Stock Market Prediction Using a Deep Learning Approach

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Agenda:

- **Objectives of this research**
- **Introduction: *Stock market prediction & Machine Learning***
- **Methodology and proposed model**
- **The details of the datasets**
- **The experimental results**
- **Conclusions**

The objective of this research:

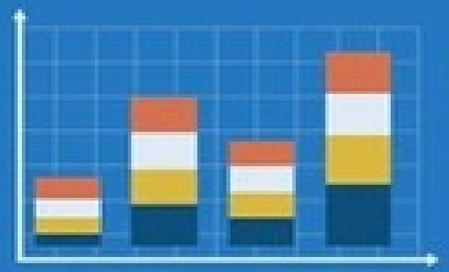
- **Develop the predictive model by using deep learning LSTM to forecast the stock prices.**
  - **Dow Jones Industrial (DJI).**
  - **S and P 500 index.**

- **To measure the effectiveness of our proposed model**
  - **we have used the best prediction values for our Deep LSTM model compared with the experimental results of deep learning techniques from the researches studied .**

Introduction:
Stock market prediction & Machine Learning

Stock prices historical data ---->> **Predictive model---->>** **Future Price Prediction**











Prediction factors :

- **Physical & physiological factors**
- **Rational & irrational behavior**



- ❑ **Simple algorithms >> averaging , linear regression**
- ❑ **Advance techniques >> Auto ARIMA**
- ❑ **Various models have been created by Machine learning**

Techniques :

- **Decision trees / Support Vector Machine (SVM)**
- **Neural Networks / K-Nearest Neighbor**
- **Deep Learning method >> LSTM**

Methodology and proposed model:

- **Long Short-Term Memory (LSTM)**
  - **LSTM model is an artificial recurrent neural network (RNN).**
  - **LSTM model are well-suited for:**
    Classifying.
    Processing.
    Making prediction based on time series data.

- **LSTM was developed to deal with the vanishing gradient problems.**

LSTM Cell:

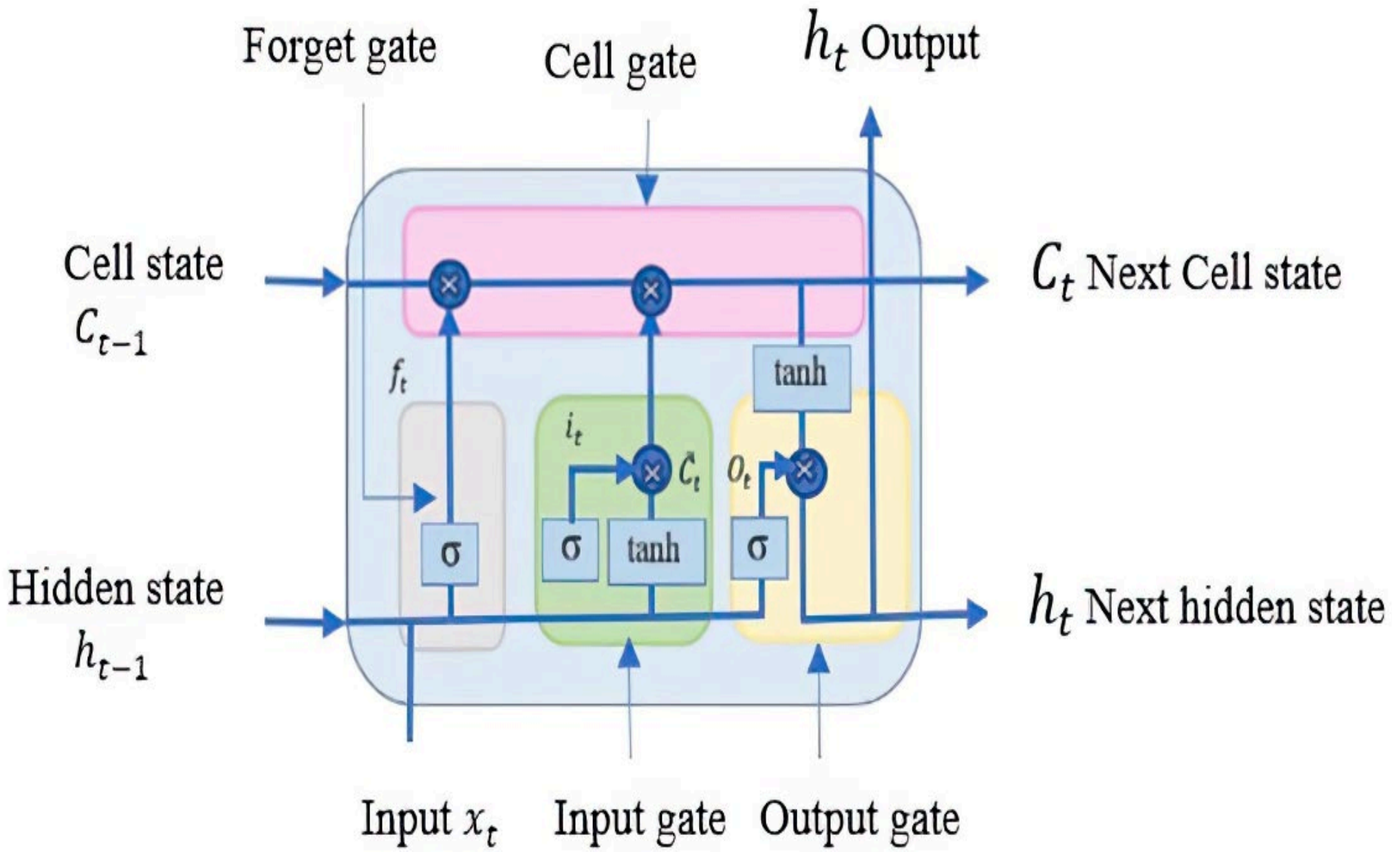


Figure 1. The structure of LSTM cell at time step t

Three gates of LSTM cell :

Input gate >> is call updated??

$$i_t = \sigma(W_i h_{t-1} + U_i x_t + b_i)$$

Forget gate >> is memory set to 0 ??

$$f_t = \sigma(W_f h_{t-1} + U_f x_t + b_f)$$

Output gate >> is current info visible??

$$\tilde{C}_t = \tanh(W_c h_{t-1} + U_c x_t + b_c)$$
$$C_t = (C_{t-1} \otimes f_t) \oplus (\tilde{C}_t \otimes i_t)$$
$$O_t = \sigma(W_o h_{t-1} + U_o x_t + b_o)$$

The diagram of the Deep LSTM model.

