Stock Index Prediction with Machine Learning and Deep Learning Models

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Problem Overview

Why Predict Stock?

- Maximize profits
- Predict the economy
- Implement suitable economic policies

Challenges

- Stochastic nature
- Multiple factors

Project Objectives

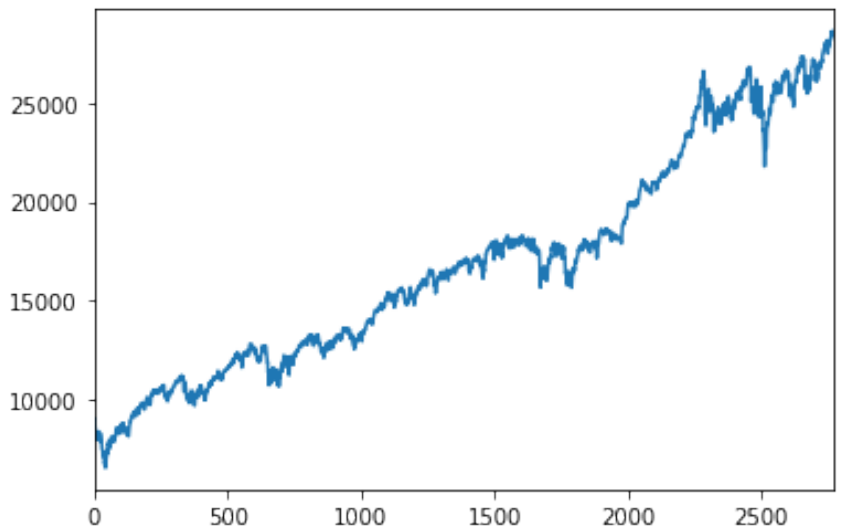
What are the Goals?

- Build a working ARIMA (Autoregressive Moving Average) model
- Build a working LSTM model
- Build a working CNN model
- Build a working feature fusion LSTM - CNN model
- Outputs: predicted daily closing for Dow Jones Industrial Average (DJIA)

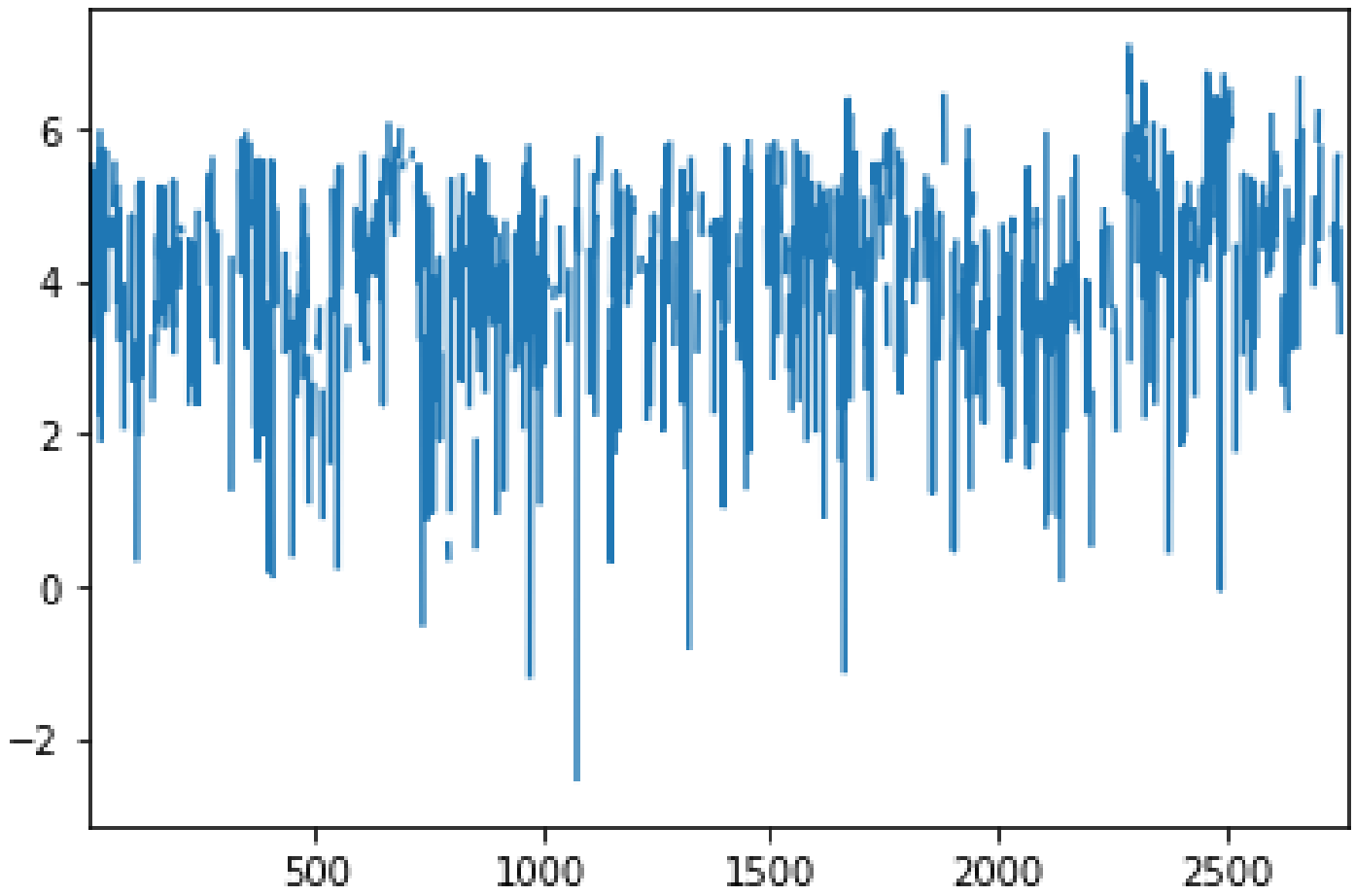
$$DJIA = \frac{\sum stock\ price}{d};\ \text{Dow divisor: } d \approx 0.152$$

Data Overview - Dow Jones 2009-2019

	Date	Open	High	Low	Close	Adj Close	Volume
0	2009-01-02	8772.250000	9065.280273	8760.780273	9034.690430	9034.690430	213700000
1	2009-01-05	9027.129883	9034.370117	8892.360352	8952.889648	8952.889648	233760000
2	2009-01-06	8954.570313	9088.059570	8940.950195	9015.099609	9015.099609	215410000
3	2009-01-07	8996.940430	8996.940430	8719.919922	8769.700195	8769.700195	266710000
4	2009-01-08	8769.940430	8770.019531	8651.190430	8742.459961	8742.459961	226620000



