STOCK PRICE PREDICTION USING SENTIMENT ANALYSIS

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INTRODUCTION: REDDIT and ALTERNATIVE DATA in STOCK PERFORMANCE ANALYSIS

- In recent times, Reddit has surfaced as a favored platform for engaging in conversations and deliberations spanning a broad array of subjects, which encompass financial matters and investments.
- With a multitude of users sharing their viewpoints and understandings concerning diverse stocks and financial markets, Reddit has transformed into a valuable information pool for gauging sentiments within the financial domain.
- Additionally, with the emergence of Alternative Data as a growing source to evaluate Market Performance, studying the impact of market sentiment could add for an invaluable measure while studying possible vulnerabilities of a stock.
- This project delves into the application of sentiment analysis for assessing the fluctuations of widely-held stocks, employing Reddit headlines and comments as a wellspring of market sentiment.
- This project aims to scrutinize pre-existing studies that leverage sentiment analysis derived from Reddit to approximate market volatility, and consequently, future gains.

KEY OBJECTIVES

- **Assessing Market Movement through Sentiment Analysis**: To investigate the feasibility and effectiveness of utilizing sentiment analysis on Reddit headlines and comments to evaluate the correlation between public sentiment and the movement of popular stocks.
- **Reviewing Existing Reddit Sentiment Analysis Research**: To conduct a comprehensive review and synthesis of existing research studies that employ sentiment analysis derived from Reddit to predict market volatility, estimate future stock returns, and assess the reliability of these approaches.
- **Comparing Social Media vs. Traditional Analysis:** To perform a comparative analysis that assesses the relative effectiveness and predictive capabilities of social media sentiment analysis in contrast to conventional methods of market analysis, such as technical and fundamental analysis.
- **Sentiment Analysis Methodology:** To implement a sentiment analysis methodology that computes the sentiment polarity of public discussions on a given day within the studied time frame, leveraging data extracted from the selected social media platform (Reddit).
- **Pattern Analysis for the Sentiment-Stock Relationship:** To systematically examine recurrent patterns in the connection between market sentiment outcomes and stock price movements, investigating whether specific sentiment patterns correlate with stock price highs and lows.
- **Develop a predictive model for Stock Returns/Prices:** To design and construct a predictive model, preferably utilizing a Recurrent Neural Network (RNN), that combines sentiment data from social media with historical stock prices to forecast future stock returns or prices within the chosen time frame.

SENTIMENT ANALYSIS IN FINANCIAL MARKETS

- Analysis of Stock market returns has been an eon-old field of research, with multiple approaches evolving over time to accurately guess market returns.
- Some of these include Fundamental and Technical Analysis, Time Series, and Forecasting using traditional methods and machine learning approaches.
- The use of Sentiment Analysis is a relatively new approach that uses unstructured textual data to extract public opinion.
- Sentiment and Lexicon-based analyses thus provide a novel, more direct approach to obtaining data that truly represents individual opinions.
- In light of this, there have been many case studies of use cases as well as public data repositories on platforms like Kaggle and GitHub that have made clean and well-organized data more accessible for everyone to contribute to creating a more sophisticated model.
- The idea vests in the understanding that public opinion drives market dynamics and a “negative” or “positive” sentiment could trigger a bearish or a bullish trend, as illustrated in the graphic below:

DATA SNAPSHOT

SELECTED COMPANIES

APPLE INC. (AAPL)
GOOGLE (GOOG)
MICROSOFT (MSFT)
NVIDIA (NVDA)
TESLA (TSLA)

DATE RANGE

TRAIN: 01/03/23 TO 09/06/23
TEST: 10/06/23 TO 01/07/23

RESPONSE VARIABLE

ADJ_CLOSE PRICE AT TIME T+1

FINANCIAL PREDICTORS

OPEN, HIGH, LOW, VOLUME

SENTIMENT PREDICTORS

WEIGHTED SUBJECTIVITY
WEIGHTED COMPOUND SCORE

TEXT DATA STRUCTURE (POST PREPROCESSING & AGG)

DATE	SCORE	W_SUBJ	W_COMP

FINANCIAL DATA STRUCTURE

DATE	OPEN	HIGH	LOW	ADJ_CLOSE	VOLUME

REDDIT DATA PROCESSSING

APPLE EXAMPLE

EXTRACTED FILES FROM REDDIT USING TICKER NAME and WWDC

- stocks_AAPLsubreddit.csv
- stocks_comments_AAPLsubreddit.csv
- stocks_comments_WWDCsubreddit.csv
- stocks_WWDCsubreddit.csv
- wallstreetbets_AAPLsubreddit.csv
- wallstreetbets_comments_AAPLsubreddit.csv
- wallstreetbets_comments_WWDCsubreddit.csv
- wallstreetbets_WWDCsubreddit.csv

