Bitcoin-Sentiment-Analysis

May 21, 2022

1 Sentiment Analysis to predict fluctuations in Bitcoin markets

1.1 *Abstract*

This study examines the impact of sentiment on the fluctuations in the cryptocurrency market and specifically the dominant cryptocurrency i.e, Bitcoin. We examine how the prices fluctuate based on the polarity and subjectivity scores of news headlines extracted from the CNBC website. Furthermore, we also consider the Fear and Greed Index and try to predict the price fluctuations of Bitcoin based on the aforementioned features. We perform binary classification on the target variable column using popular machine learning models such as Random Forest, Decision Tree, Support Vector Machines, and Naive Bayes. We have obtained an accuracy of 75.4% on the training set and 72.11% on the testing set using Random Forest Classifier. As is indicative, when the equity market investors' sentiment is bearish, cryptocurrency prices rise, indicating that cryptocurrency can act as an alternative avenue for investment.

[1]:
```
# # Uncomment during first run >>

!pip install contractions
import nltk
nltk.download('stopwords')
nltk.download('punkt')
nltk.download('wordnet')
nltk.download('vader_lexicon')
```

```
Collecting contractions
  Downloading contractions-0.1.72-py2.py3-none-any.whl (8.3 kB)
Collecting textsearch>=0.0.21
  Downloading textsearch-0.0.21-py2.py3-none-any.whl (7.5 kB)
Collecting pyahocorasick
  Downloading
pyahocorasick-1.4.4-cp37-cp37m-manylinux_2_17_x86_64.manylinux2014_x86_64.whl
(106 kB)
     |                | 106 kB 5.4 MB/s
Collecting anyascii
  Downloading anyascii-0.3.1-py3-none-any.whl (287 kB)
     |                | 287 kB 10.4 MB/s
Installing collected packages: pyahocorasick, anyascii, textsearch,
contractions
```

```
Successfully installed anyascii-0.3.1 contractions-0.1.72 pyahocorasick-1.4.4
textsearch-0.0.21
[nltk_data] Downloading package stopwords to /root/nltk_data…
[nltk_data]   Unzipping corpora/stopwords.zip.
[nltk_data] Downloading package punkt to /root/nltk_data…
[nltk_data]   Unzipping tokenizers/punkt.zip.
[nltk_data] Downloading package wordnet to /root/nltk_data…
[nltk_data]   Unzipping corpora/wordnet.zip.
[nltk_data] Downloading package vader_lexicon to /root/nltk_data…
```

[1]:
```
True
```

[2]:
```
import pandas as pd
from nltk.corpus import stopwords
import unicodedata
from nltk.tokenize import word_tokenize # Can also use RegexpTokenizer
from nltk.stem import WordNetLemmatizer
import re
import contractions
import string
import numpy as np
from nltk.sentiment.vader import SentimentIntensityAnalyzer
from textblob import TextBlob
from scipy import stats
```

```
/usr/local/lib/python3.7/dist-packages/nltk/twitter/__init__.py:20: UserWarning:
The twython library has not been installed. Some functionality from the twitter
package will not be available.
  warnings.warn("The twython library has not been installed. "
```

[46]:
```
df = pd.read_csv('final_data-v2.csv')
```

[47]:
```
df = df.drop(['Unnamed: 0'], axis=1)
```

[48]:
```
df.rename(columns = {'fear-and-greed-index':'FG'}, inplace = True)
```

[49]:
```
df.head()
```

[49]:

	Date	News	Price	FG
0	4/10/2022	MicroStrategy CEO Michael Saylor speaks with C…	0	39
1	4/8/2022	My first experience with one of the men Peter …	0	54
2	4/8/2022	Cryptocurrency was initially created to sidest…	0	54
3	4/8/2022	William Quigley, Tether and Worldwide Asset Ex…	0	54
4	4/8/2022	CNBC’s Kate Rooney speaks to ARK Invest CEO Ca…	0	54

[50]:
```
df.tail()
```

[50]:

	Date	News	Price	FG
757	6/25/2019	The new safety trade. Would you rather buy gol…	1	86
758	6/25/2019	CNBC’s Seema Mody reports on bitcoin’s surge a…	1	86
759	6/19/2019	Bitcoin appears to be back in business.Having …	1	81
760	6/19/2019	Bitcoin appears to be back in business.Having …	1	81
761	6/17/2019	Bitcoin leaped across the $9,000 mark on Sunda…	1	77