Data Overview - Dow Jones 2009-2017



ARIMA Model Results

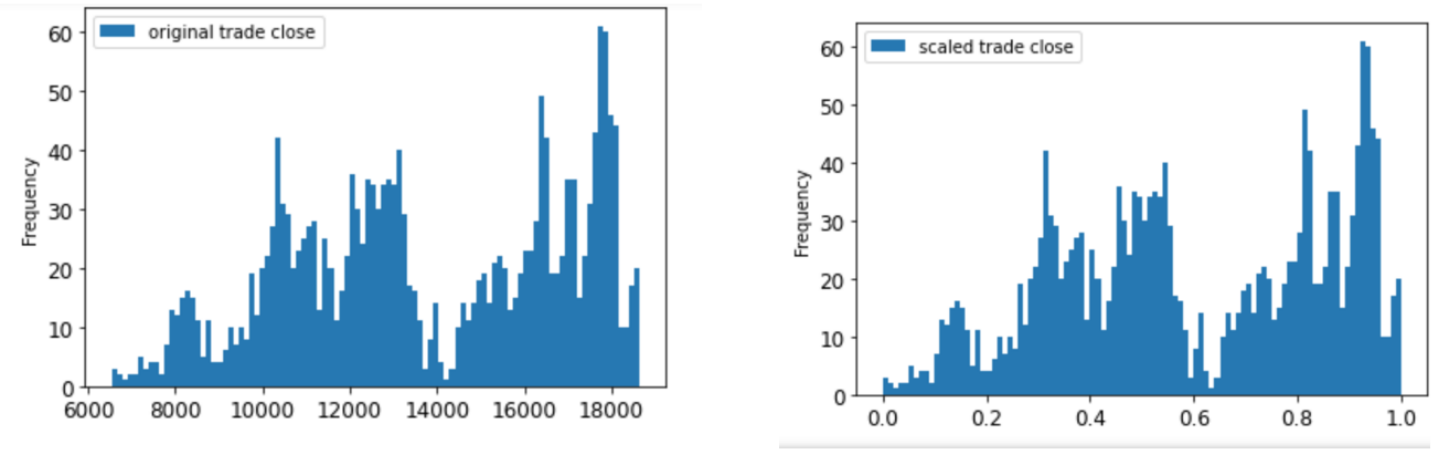
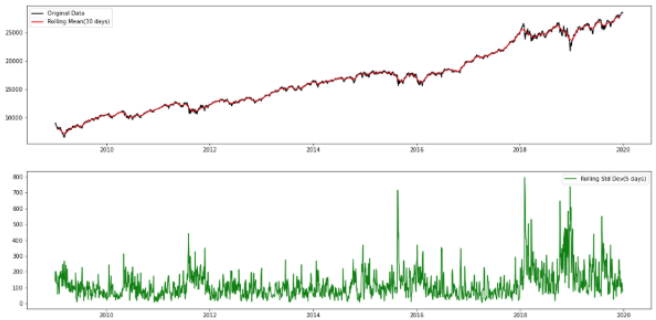


Figure: Original Trade Close and Scaled Trade Close

ARIMA Model Results

```
Dickey-Fuller test results

Test Statistic        0.220418
p-value               0.973384
# of lags            26.000000
# of obs           2740.000000
dtype: float64
Critical value at 1%: -3.43274
Critical value at 5%: -2.86260
Critical value at 10%: -2.56733
```



```
Dickey-Fuller test results

Test Statistic   -1.127456e+01
p-value           1.507773e-20
# of lags         2.500000e+01
# of obs          2.740000e+03
dtype: float64
Critical value at 1%: -3.43274
Critical value at 5%: -2.86260
Critical value at 10%: -2.56733
```

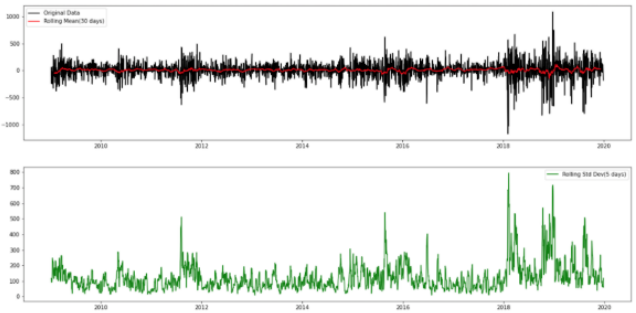


Figure: Test for Data Stationarity

ARIMA Model Results

Hyper-parameters estimation:

- Differencing (d): make time series stationary, avoding ovr differenced series.
- Auto-Regression AR (p): Investigating Partial Auto-correction (PACF) for defining p
- Moving Average MA (q): Investigating Auto-correlation (ACF) for estimating q