MERGE HEADLINES FILES

```
apple_headline.head(3)
```

	id	date	text	score	headline_url	comms_num
0	zcpv08	2022-12-04	Someone purchased $1.3 BILLION worth of $AAPL stock on Friday at the close😱	20775	https://i.redd.it/49zb21awd04a1.jpg	1568
1	z3v93y	2022-11-24	Chinese Foxconn workers facing off against police at the largest iPhone factory. Puts on AAPL	10468	https://v.redd.it/fz7jws2lwy1a1	954

MERGE COMMENTS FILES

```
apple_comments.head(3)
```

	id	date	text	score	comment_parent_id	comment_link_id
0	iyxtez3	2022-12-04	Warren Buffet. He did his annual couch cleaning in the morning	12038	t3_zcpv08	t3_zcpv08
1	iyxte97	2022-12-04	Yes, I saw that on Friday. That's pretty significant, it's about 10% of the average daily traded volume. If you look back to either Thursday or Wednesday of last week, the same thing happened ri...	2476	t3_zcpv08	t3_zcpv08
2	iyxrok5	2022-12-04	The proportion of that to market cap is like your pp compared to mine	5831	t3_zcpv08	t3_zcpv08

LEMMATIZATION

WORDNETLEMMATIZER() USING NLTK

Considers the Context and converts the word to its meaningful base form

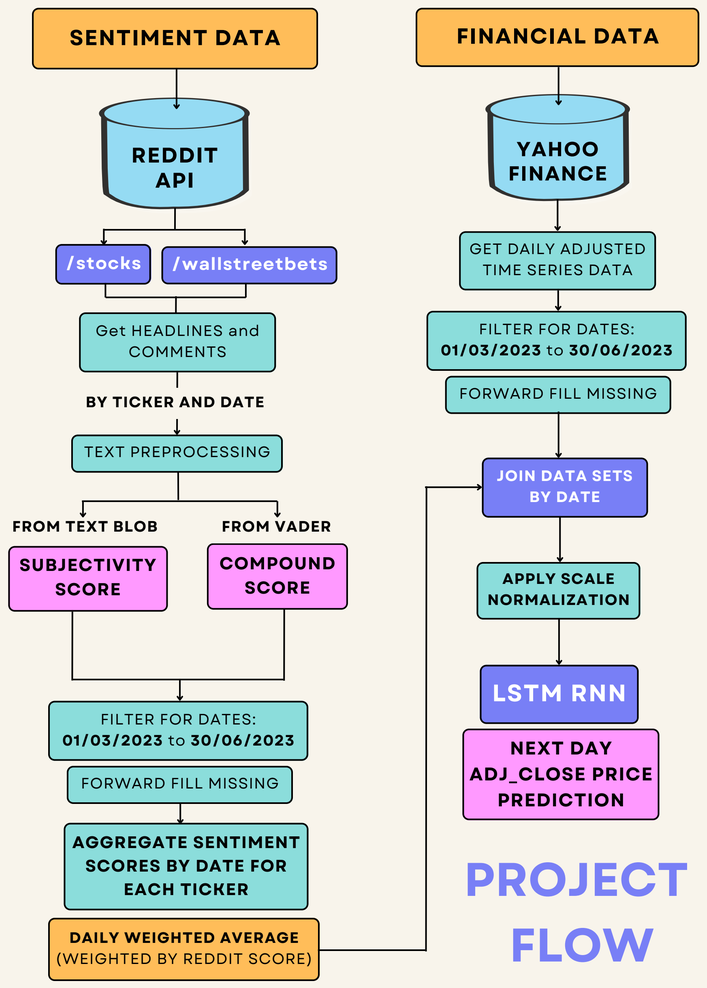
```
# Apply the preprocessing function to your 'text' column
apple['preprocess'] = apple['text'].apply(preprocess_text)
```

PREPROCESSING STEPS preprocess_text() function

- CHECK IF 'TEXT' IS A NON-NULL STRING
- REMOVE PUNCTUATION
- CONVERT TO LOWERCASE
- TOKENIZE TEXT
- REMOVE STOPWORDS
- FILTER OUT SHORT WORDS
- JOIN TOKENS BACK INTO A STRING

```
apple[['date','text','preprocess']].head()
```

	date	text	preprocess
0	2022-12-04	Someone purchased $1.3 BILLION worth of $AAPL stock on Friday at the close😱	someone purchased billion worth aapl stock friday close
1	2022-11-24	Chinese Foxconn workers facing off against police at the largest iPhone factory. Puts on AAPL.	chinese foxconn worker facing police largest iphone factory put aapl
2	2022-09-13	Diversification is Important	diversification important