[51]:
```
df['Date'] = pd.to_datetime(df['Date'], dayfirst = True, infer_datetime_format
↪= True)
```

[52]:
```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 762 entries, 0 to 761
Data columns (total 4 columns):
 #   Column  Non-Null Count  Dtype
---  ------  --------------  -----
 0   Date    762 non-null    datetime64[ns]
 1   News    759 non-null    object
 2   Price   762 non-null    int64
 3   FG      762 non-null    int64
dtypes: datetime64[ns](1), int64(2), object(1)
memory usage: 23.9+ KB
```

[53]:
```
df.isnull().sum()
```

[53]:
```
Date     0
News     3
Price    0
FG       0
dtype: int64
```

[54]:
```
df.dropna(axis = 0, inplace = True)
```

[55]:
```
df.describe()
```

[55]:

	Price	FG
count	759.000000	759.000000
mean	0.515152	56.487484
std	0.500100	19.111519
min	0.000000	3.000000
25%	0.000000	41.000000
50%	1.000000	60.000000
75%	1.000000	71.000000
max	1.000000	92.000000

[56]:
```
df.describe(include='object')
```

[56]:
```
                                                  News
count                                              759
unique                                             709
top     CNBC Crypto World features the latest news and…
freq                                                 9
```

[57]:
```
df['Price'].value_counts()
```

[57]:
```
1    391
0    368
Name: Price, dtype: int64
```

[58]:
```
df.reset_index(inplace = True, drop = True)
```

[59]:
```
lemma = WordNetLemmatizer()
stop_words = stopwords.words('english')
```

[60]:
```
# Function to perform text preparation on the given text data
def text_prep(x: str) -> list:
    corp = str(x).lower()
    corp = contractions.fix(corp)
    corp = re.sub('[^a-zA-Z]+',' ', corp).strip()
    tokens = word_tokenize(corp)
    words = [t for t in tokens if t not in stop_words]
    lemmatize = [lemma.lemmatize(w) for w in words]
    return lemmatize

prep_tag = [text_prep(i) for i in df['News']]
df["prep_text"] = prep_tag
df['prep_text'] = [" ".join(i) for i in df['prep_text']]
```

[61]:
```
df.sample(n=5)
```

[61]:

	Date	News	Price	FG	\
43	2022-02-23	Juthica Chou, head of OTC options trading at K…	0	40	
9	2022-06-04	CNBC’s Kate Rooney reports on the Bitcoin 2022…	0	69	
656	2020-12-24	Michael Saylor, Microstrategy CEO, discusses h…	1	71	
741	2019-07-19	Venture capitalist Tim Draper told CNBC on Fri…	0	32	
108	2021-12-19	For years, the U.S. government has maintained …	0	33	

	prep_text
43	juthica chou head otc option trading kraken di…
9	cnbc kate rooney report bitcoin conference miami
656	michael saylor microstrategy ceo discus bitcoi…
741	venture capitalist tim draper told cnbc friday…
108	year government maintained side hustle auction…

2 VADER

[62]:
```
# lets calculate the Sentiment from news articles

from nltk.sentiment.vader import SentimentIntensityAnalyzer
sid = SentimentIntensityAnalyzer()

train_sentiments = []

for i in df['prep_text']:
    train_sentiments.append(sid.polarity_scores(i).get('compound'))

train_sentiments = np.asarray(train_sentiments)
df['polarity'] = pd.Series(data=train_sentiments)
```

[63]:
```
df['polarity'].describe()
```

[63]:
```
count    759.000000
mean       0.141251
std        0.341621
min       -0.871200
25%        0.000000
50%        0.128000
75%        0.361200
max        0.949300
Name: polarity, dtype: float64
```

3 Using TextBlob

[64]:
```
# def subjectivity(x):
#   return TextBlob(x).sentiment.subjectivity
```

[65]:
```
# df['subjectivity'] = df['prep_text'].apply(lambda x: round(subjectivity(x),2))
```

[66]:
```
df.sample(n=5)
```

[66]:

	Date	News	Price	FG	\
537	2021-02-22	Giles Keating, director of Bitcoin Suisse, giv…	0	90	
44	2022-02-23	A key investment case for bitcoin is deteriora…	0	40	
487	2021-07-04	A Missouri man who used the cryptocurrency bit…	0	78	
375	2021-04-06	CNBC’s MacKenzie Sigalos reports from Miami wh…	0	34	
509	2021-03-20	CNBC’s Kate Rooney explains how bitcoin is cre…	0	78	

	prep_text	polarity
537	giles keating director bitcoin suisse give out…	0.0000

```
44   key investment case bitcoin deteriorating geop…   -0.5423
487  missouri man used cryptocurrency bitcoin try b…   -0.8000
375  cnbc mackenzie sigalos report miami world larg…    0.0000
509  cnbc kate rooney explains bitcoin creating dil…    0.4767
```

[68]:
```
from sklearn.preprocessing import StandardScaler

sc = StandardScaler()

f = pd.Series(df['FG'])
arr = f.values
arr = arr.reshape(-1, 1)
df['FG'] = sc.fit_transform(arr)

f = pd.Series(df['polarity'])
arr = f.values
arr = arr.reshape(-1, 1)
df['polarity'] = sc.fit_transform(arr)

# f = pd.Series(df['subjectivity'])
# arr = f.values
# arr = arr.reshape(-1, 1)
# df['subjectivity'] = sc.fit_transform(arr)
```

[69]:
```
y = df['Price']
X = df.drop(['Date', 'News', 'Price', 'prep_text'], axis = 1)
```

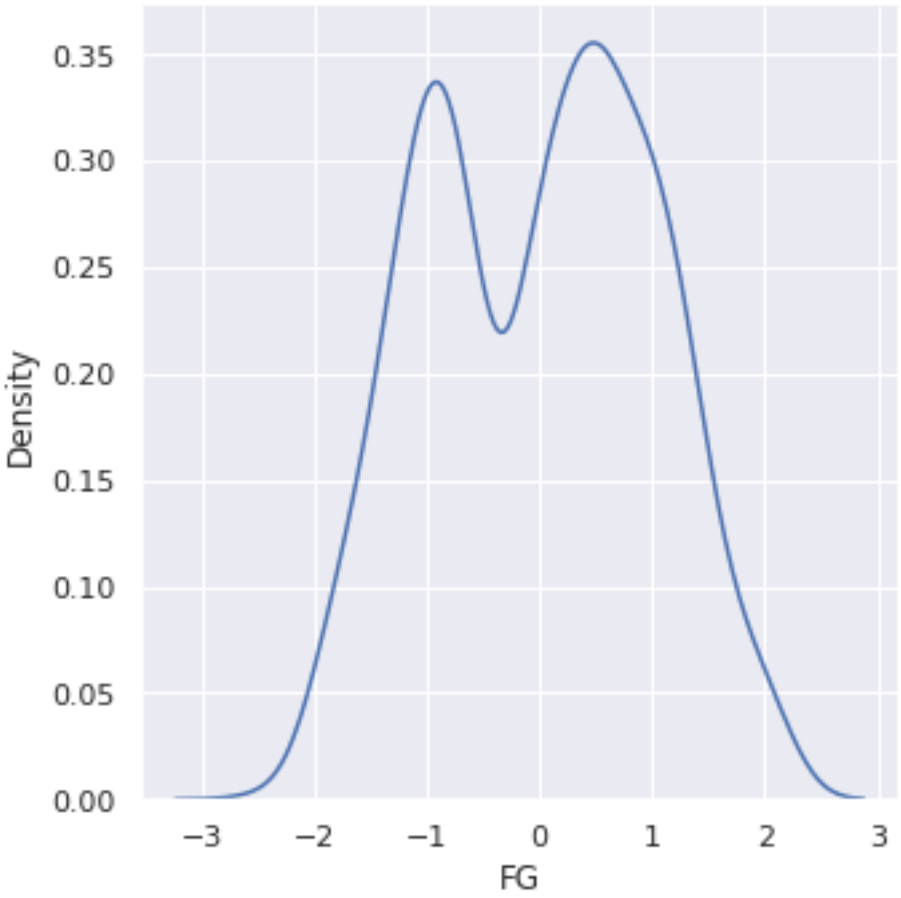
4 Removing Heteroscedasticity from the numerical variables