ARIMA Model Results

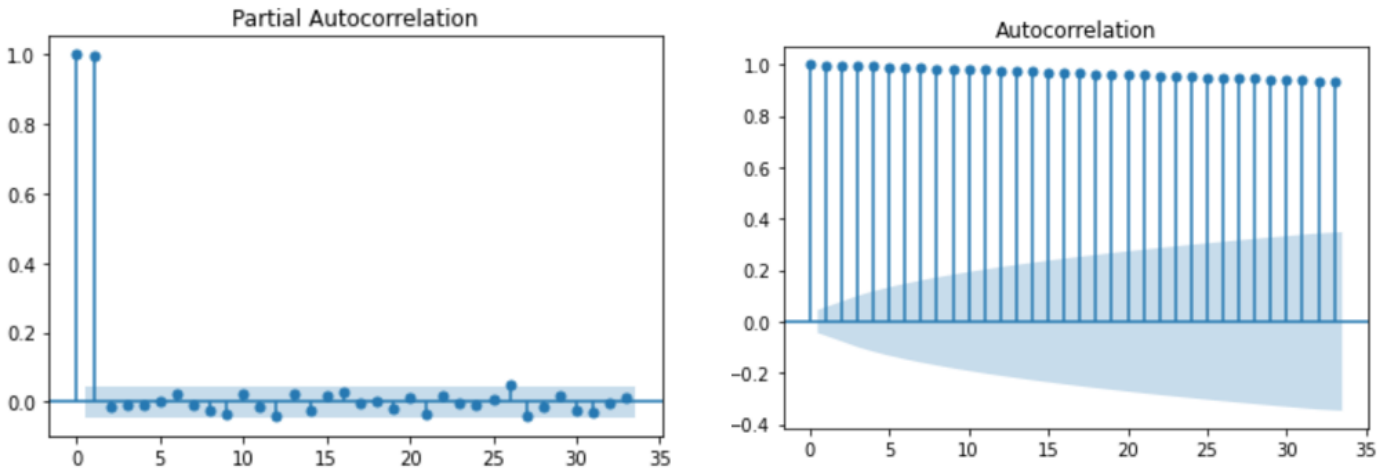


Figure: PACF and ACF plot

ARIMA Model Results

SARIMAX Results

Dep. Variable:	Close	No. Observations:	1936
Model:	ARIMA(1, 1, 1)	Log Likelihood	6068.774
Date:	Sun, 27 Dec 2020	AIC	-12131.548
Time:	02:43:23	BIC	-12114.844
Sample:	0	HQIC	-12125.404
	- 1936		
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
ar.L1	-0.5159	0.254	-2.033	0.042	-1.013	-0.018
ma.L1	0.4718	0.262	1.797	0.072	-0.043	0.986
sigma2	0.0001	2.5e-06	44.166	0.000	0.000	0.000

Ljung-Box (L1) (Q):	0.01	Jarque-Bera (JB):	409.21
Prob(Q):	0.94	Prob(JB):	0.00
Heteroskedasticity (H):	1.73	Skew:	-0.32
Prob(H) (two-sided):	0.00	Kurtosis:	5.16

Figure: Results for ARIMA Model(1,1,1)

ARIMA Model Results

	timestamp	h	prediction	actual
1	8/10/15	t+1	17370.500507	17615.16992
2	8/11/15	t+1	17685.151502	17402.83984
3	8/12/15	t+1	17361.905542	17402.50977
4	8/13/15	t+1	17412.633924	17408.25000
5	8/14/15	t+1	17401.151941	17477.40039

Figure: Predictions from ARIMA with MAPE(Multi-step)=1.06%

ARIMA Model Results

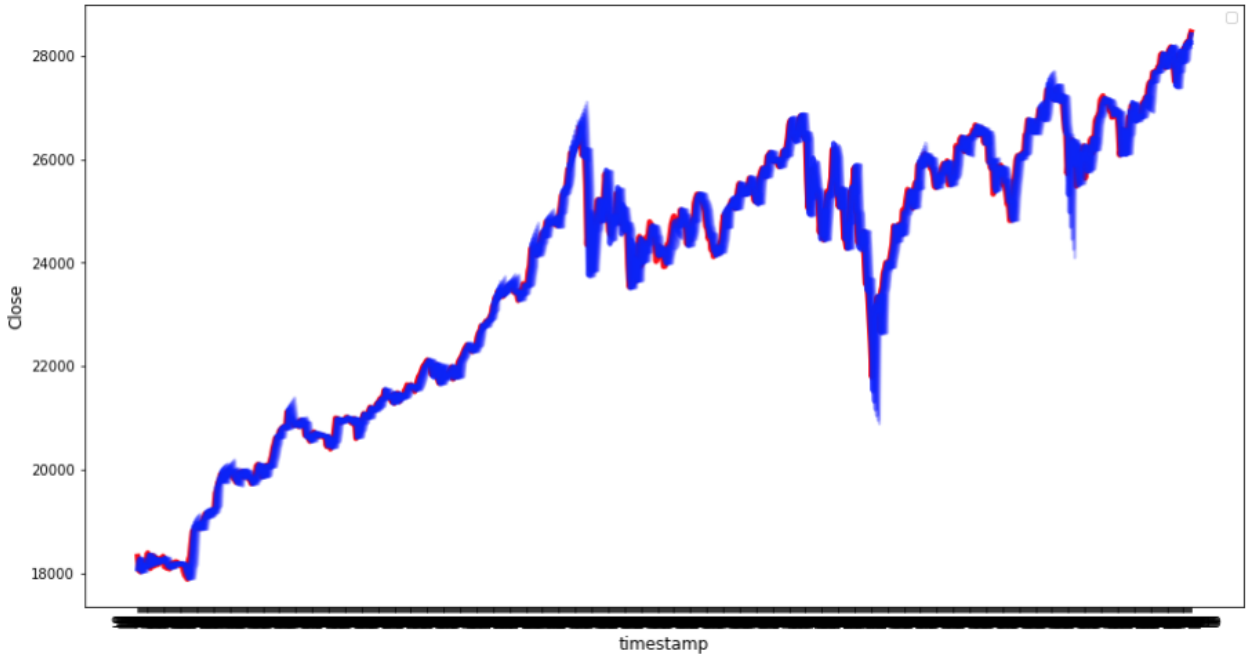
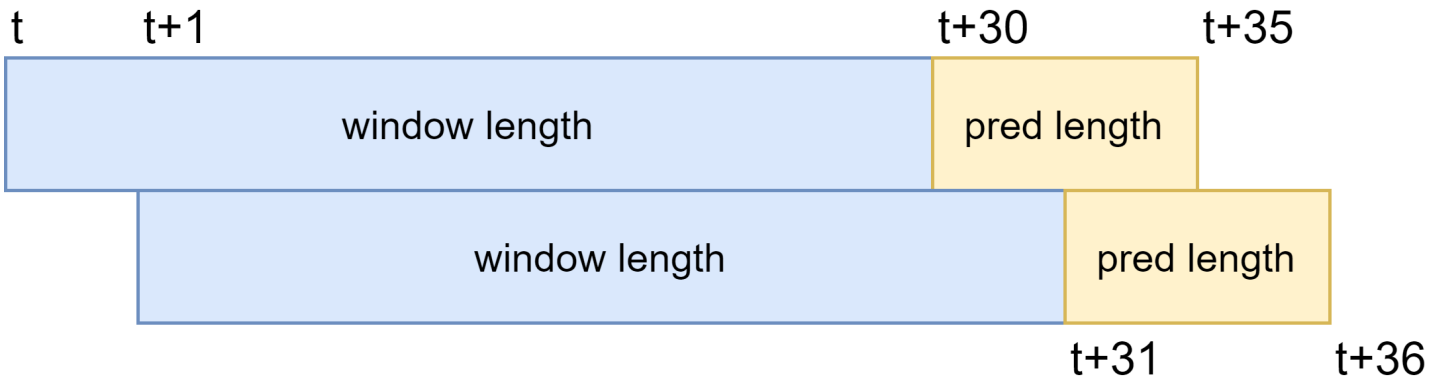


