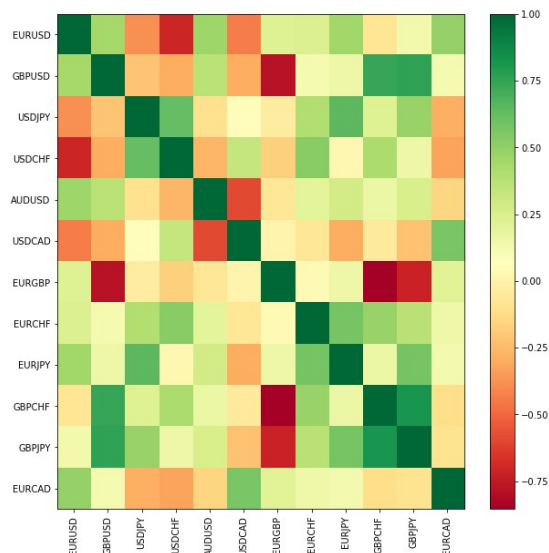


Figure 2. Correlation of the behavior by exchange currency pairs corresponding of an one day of year 2019.

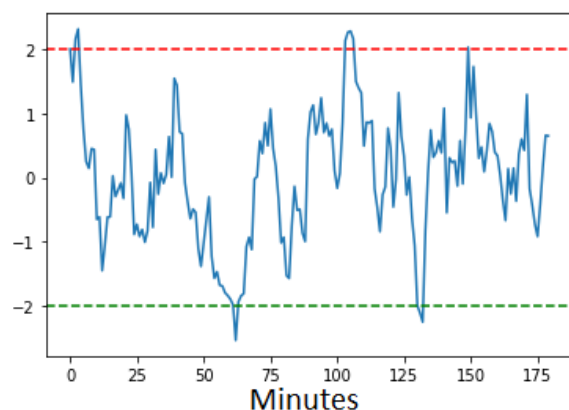


Figure 3. Temporal evolution of the behavior of the pairs of foreign exchange Pound-Dollar in function of time in minutes.

In addition to the relationship of the behavior of currencies, another important aspect to study is the economic profile of the stock market, we have collected and organized the information about the behavior of the stock market in this year (2019), obtaining the result shown in Figure 4.

One of the most influential factors that should be taken into account when studying the behavior of the stock market is the volume of investments per day, this is done in order to have a very good forecast, to know in which months of the year there is a greater growth or decrease in investments. From Figure 5, the days in which the highest volume of investments was presented were the final days of October and the beginning of November 2018. In addition, two peaks at the end of January 2019 and at the end of October 2019 are shown.

Finally, the application of the Machine Learning LSTM method to improve the prediction of stock market behavior was developed. We have used 67% of the statistical information of the stock market to carry out the training of the data and we have left the value of 32% of the sample data to perform the evaluation test of the LSTM prediction method (see Figure 6). We chose to make a model by mixing data from the two models, taking our own variables to make a model that fits the best of the two models described above, based on this a python server was made to connect the Meta Trader 5 platform [15,16], which is the one used with our code in python (see Figure 7). as it is observed we get that the price always touches the trend line made by the prediction, this is done for any time slot, since the server sends the data to our python code, it analyzes it and returns the calculation with the result, this is done in any desired time slot, since the server is always receiving the current data, in this case, it was done in 1 minute, but it can be in an hour, in a day, or in a month (see Figure 7).

An accuracy percentage of 88.8% for the prediction method implemented in this study to evaluate the economic behavior of currencies and the stock market. It should be noted that the line always takes an incoming value (the most current price) and takes one of the predictions (the oldest data) to always be updated according to the current price. Therefore, the aim is the prediction always fits the future closing price for a period of time, perfectly achieving the goal that at the closing of a certain candle the prediction point is always touched, and it is only to calculate how long the predicted trend will remain (see Figure 7).



Figure 4. Stock market behavior based on historical price in united states dollars, from data presented in this year (2019), where the blue curve indicates the open values, the orange curve the high ones, the green curve the low ones and finally the red curve close values respectively.

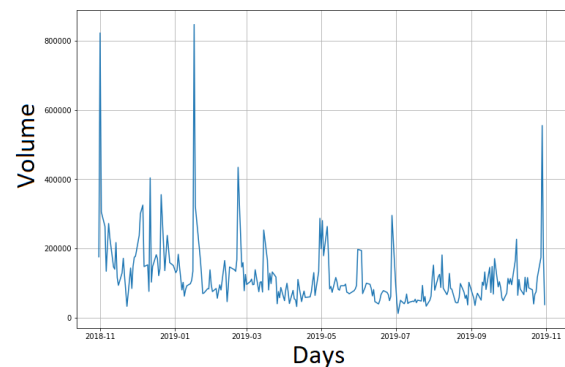


Figure 5. Behavior of the volume of investments made in the stock exchange during the year 2019.

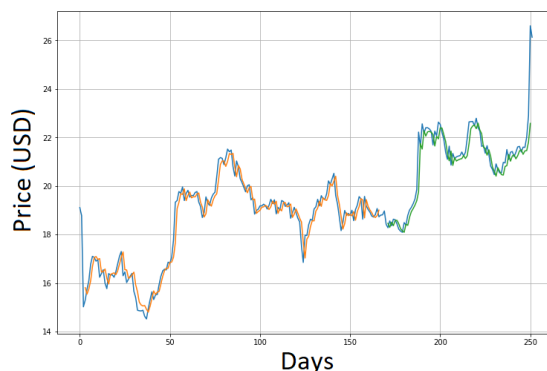


Figure 6. Prediction of the behavior of the stock exchange using the Machine Learning LSTM method, wherein this graph the blue curve is the actual data taken, the orange curve is the portion of data that was taken as training and the green curve it gives us the prediction made by the LSTM method.



Figure 7. Screenshot of the Prediction of the behavior of the stock exchange using the MetaTrader 5 platform, which is indicated from the red line.

4. Conclusions

Two prediction models were implemented in which both linear regression (Machine Learning LSTM method) and logistics can be used to make predictions in a dataset of financial operations on the stock exchange. Both models are useful to identify trends and to predict certain values in the future (88.8% accuracy of the method), such as opening prices, closing prices (used in this case), tick prices, ask or bid. According to what the user wants to predict, he can adjust the prediction methods to see which one can be more accurate. In addition, we are currently working on code optimization, and automation is being performed to perform operations on a bot applied commercial so that these operations are performed automatically.

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