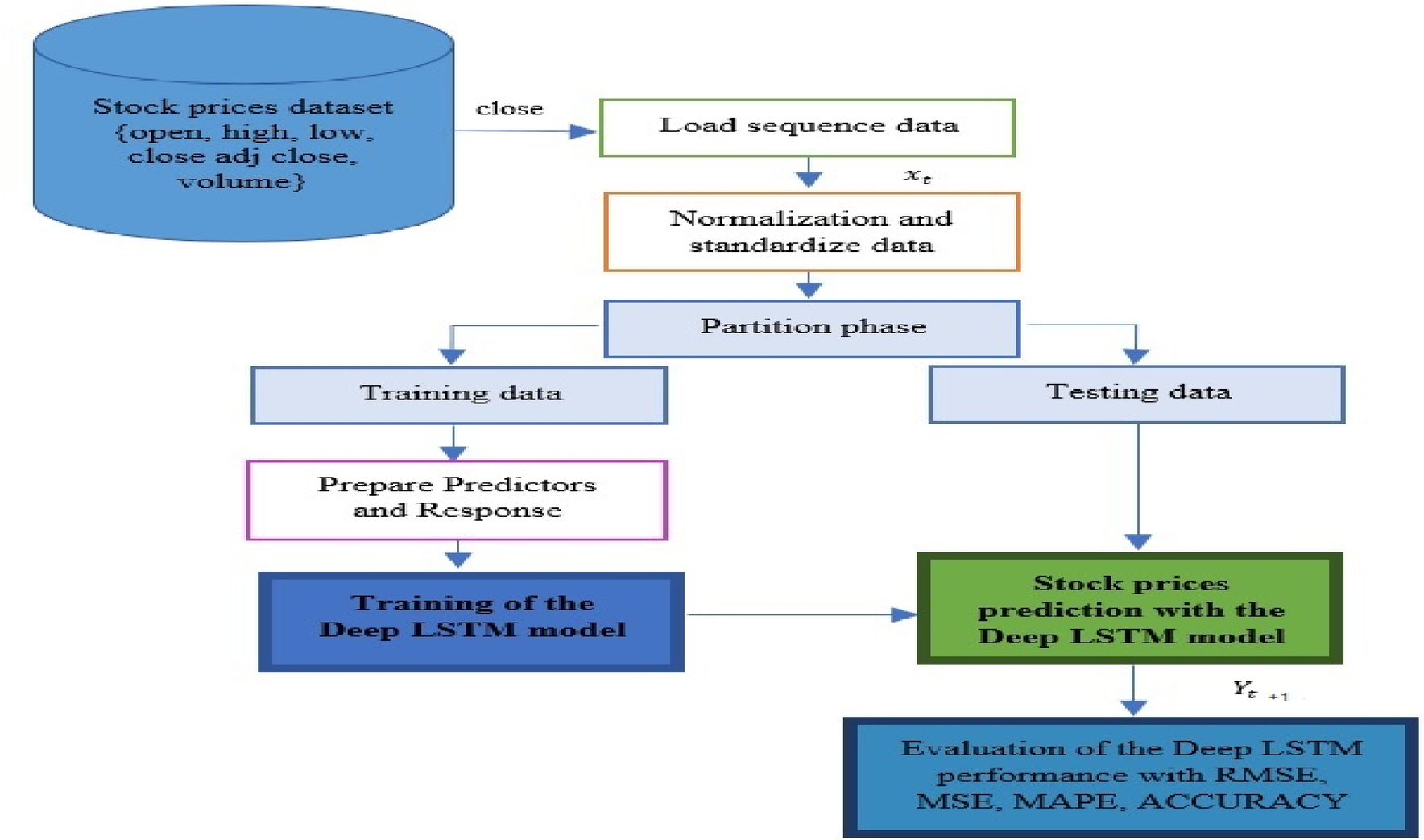


Figure 2. The framework of the Deep LSTM model.

The architecture of the Deep LSTM model.