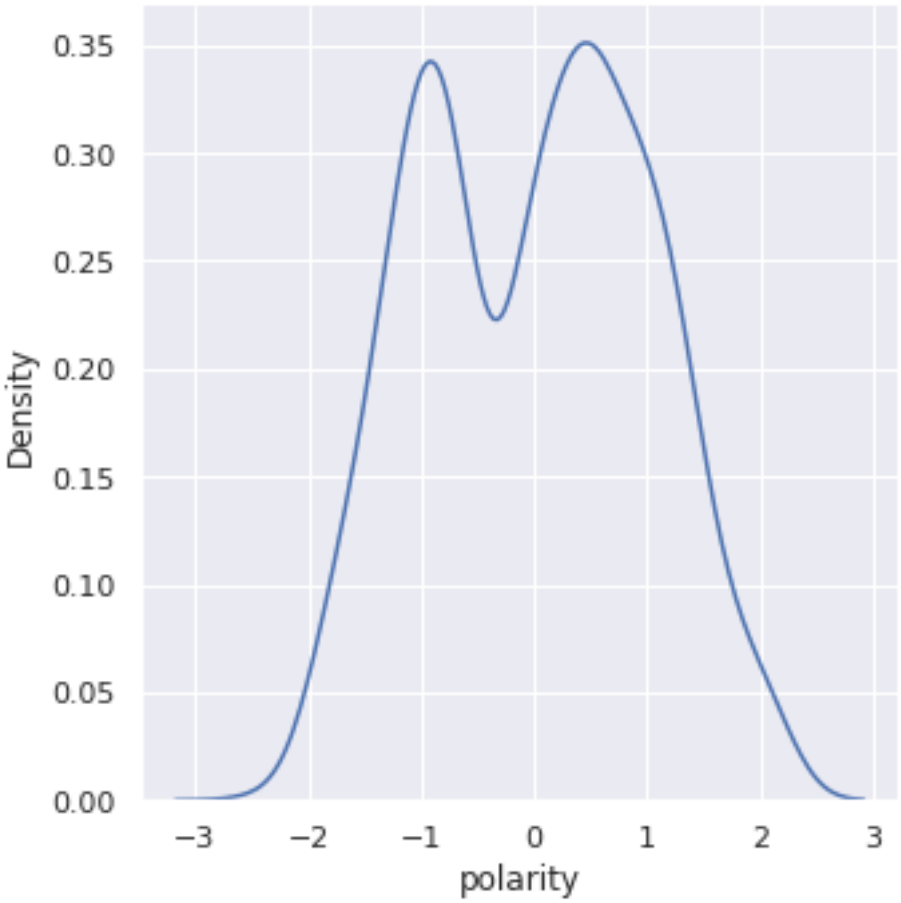
4.1 Using 'Yeo-Johnson' Transformation

[70]:
```
from sklearn.preprocessing import PowerTransformer

pt = PowerTransformer(method='yeo-johnson')

for col in X.columns:
  X[col] = pt.fit_transform(X)
```

[71]:
```
import matplotlib.pyplot as plt
import seaborn as sns

plt.figure(figsize = (14, 10))
for col in X.columns:
  sns.displot(data = X[col], kind = "kde")
```

```
<Figure size 1008x720 with 0 Axes>
```





[72]:
```
from sklearn.model_selection import train_test_split as tts

xtrain, xtest, ytrain, ytest = tts(X, y, random_state=1, train_size = 0.75)
```

[73]:
```
xtrain
```

[73]:
```
           FG  polarity
160 -0.655635 -0.662484
706  1.168516  1.174123
554  1.168516  1.174123
507  0.920420  0.919448
119 -1.459959 -1.446141
..        …       …
645  1.043727  1.045884
715 -0.749551 -0.754601
72  -1.417340 -1.404884
235  0.920420  0.919448
37  -1.201029 -1.195064
```

```
[569 rows x 2 columns]
```

[74]:
```
ytrain
```

[74]:
```
160    1
706    1
554    1
507    0
119    0
      ..
645    1
715    0
72     1
235    1
37     1
Name: Price, Length: 569, dtype: int64
```