PROJECT FLOW

SENTIMENT ANALYSIS

APPLE EXAMPLE

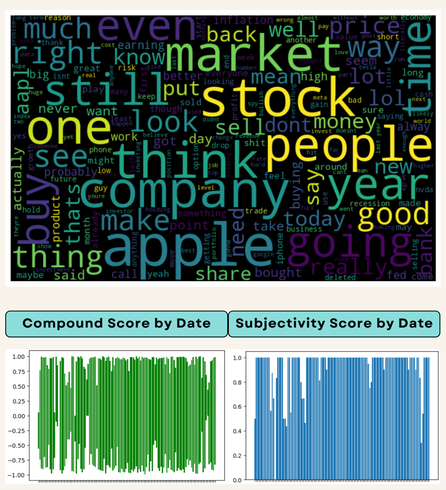
SENTIMENT ANALYSIS

```
#Create a function to get the subjectivity
def getSubjectivity(text):
  return TextBlob(text).sentiment.subjectivity

#Create a function to get the sentiment scores
def getSIA(text):
  sia = SentimentIntensityAnalyzer()
  sentiment = sia.polarity_scores(text)
  return sentiment
```

SUBJECTIVITY FROM **TEXTBLOB**
COMPOUND SCORE FROM **SIA (VADER)**

	date	score	Subjectivity	Compound
0	2023-06-06	6842	0.600000	0.4404
1	2023-06-06	5802	0.000000	0.0000
2	2023-05-09	5734	0.314167	-0.0258
3	2023-03-03	4954	0.000000	0.2500

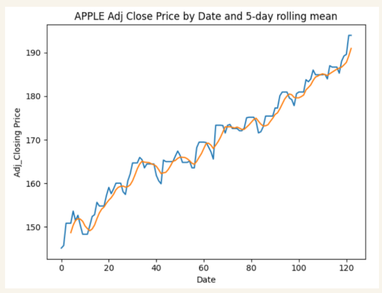
	date	score	w_subj	w_comp
0	2023-03-01	3	0.166667	-0.168600
1	2023-03-02	3600	0.155467	-0.355207
2	2023-03-03	8677	0.185994	0.186974
3	2023-03-04	4358	0.391205	0.397080



Compound Score by Date

Subjectivity Score by Date

- **Sentiment measures do not have a sequential dependence**
- **Most text samples are subjective in nature**



RECURRENT NEURAL NET (LSTM)

MODEL = SEQUENTIAL()
MODEL LAYER 1:
*** LSTM UNITS = 64**
DROPOUT LAYER: 0.25
OUTPUT LAYER:
*** UNITS = 1**
*** ACTIVATION: LINEAR**

ADAM OPTIMIZER (LR = 0.01)
EPOCHS = 60

EARLY STOPPING:
PATIENCE = 15
REDUCE LR ON PLATEAU:
PATIENCE = 15

RMSE	2.9831
MAE	2.5370
MAPE	0.0135

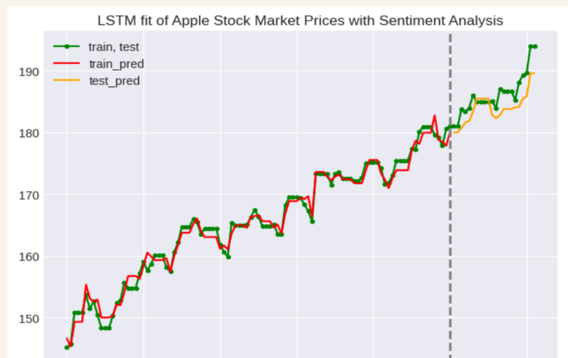
Train Loss	0.0022
Test Loss	0.0149

```
Layer (type)                 Output Shape              Param #
=================================================================
lstm_1 (LSTM)                (None, 64)                16896

dropout_1 (Dropout)          (None, 64)                0

dense_1 (Dense)              (None, 1)                 65

=================================================================
Total params: 16,961
Trainable params: 16,961
Non-trainable params: 0
```