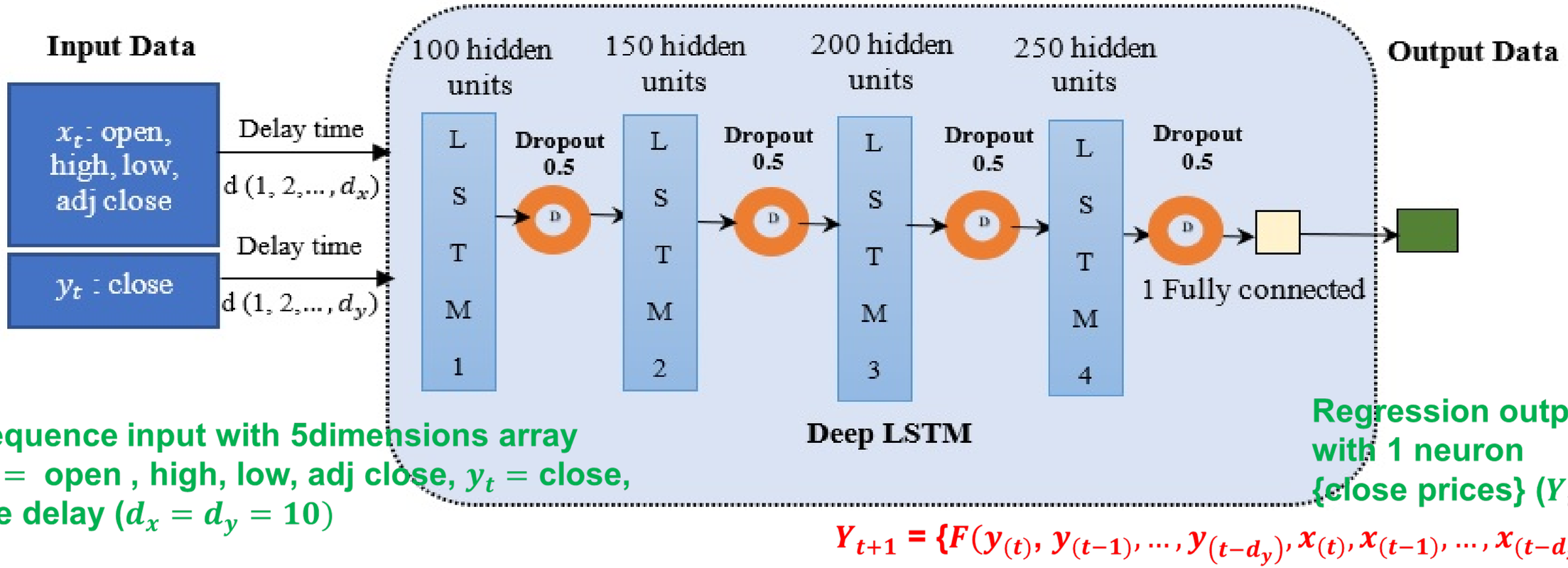


Figure 3. The architecture of the Deep LSTM model.

A Deep LSTM model layers:

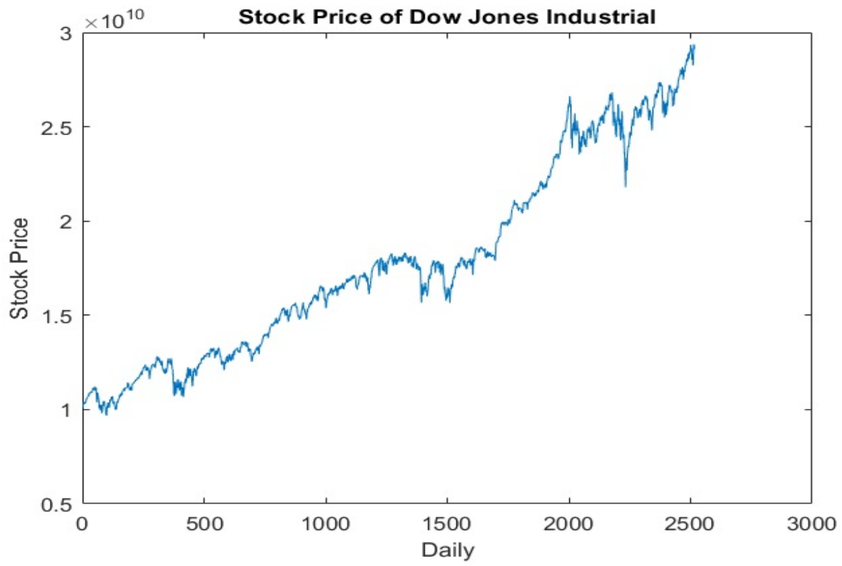
Table 1. The network analysis results of the deep LSTM model.

Layer	Name	Type	Activations	Learnables
1	Sequence input with 5 dimensions	Sequence Input	5	-
2	LSTM with 100 hidden units	LSTM	100	Input weights 400 ×5 Recurrent weight 400×100 Bias 400×1
3	Dropout1	Dropout	100	-
4	LSTM with 150 hidden units	LSTM	150	Input weights 600 ×100 Recurrent weights 600×150 Bias 600×1
5	Dropout2	Dropout	150	-
6	LSTM with 200 hidden units	LSTM	200	Input weights 800 ×150 Recurrent weights 800×200 Bias 800 ×1
7	Dropout3	Dropout	200	
8	LSTM with 250 hidden units	LSTM	250	Input weights 1000 ×200 Recurrent weights 1000×250 Bias 1000×1
9	Dropout4	Dropout	250	-
10	1 fully connected	Fully connected	1	Weights 1×250 Bias 1×1
11	Regression output with 1 neuron	Regression output	-	-