[75]:
```
print(xtrain.shape)
print(ytrain.shape)
print(xtest.shape)
print(ytest.shape)
```

```
(569, 2)
(569,)
(190, 2)
(190,)
```

[76]:
```
np.nan_to_num(xtrain, copy = False)
np.nan_to_num(ytrain, copy = False)
np.nan_to_num(xtest, copy = False)
np.nan_to_num(ytest, copy = False)
```

[76]:
```
array([1, 1, 1, 0, 0, 1, 0, 1, 0, 1, 1, 0, 1, 1, 0, 0, 1, 1, 0, 1, 0, 0,
       1, 0, 0, 0, 1, 0, 1, 1, 1, 1, 0, 1, 0, 1, 1, 0, 1, 0, 0, 0, 0, 0,
       0, 0, 0, 1, 0, 1, 1, 1, 1, 1, 0, 1, 1, 1, 0, 0, 0, 0, 0, 0, 1, 1,
       1, 0, 1, 1, 1, 0, 1, 1, 0, 0, 0, 0, 0, 1, 1, 1, 0, 0, 1, 1, 1, 1,
       0, 1, 1, 1, 1, 1, 0, 1, 1, 1, 0, 0, 0, 0, 0, 1, 0, 1, 1, 0, 0, 1,
       0, 0, 0, 1, 0, 0, 1, 1, 1, 1, 0, 1, 1, 0, 0, 1, 0, 1, 0, 1, 0, 0,
       0, 1, 0, 0, 1, 0, 0, 0, 0, 1, 1, 1, 0, 0, 1, 1, 0, 1, 1, 1, 0, 0,
       0, 0, 1, 1, 1, 1, 1, 1, 1, 0, 1, 0, 1, 1, 1, 1, 1, 1, 1, 1, 1, 0,
       1, 1, 1, 0, 1, 1, 0, 0, 0, 1, 1, 0, 1, 1])
```

[77]:
```
from sklearn.linear_model import LogisticRegression

log = LogisticRegression()
log.fit(xtrain,ytrain)
```

[77]:
```
LogisticRegression()
```

[78]:
```
from sklearn.naive_bayes import GaussianNB

gnb = GaussianNB()
gnb.fit(xtrain, ytrain)
```

[78]:
```
GaussianNB()
```

[79]:
```
from sklearn.ensemble import RandomForestClassifier

rf = RandomForestClassifier()
rf.fit(xtrain, ytrain)
```

[79]:
```
RandomForestClassifier()
```

[80]:
```
from sklearn.svm import SVC

svm = SVC()
svm.fit(xtrain, ytrain)
```

[80]:
```
SVC()
```

[81]:
```
from sklearn.tree import DecisionTreeClassifier

dt = DecisionTreeClassifier()
dt.fit(xtrain, ytrain)
```

[81]:
```
DecisionTreeClassifier()
```

[82]:
```
results = pd.DataFrame({
    'Model': ['Logistic Regression', 'Gaussian Naive Bayes', 'Random Forest␣
 ↪Classifier', 'Support Vector Machine', 'Decision Tree Classifier'],
    'Train Score': [round(log.score(xtrain, ytrain), 4)*100,
              round(gnb.score(xtrain, ytrain), 4)*100,
              round(rf.score(xtrain, ytrain), 4)*100,
              round(svm.score(xtrain, ytrain), 4)*100,
              round(dt.score(xtrain, ytrain), 4)*100],
    'Test Score': [round(log.score(xtest, ytest), 4)*100,
              round(gnb.score(xtest, ytest), 4)*100,
              round(rf.score(xtest, ytest), 4)*100,
              round(svm.score(xtest, ytest), 4)*100,
              round(dt.score(xtest, ytest), 4)*100]})
result_df = results.sort_values(by='Test Score', ascending=False).
 ↪reset_index(drop = True)
result_df
```

[82]:

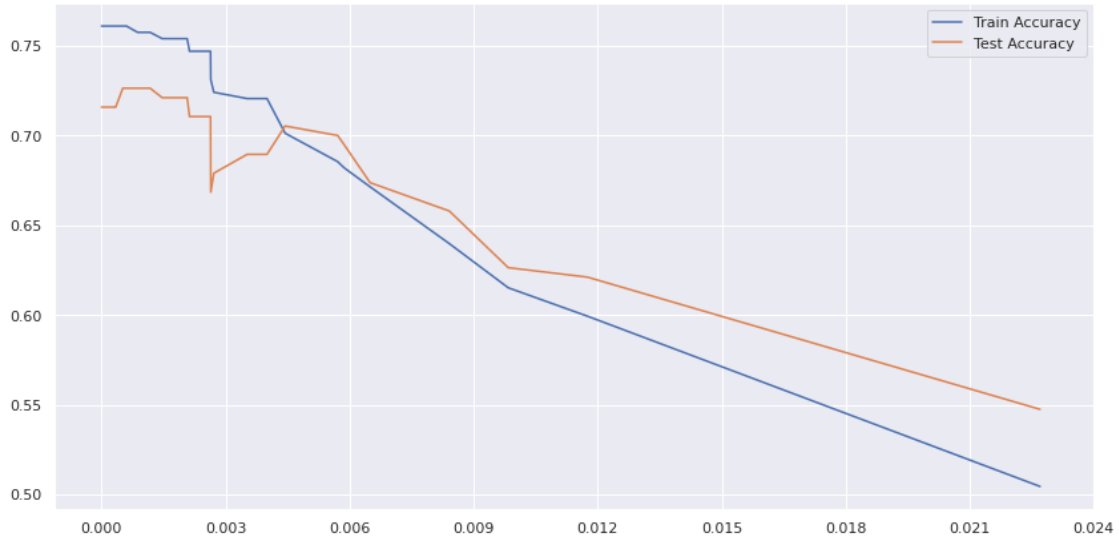
	Model	Train Score	Test Score
0	Random Forest Classifier	76.10	74.74
1	Decision Tree Classifier	76.10	71.58
2	Support Vector Machine	59.05	61.58
3	Logistic Regression	58.88	60.53
4	Gaussian Naive Bayes	57.82	59.47

5 Pruning Decision Tree and Random Forest

[83]:
```
path = dt.cost_complexity_pruning_path(xtrain, ytrain)
alphas = path['ccp_alphas']

alphas
```

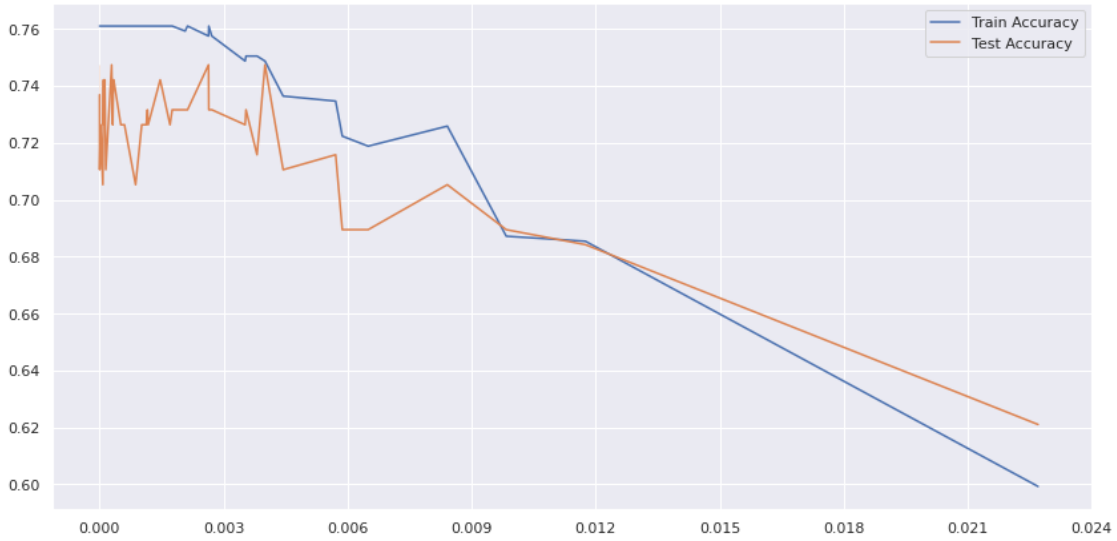
[83]:
```
array([0.00000000e+00, 0.00000000e+00, 3.13274375e-06, 2.28242759e-05,
       8.01125581e-05, 8.78734622e-05, 9.58619588e-05, 1.02519039e-04,
       1.27033321e-04, 1.50640221e-04, 2.92010274e-04, 3.19539863e-04,
       3.34756047e-04, 3.42364138e-04, 5.13721779e-04, 6.02560884e-04,
       8.71797244e-04, 1.02082943e-03, 1.12980166e-03, 1.15833200e-03,
       1.17572855e-03, 1.46689865e-03, 1.70421260e-03, 1.75746924e-03,
       2.07040208e-03, 2.12800688e-03, 2.63620387e-03, 2.64199074e-03,
       2.71536915e-03, 3.52188501e-03, 3.54201006e-03, 3.80856971e-03,
       4.00154960e-03, 4.44111205e-03, 5.71081973e-03, 5.87154498e-03,
       6.49679096e-03, 8.41214458e-03, 9.83774764e-03, 1.17516841e-02,
       2.27006285e-02])
```