Figure: Plot of Actual and Predicted Values

LSTM Model Results



Previous 30 Days Data $\xrightarrow{\text{LSTM}}$ 5 Days Prediction

LSTM Model Results

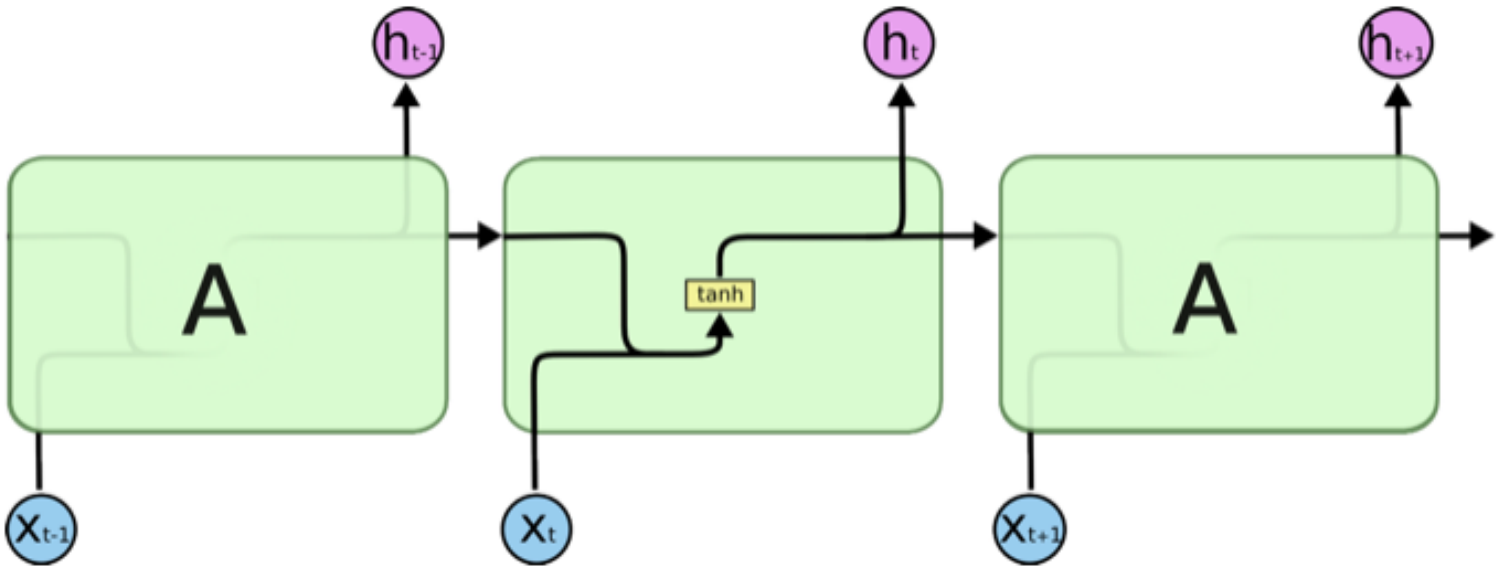


Figure: Simple 1-layer LSTM architecture

LSTM Model Results (Training)

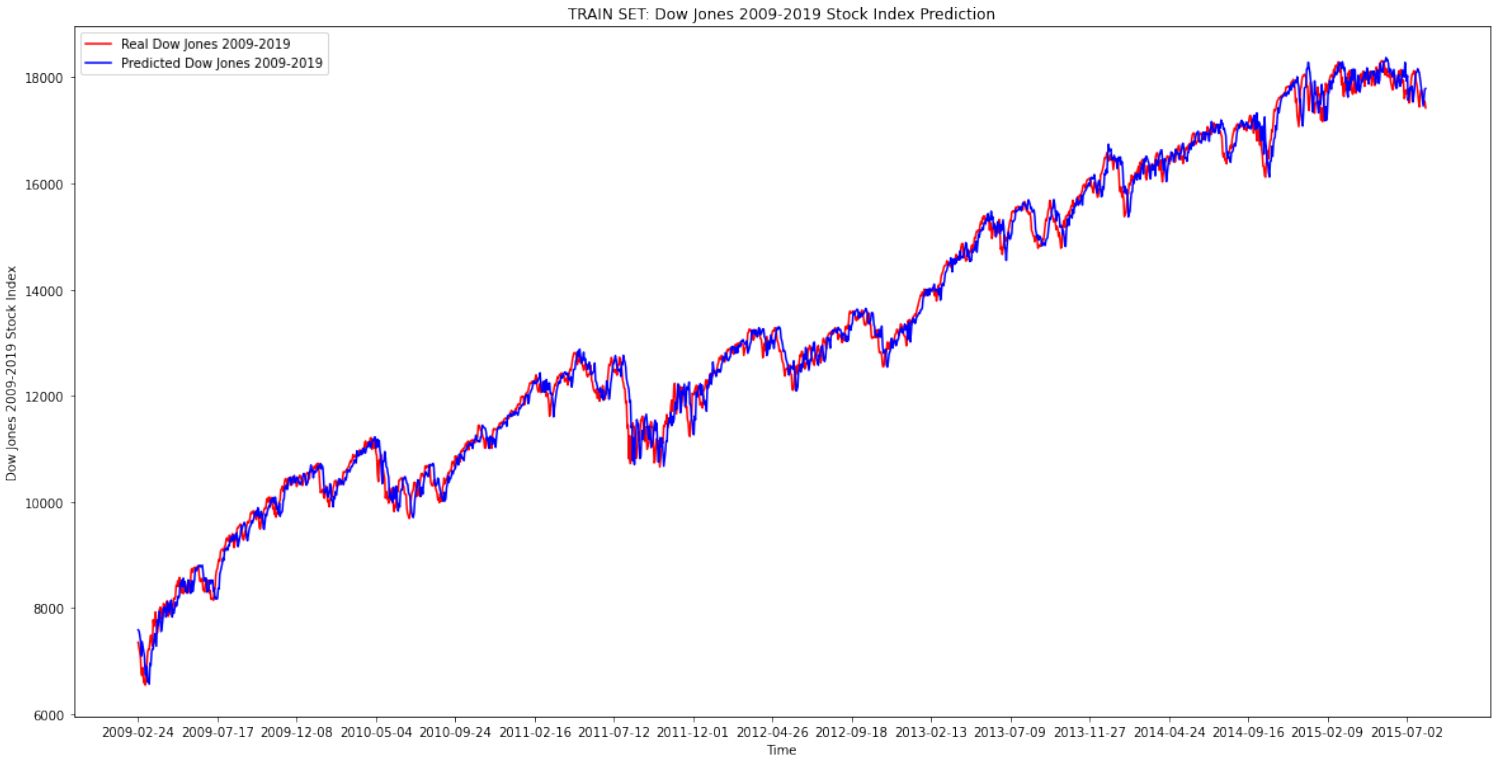


Figure: LSTM Model on Training Set

RMSE = 263.2288, MAE = 208.7557

LSTM Model Results (Testing)