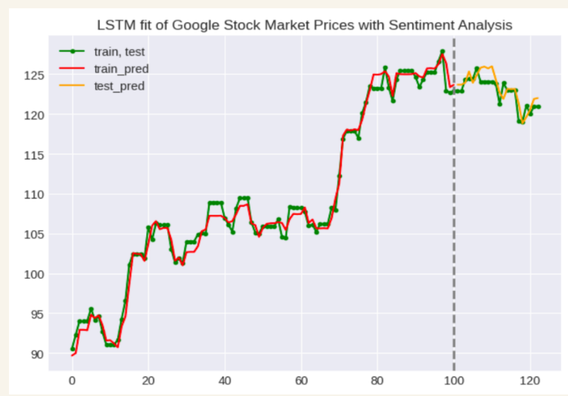
VALIDATION SPLIT = 0.2

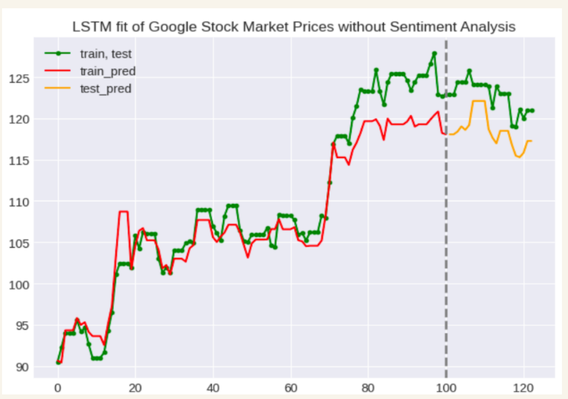
COMPANY-WISE RESULTS OF FIT WITH AND WITHOUT THE INCLUSION OF SENTIMENT SCORES (TRAIN AND TEST)

APPLE (AAPL)

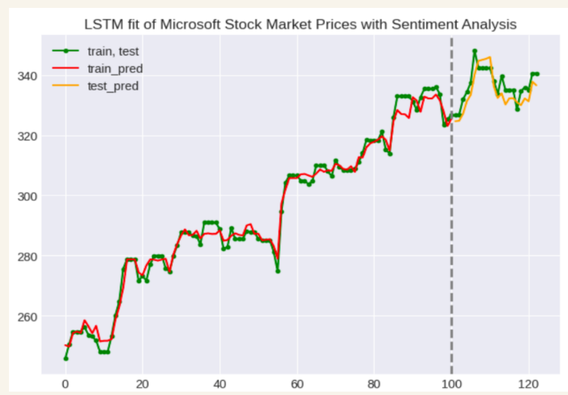


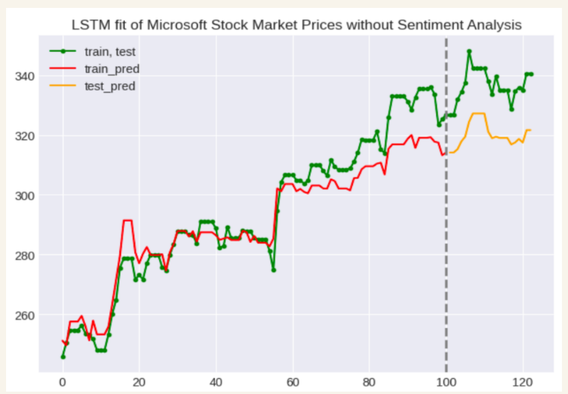
GOOGLE (GOOG)



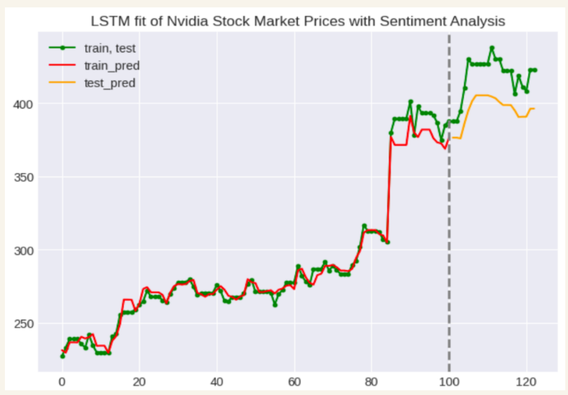


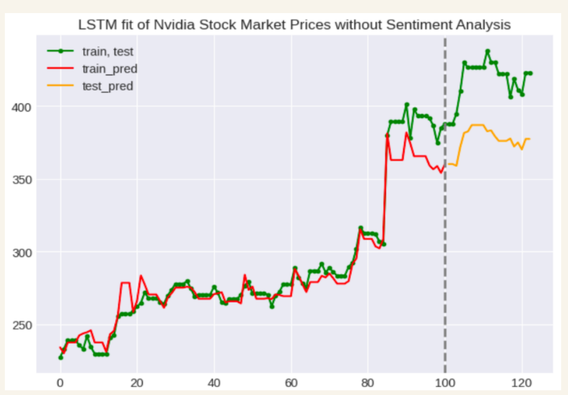
MICROSOFT (MSFT)