[84]:
```
accuracy_train, accuracy_test = [], []

for i in alphas:
  dt = DecisionTreeClassifier(ccp_alpha=i)

  dt.fit(xtrain, ytrain)

  accuracy_train.append(dt.score(xtrain, ytrain))
  accuracy_test.append(dt.score(xtest, ytest))

sns.set()
plt.figure(figsize = (14,7))
sns.lineplot(y=accuracy_train, x=alphas, label = 'Train Accuracy')
sns.lineplot(y=accuracy_test, x=alphas, label = 'Test Accuracy')
plt.xticks(ticks = np.arange(0.00, 0.025, 0.003))
plt.show()
```



It is evident that the ideal value of `ccp_alpha` is around 0.0005 from the above figure.

[90]:
```
accuracy_train, accuracy_test = [], []

for i in alphas:
  rf = RandomForestClassifier(ccp_alpha=i)

  rf.fit(xtrain, ytrain)

  accuracy_train.append(rf.score(xtrain, ytrain))
  accuracy_test.append(rf.score(xtest, ytest))

sns.set()
plt.figure(figsize = (14,7))
sns.lineplot(y=accuracy_train, x=alphas, label = 'Train Accuracy')
sns.lineplot(y=accuracy_test, x=alphas, label = 'Test Accuracy')
plt.xticks(ticks = np.arange(0.00, 0.025, 0.003))
plt.show()
```



It is evident from the above figure that the ideal `ccp_alpha` value is 0.0035.

6 Hyperparameter Tuning by GridSearchCV

[104]:
```
model_params = {
    'svm': {
        'model': SVC(gamma = 'auto'),
        'params': {
            'C': [0.01, 0.05, 0.1],
            'kernel': ['rbf', 'linear']
        }
    },
    'logistic_regression': {
        'model': LogisticRegression(solver = 'liblinear',
                                    multi_class = 'ovr',
                                    penalty = 'l1'),
        'params': {
            'C': [0.01, 0.05, 0.1]
        }
    },
    'decision_tree': {
        'model': DecisionTreeClassifier(),
        'params': {
            'criterion': ['gini', 'entropy'],
            'ccp_alpha': np.arange(0.00, 0.006, 0.0005)
        }
    },
```

```
    'random_forest': {
        'model': RandomForestClassifier(n_estimators=100),
        'params': {
            'criterion': ['gini', 'entropy'],
            'ccp_alpha': [0.003, 0.0035, 0.004]
        }
    }
}
```

[105]:
```
from sklearn.model_selection import GridSearchCV

scores = []

for model_name, mp in model_params.items():
  clf = GridSearchCV(mp['model'], mp['params'], cv = 100, return_train_score =␣
 ↪False)
  clf.fit(X, y)
  scores.append({
      'model': model_name,
      'best_score': clf.best_score_,
      'best_params': clf.best_params_
  })
```

[106]:
```
results = pd.DataFrame(scores, columns = ['model', 'best_score', 'best_params'])
results
```