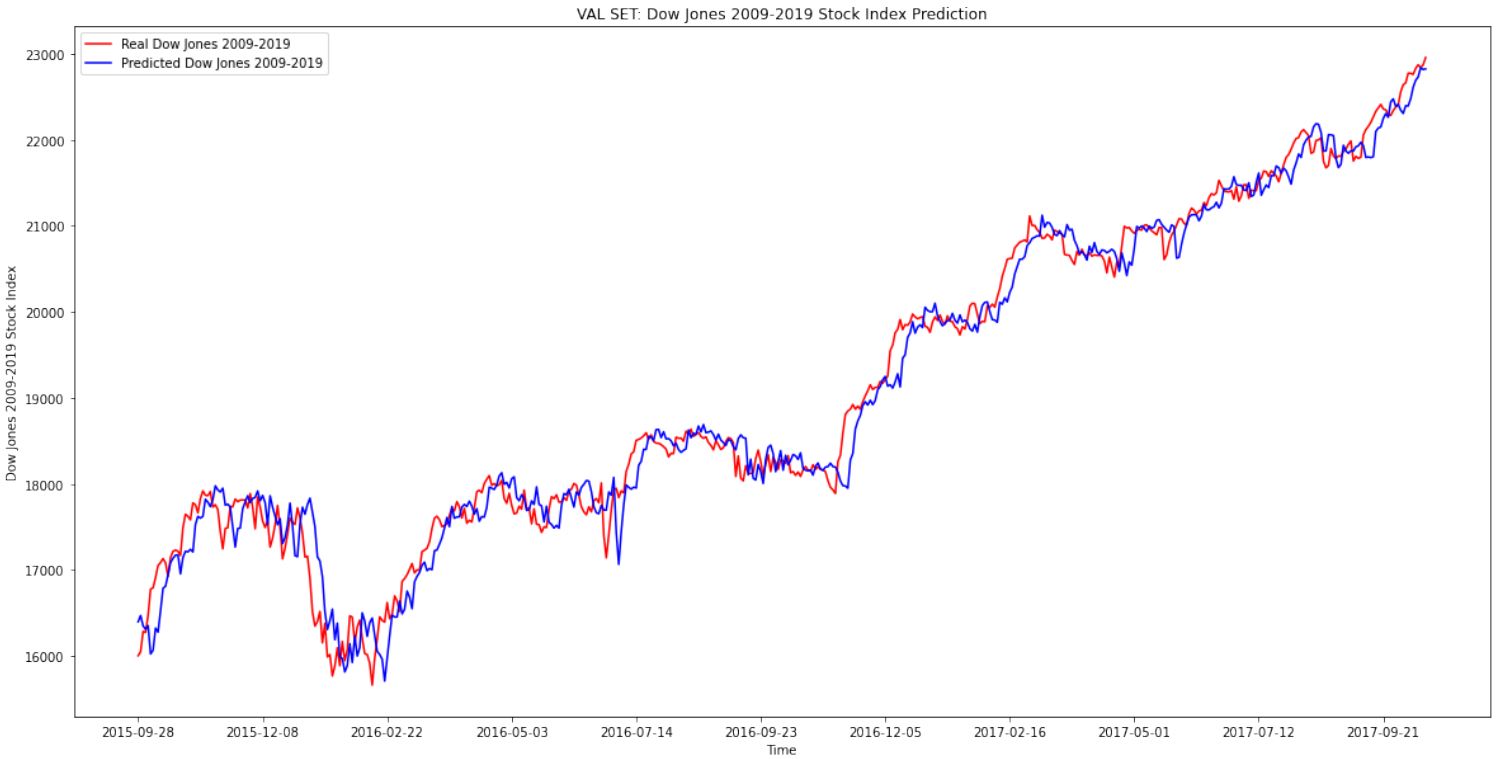
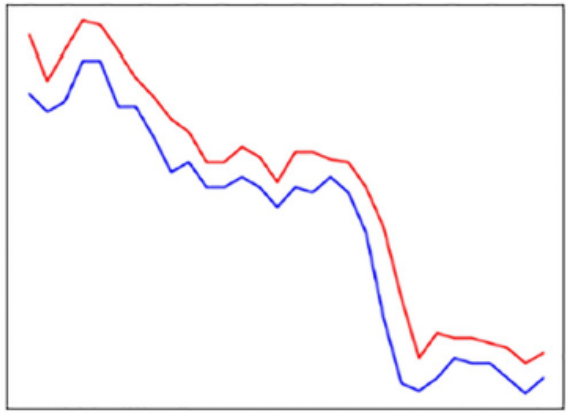


Figure: LSTM Model on Test Set

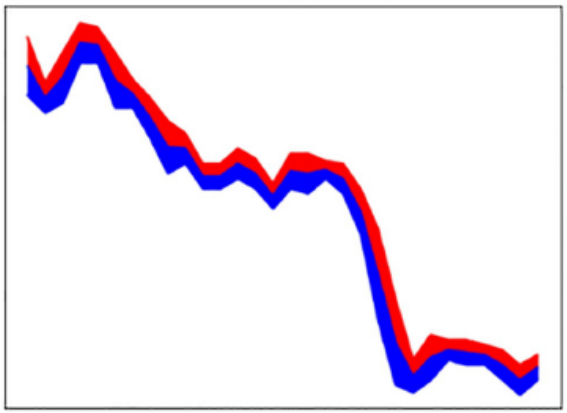
RMSE = 296.7456, MAE = 228.3258

CNN Model Results

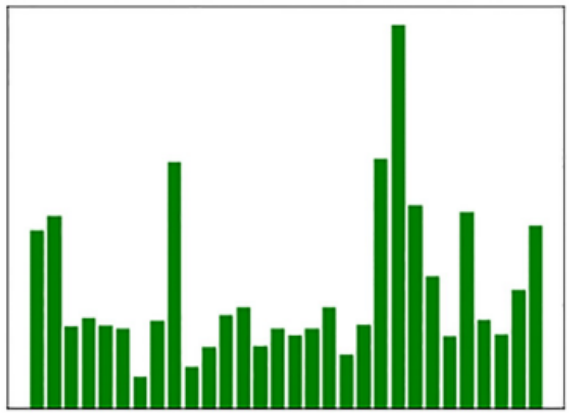
(a)



(b)



(c)



(d)

CNN Model Results (Training)