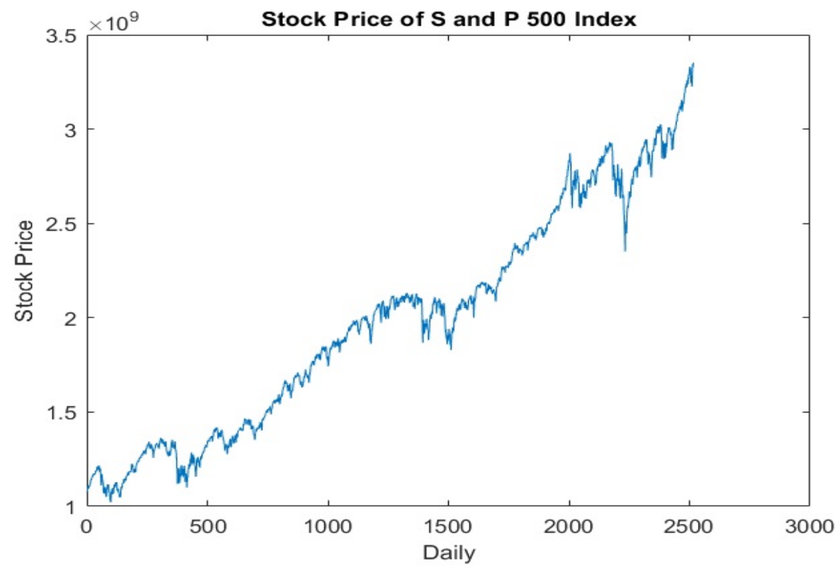
Stock prices datasets:

Table 2. The details of stock prices datasets from yahoo's finance data.

Stock prices dataset	Feature	Training set	Testing set
		80%	20%
Dow Jones Industrial	open, low, high, close, adj close, volume	February 2010 - January 2018 (2012 days)	February 2018 - February 2020 (499 days)
S and P 500 Index	open, low, high, close, adj close, volume	February 2010 - January 2018 (2012 days)	February 2018 - February 2020 (499 days)



a)



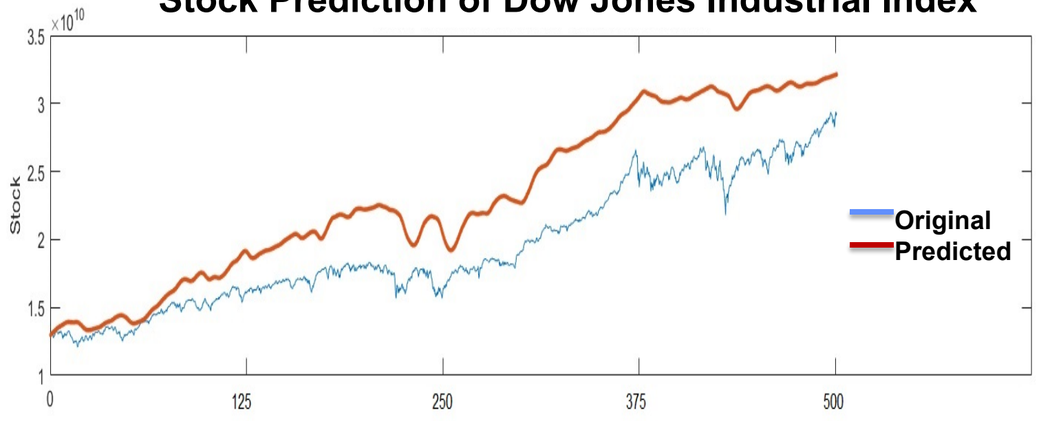
b)