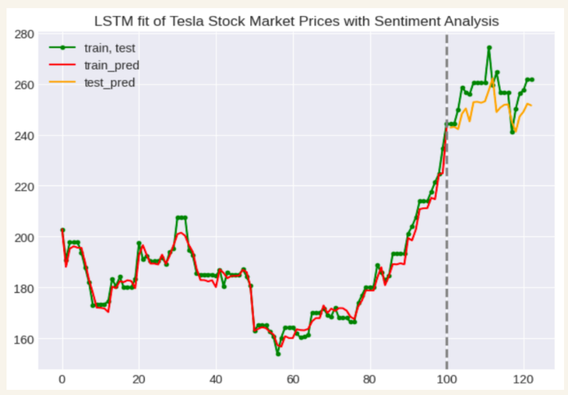


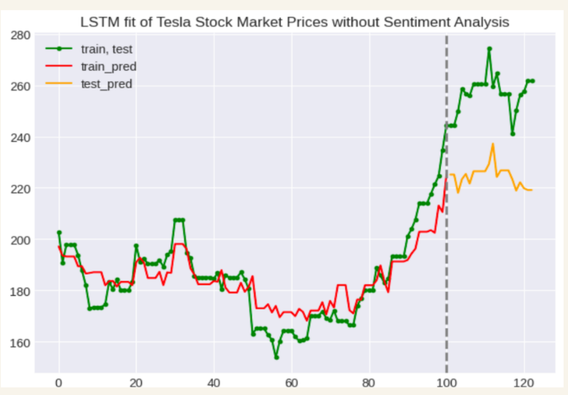
NVIDIA (NVDA)





TESLA (TSLA)





MODEL EVALUATION (RMSE, MAE, MAPE, TEST & VALIDATION LOSS)

Company	Metrics	With Sentiment Metrics	Without Sentiment Metrics
APPLE	RMSE	**2.9831**	7.4547
	MAE	**2.5370**	7.0735
	MAPE	**0.0135**	0.0379
GOOGLE	RMSE	**1.2020**	4.5130
	MAE	**1.0026**	4.2552
	MAPE	**0.0082**	0.0346
MICROSOFT	RMSE	**3.7656**	16.6647
	MAE	**3.4598**	16.4653
	MAPE	**0.0102**	0.0488
NVIDIA	RMSE	**23.7111**	42.1509
	MAE	**22.8826**	41.5345
	MAPE	**0.0544**	0.0989
TESLA	RMSE	**8.5815**	33.1223
	MAE	**7.6951**	32.3034
	MAPE	**0.0297**	0.1252

Company	Metrics	With Sentiment Metrics	Without Sentiment Metrics
APPLE	Validation Loss	**0.0022**	0.0138
	Test Loss	**0.0149**	0.0931
GOOGLE	Validation Loss	**0.0027**	0.0266
	Test Loss	**0.0055**	0.0582
MICROSOFT	Validation Loss	**0.0025**	0.0216
	Test Loss	**0.0054**	0.1060
NVIDIA	Validation Loss	**0.0038**	0.0125
	Test Loss	**0.0504**	0.1594
TESLA	Validation Loss	**0.0025**	0.0191
	Test Loss	**0.0202**	0.3012

RESULTS AND CONCLUSIONS

- The results obtained upon the implementation of the prediction algorithm for Adjusted Closing Price, we notice that the inclusion of the Sentiment Parameters makes a positive impact on improving performance
- The model fit didn't require a lot of hyperparameter tuning, with only minor adjustments made to the **number of input units**, **number of epochs**, and **dropout rate**.
- The sentiment analysis scores weighted by **Reddit Score** (Given as Number of Upvotes - Number of Downvotes) as the weight component in calculating the aggregate sentiment score for each day accounted for the level of interaction on a particular comment/headline thereby evaluating the average sentiment for each day appropriately in accordance with the "influence" of the particular text.
- Sentiment features, i.e., Subjectivity Score and Compound score prove to be particularly impactful in predicting future values where there have been huge spikes/dips (as observed in behaviour of Microsoft, Nvidia, and Tesla) since the improvement in the evaluation measures of Root Mean Squared Error, Mean Absolute Error and Mean Absolute Percentage Error has been greater in these cases than the rest.
- As an extended study, evaluating the data and analysing the unpredictable highs and lows might facilitate for the creation of a simulation to generate worst-case scenarios for companies to use while conducting stress tests or developing Business Continuity Plans.