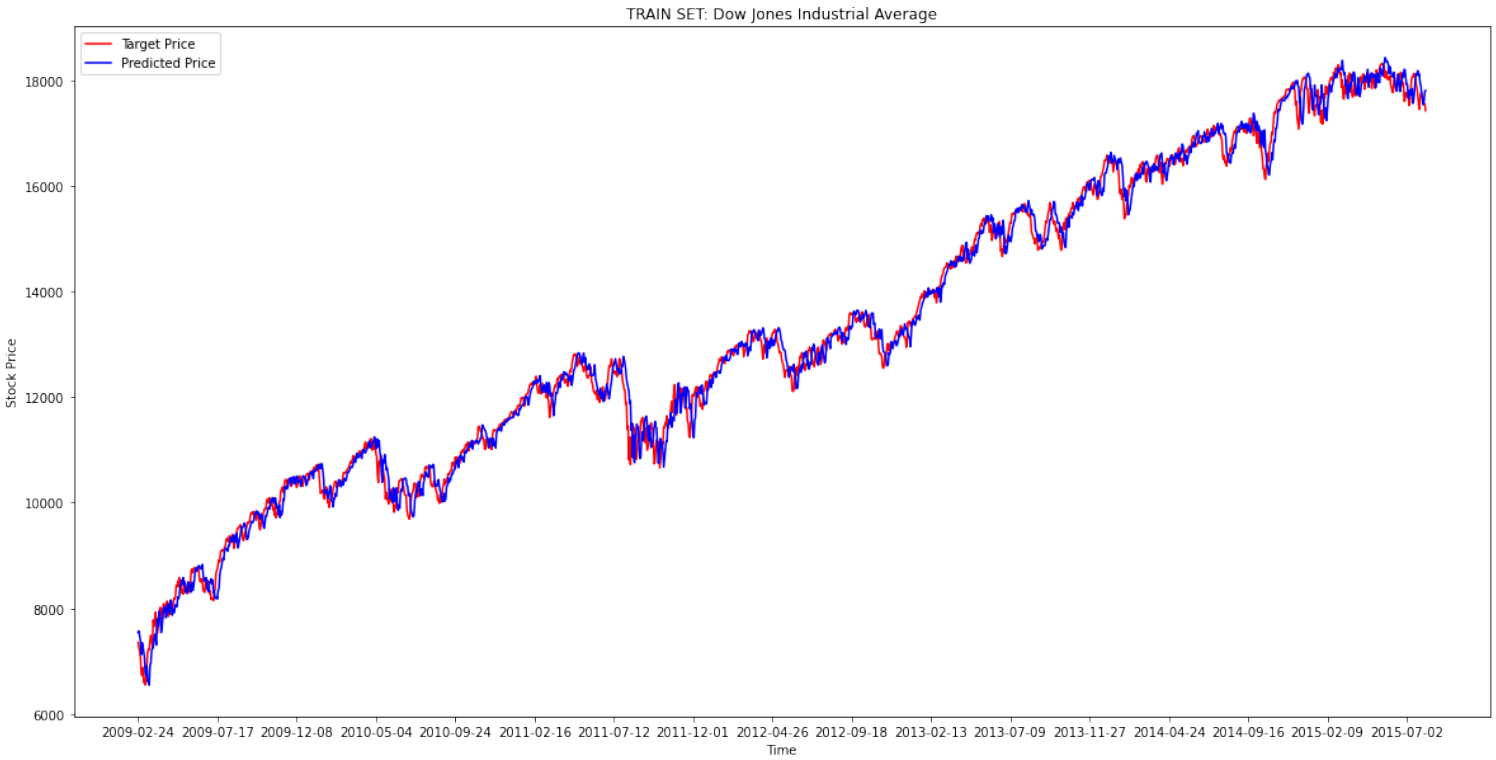


Figure: CNN Model on Training Set

RMSE = 250.6945, MAE = 191.6990

CNN Model Results (Testing)