[106]:
```
                 model  best_score  \
0                  svm    0.591607
1  logistic_regression    0.595536
2        decision_tree    0.670000
3        random_forest    0.691071

                                    best_params
0                   {'C': 0.1, 'kernel': 'rbf'}
1                                       {'C': 0.05}
2     {'ccp_alpha': 0.0005, 'criterion': 'gini'}
3  {'ccp_alpha': 0.0035, 'criterion': 'entropy'}
```

7 Validation with Decision Tree

[110]:
```
dt = DecisionTreeClassifier(criterion='gini', ccp_alpha=0.0005)
dt.fit(xtrain, ytrain)
print("Decision Tree Test score: ", round(dt.score(xtest, ytest), 4)*100)
print("Decision Tree Train score: ", round(dt.score(xtrain, ytrain), 4)*100)
```

```
Decision Tree Test score:  71.58
Decision Tree Train score:  76.1
```

8 Validation with Random Forest

[111]:
```
rf = DecisionTreeClassifier(criterion='entropy', ccp_alpha=0.0035)
rf.fit(xtrain, ytrain)
print("Random Forest Test score: ", round(rf.score(xtest, ytest), 4)*100)
print("Random Forest Train score: ", round(rf.score(xtrain, ytrain), 4)*100)
```

```
Random Forest Test score:  72.11
Random Forest Train score:  75.4
```

9 K-fold Cross Validation

[89]:
```
from sklearn.model_selection import cross_val_score

cv_scores = cross_val_score(DecisionTreeClassifier(criterion='gini', ccp_alpha␣
 ↪= 0.0005), X, y, cv = 100)
print("Cross-val score: ", round(np.average(cv_scores), 4)*100)
```

```
Cross-val score:  67.0
```

[116]:
```
cv_scores = cross_val_score(RandomForestClassifier(criterion='entropy',␣
 ↪ccp_alpha = 0.0035), X, y, cv = 100)
print("Cross-val score: ", round(np.average(cv_scores), 4)*100)
```

```
Cross-val score:  67.86
```

10 Summarizing Results:

- Best Fit Model: **Random Forest**
- Best Fit Model Parameters:
- `criterion = 'entropy'`
- `ccp_alpha = 0.0035`
- Training set score **(before Pruning)**: 76.10
- Testing set score **(before Pruning)**: 74.74
- GridSearchCV score = 69.10 (with `CV = 100`)
- Training set score **(after Pruning and CV)**: 75.4
- Testing set score **(after Pruning and CV)**: 72.11
- 100-Fold Cross Validation Score: 67.86

[118]:
```
!wget -nc https://raw.githubusercontent.com/brpy/colab-pdf/master/colab_pdf.py
from colab_pdf import colab_pdf
colab_pdf('Bitcoin-Sentiment-Analysis.ipynb')
```

```
File ‘colab_pdf.py’ already there; not retrieving.


WARNING: apt does not have a stable CLI interface. Use with caution in scripts.


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[NbConvertApp] Converting notebook /content/drive/MyDrive/Colab
Notebooks/Bitcoin-Sentiment-Analysis.ipynb to pdf
[NbConvertApp] Support files will be in Bitcoin-Sentiment-Analysis_files/
[NbConvertApp] Making directory ./Bitcoin-Sentiment-Analysis_files
[NbConvertApp] Making directory ./Bitcoin-Sentiment-Analysis_files
[NbConvertApp] Making directory ./Bitcoin-Sentiment-Analysis_files
[NbConvertApp] Making directory ./Bitcoin-Sentiment-Analysis_files
[NbConvertApp] Writing 78802 bytes to ./notebook.tex
[NbConvertApp] Building PDF
[NbConvertApp] Running xelatex 3 times: ['xelatex', './notebook.tex', '-quiet']
[NbConvertApp] Running bibtex 1 time: ['bibtex', './notebook']
[NbConvertApp] WARNING | bibtex had problems, most likely because there were no
citations
[NbConvertApp] PDF successfully created
[NbConvertApp] Writing 180176 bytes to /content/drive/My Drive/Bitcoin-
Sentiment-Analysis.pdf
```

```
<IPython.core.display.Javascript object>


<IPython.core.display.Javascript object>
```

[118]:
```
'File ready to be Downloaded and Saved to Drive'
```

[ ]:
```

```