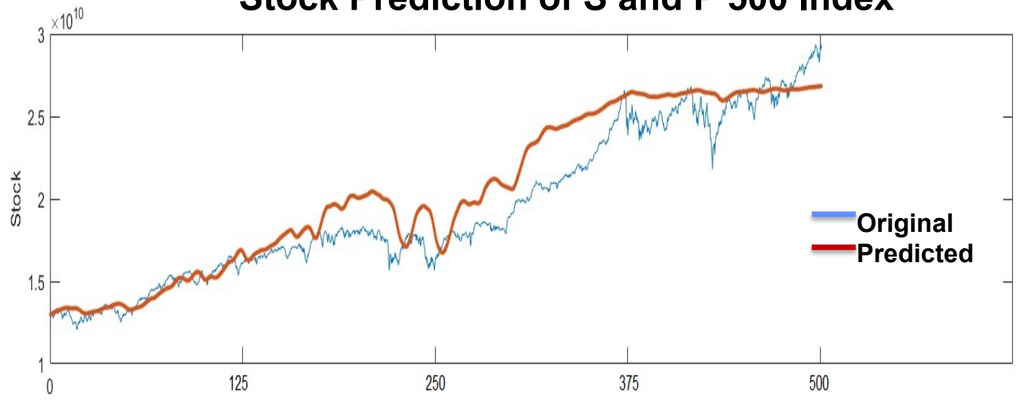
The experimental results

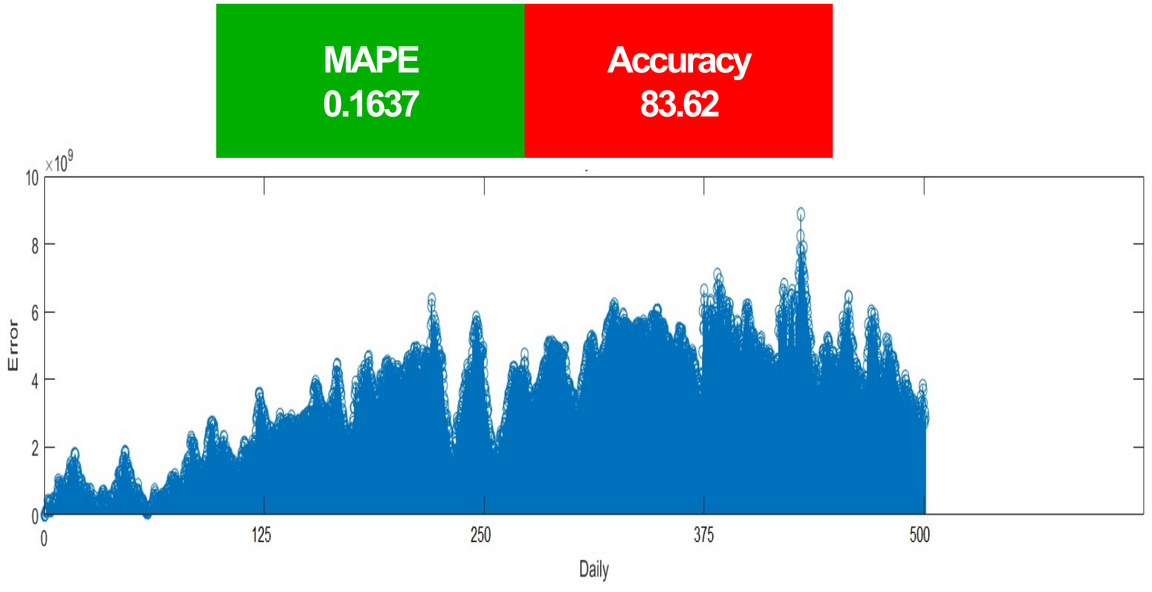
Table 3. The experimental results of Deep LSTM model has 4 main LSTM layers with the corresponding numbers of neurons {100, 150, 200, 250}.