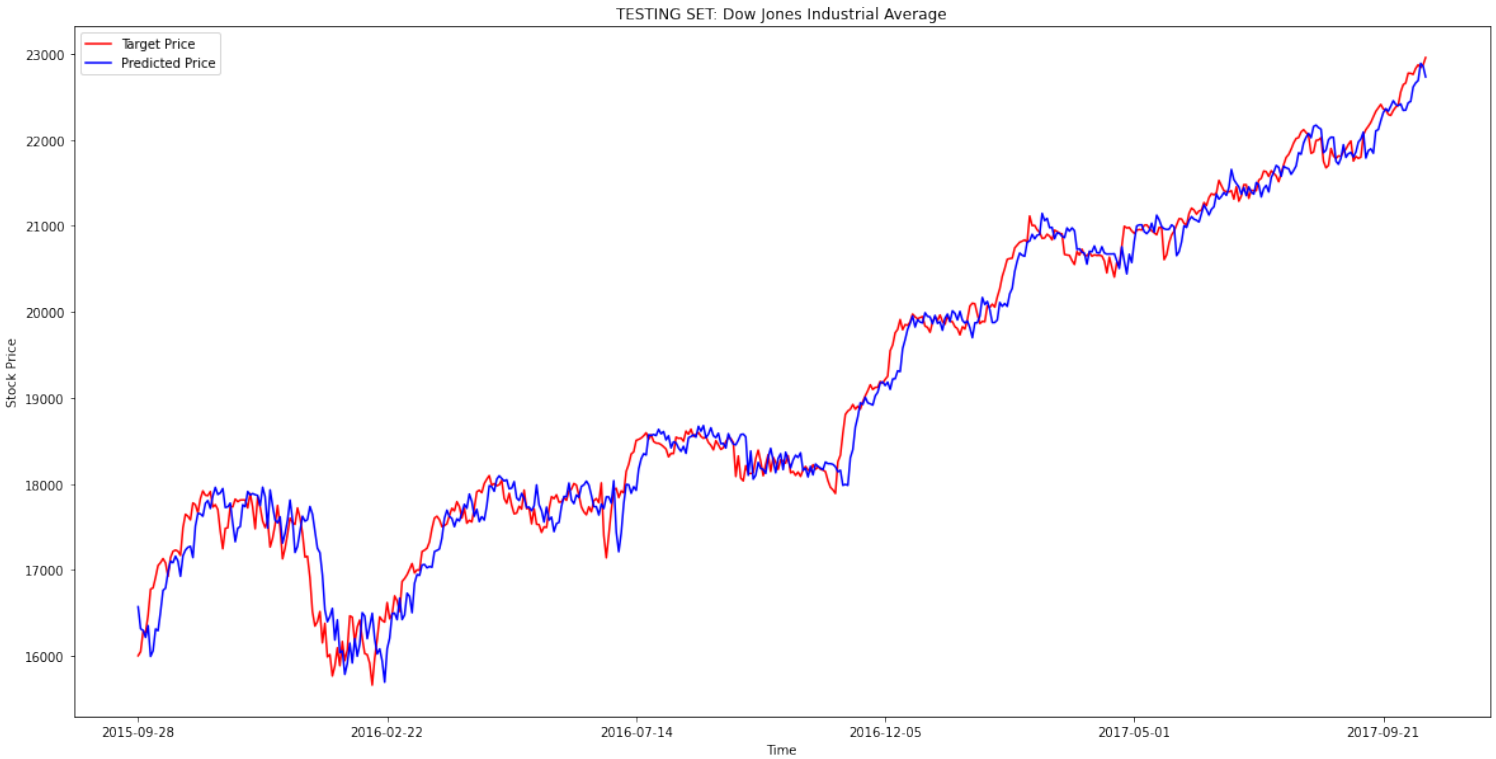
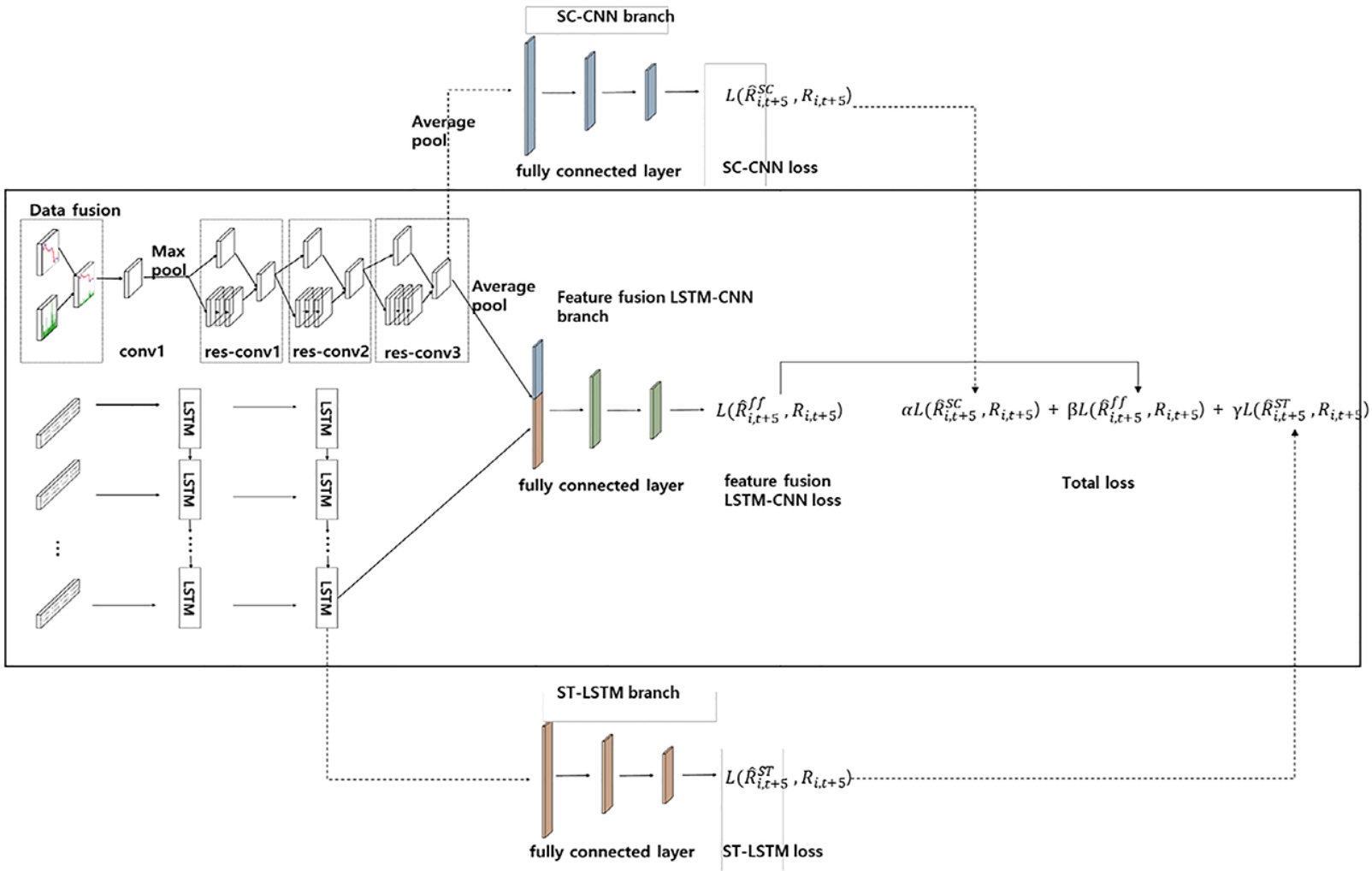


Figure: CNN Model on Test Set

$$\text{RMSE} = 270.6161,\ \text{MAE} = 201.3691$$

LSTM-CNN Model Results



LSTM-CNN Model Results (Training)

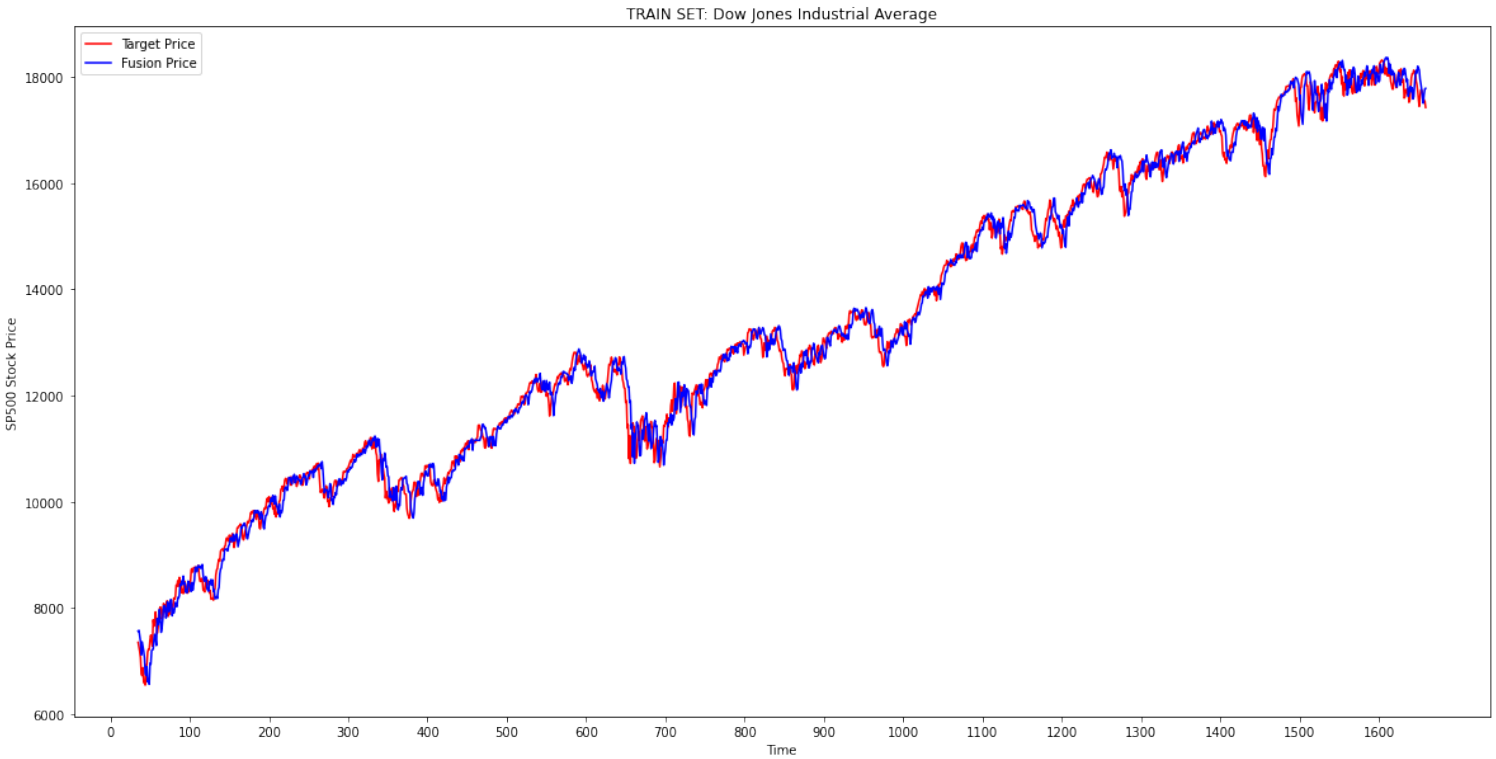


Figure: LSTM-CNN Model on Training Set

$$\text{RMSE} = 251.2169,\ \text{MAE} = 191.4447$$

LSTM-CNN Model Results (Testing)

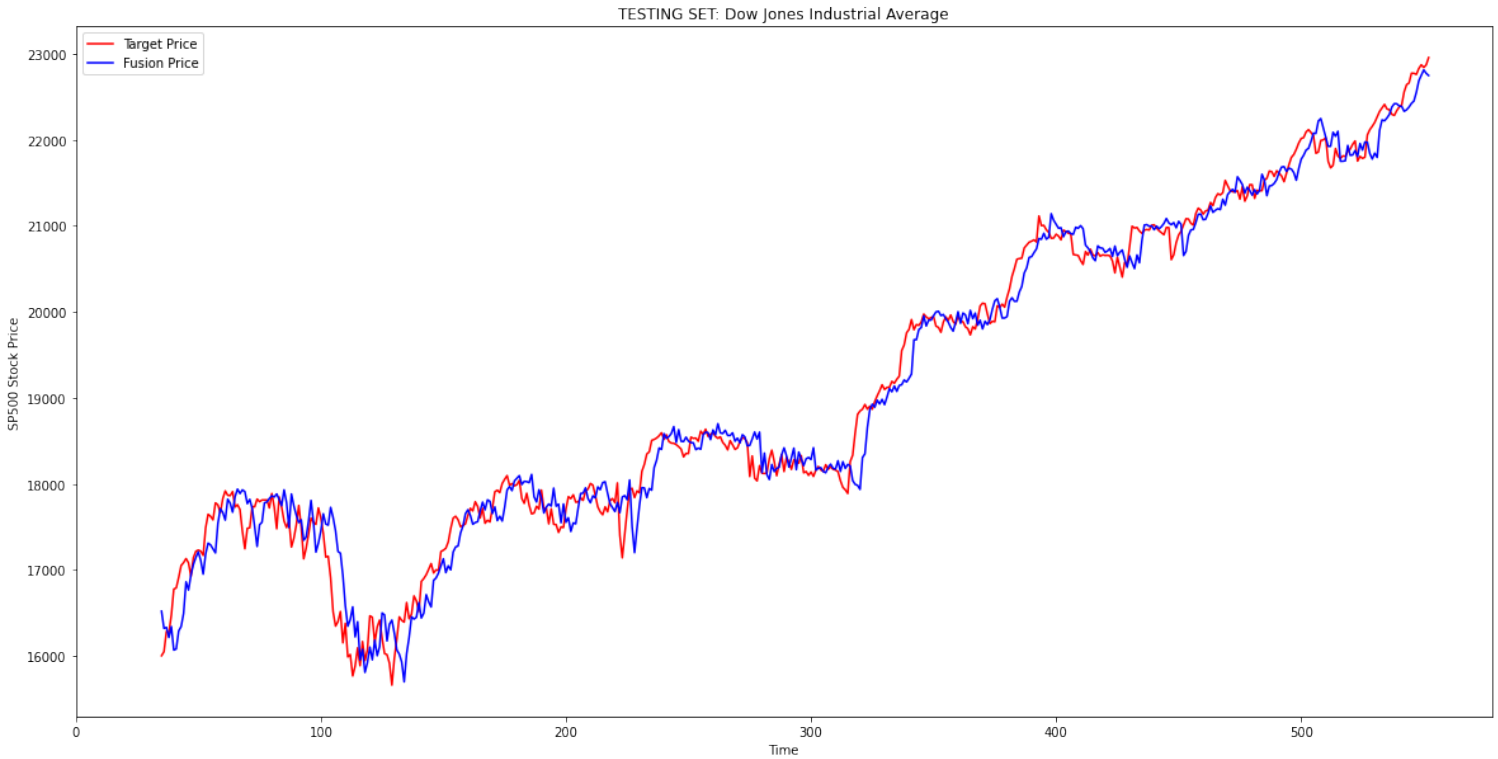


Figure: LSTM-CNN Model on Test Set

RMSE = 267.5648, MAE = 198.2916

Future Work

- Implement sentiment analysis to extract relevant stock news.
- Implement Generative Adversarial Network (GAN) with LSTM.
- Use Deep Reinforcement Learning (DRL) for deciding GAN's hyper-parameters.

Reference

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