Historical stock price data	Epochs/ iterations	Forecast measures			
		RMSE	MSE	MAPE	%Accuracy
Dow Jones Industrial					
	10	***9.2103***	***8.4830***	***0.1637***	***83.62***
	20	*9.1710*	*8.4107*	*0.1641*	*83.58*
	30	9.4367	8.9052	0.1701	82.98
	40	9.5171	9.0575	0.1716	82.83
	50	12.6853	1.6091	0.2512	74.87
S and P 500 Index					
	10	9.3511	8.7443	0.1672	83.27
	20	***8.4165***	***7.1673***	***0.1413***	***85.86***
	30	*8.8523*	*7.8673*	*0.1559*	*84.40*
	40	8.7039	7.5758	0.1534	84.65
	50	9.2103	8.4830	0.1637	83.62

The experimental results







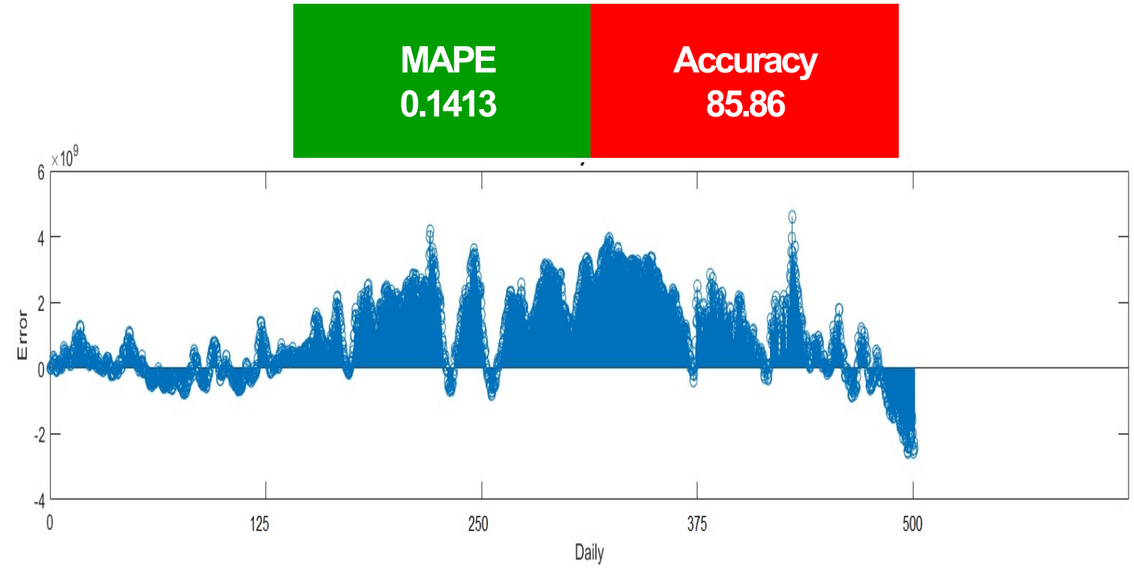


Figure 4. The best results of the original and the predicted stock prices (close price) on testing data.

Comparison:

Table 4. The results of our proposed Deep LSTM model compared with other models on Dow Jones Industrial.

Model	Performance Measure	References
	% Accuracy	
Deep LSTM	83.62	This paper
Recurrent Embedding Kernel (REK)	71.89	[17]
Events Embedding and Technical Indicators on CNN+LSTM	69.86	[18]

Comparison:

Table 5. The results of our proposed Deep LSTM model compared with other models on S and P 500 Index

Model	Performance Measure	References
	% Accuracy	
Deep LSTM	85.86	This paper
Variational Autoencoder LSTM (VAE-LSTM)	84.30	[19]
Recurrent Embedding Kernel (REK)	71.43	[17]
Events Embedding and Technical Indicators on CNN+LSTM	62.02	[18]

Conclusions :



We have presented a deep learning approach for stock prices prediction by using a ***Deep Long Short-Term Memory (Deep LSTM) model*** for the issue of the daily stock prices data.



The results of the Dow Jones industrial stock forecast have led to the least predictive with an accurate prediction of the stock market closing price as high as 83.62 percent.

The S and P 500 index prediction showed the least predictive with an accurate prediction of the stock market closing price as high as 85.86 percent.



To assess the effectiveness of the model, we have compared our test results with other research performances [17], [18], [19] that use Machine Learning techniques for stock market price prediction. ***It is obvious that the model we have designed provides the best predictive results***

THANK YOU FOR YOU ATTENTION

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