References

https://andhint.github.io/machine-learning/nlp/Feature-Extraction-From-Text/ (https://andhint.github.io/machine-learning/nlp/Feature-Extraction-From-Text/)

Tweet Sentiment Classification

Objective

Determine whether the sentiment on the Tweets related to a product or company is positive, negative or neutral.

Classification Techniques

A1. Supervised Learning

*** Step 1: Using Manually Labelled Tweet Sentiments for Supervised Training***

In [1]:
```
from IPython.core.interactiveshell import InteractiveShell
InteractiveShell.ast_node_interactivity = "all"
from IPython.display import HTML, display
```

In [7]:
```
import pandas as pd
import numpy as np

np.random.seed(7)

print("[INFO] Data Frame created with Manually-labelled data for individual stocks")
aapl=pd.read_csv("/Users/hardeepsingh/Desktop/IS/University/sem-4/FE-520/Project/Manually_labelle

print("\n[INFO] Apple Data Frame - Manually Labelled Sentiments")
aapl.info()

aapl=aapl.dropna()
```

```
[INFO] Data Frame created with Manually-labelled data for individual stocks

[INFO] Apple Data Frame - Manually Labelled Sentiments
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 10481 entries, 0 to 10480
Data columns (total 3 columns):
date         3977 non-null object
sentiment    3969 non-null float64
text         3977 non-null object
dtypes: float64(1), object(2)
memory usage: 245.7+ KB
```

*** Step 2: Splitting the Data into Train (for Model training) and Test (for validation)***

In [9]:
```
from sklearn.model_selection import train_test_split

text=aapl.text
target=aapl.sentiment

X_train,X_test,y_train,y_test=train_test_split(text,target, random_state=27,test_size=0.2)
```

*** Step 3: Selecting the best Model***

WordCloud Of Tweets

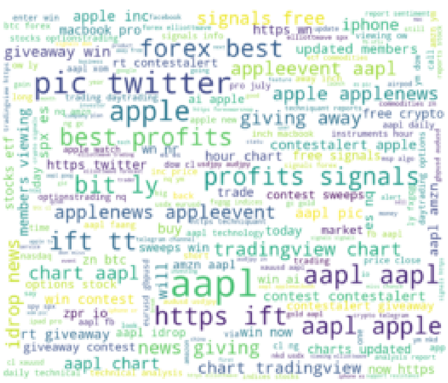
In [11]:

```python
# REFERENCE: https://github.com/amueller/word_cloud
from os import path
from wordcloud import WordCloud, STOPWORDS
import matplotlib.pyplot as plt

d = path.dirname('manually_labeled_data/')

# Read the whole text.
text1 = open(path.join(d,'/Users/hardeepsingh/Desktop/IS/University/sem-4/FE-520/Project/Manually_

stopwords = set(STOPWORDS)

# lower max_font_size
wordcloud = WordCloud(max_font_size=100,
                                background_color='white',
                                width=1200,
                                height=1000,
                           stopwords=stopwords).generate(text1)
plt.figure()
plt.imshow(wordcloud, interpolation="bilinear")
plt.axis("off")
plt.show()

```

Out[11]: <Figure size 432x288 with 0 Axes>

Out[11]: <matplotlib.image.AxesImage at 0x1a15af8f60>

Out[11]: (-0.5, 1199.5, 999.5, -0.5)



- **Choice 1: CountVectorizer OR TfidfVectorizer (both from sklearn.feature_extraction.text)**
  - CountVectorizer takes the bag of word approach, i.e. each message is seperated into tokens and the number of times each token occurs in a message is counted. It create a matrix populated with token counts to represent all the messages. This is often referred to as a document term matrix(DTM).
  - TfidfVectorizer, instead of filling the DTM with token counts it calculates term frequency-inverse document frequency value for each word(TF-IDF). The TF-IDF is the product of two weights, the term frequency and the inverse document frequency. Term frequency is a weight representing how often a word occurs in a document. If we have several occurences of the same word in one document we can expect the TF-IDF to increase. Inverse document frequency is another weight representing how common a word is across documents. If a word is used in many documents then the TF-IDF will decrease.

- **Choice 2: Classifier**
  - LogisticRegression
  - DecisionTree
  - MultinomialNB
  - Linear SVC

** i. CountVectorizer + Logistic Regression **

In [13]:

```python
# importing required libraries
from sklearn.feature_extraction.text import CountVectorizer, TfidfVectorizer
from sklearn.pipeline import Pipeline
from sklearn.linear_model import LogisticRegression
import warnings
warnings.filterwarnings('ignore')

# import GridSearch
from sklearn.model_selection import GridSearchCV

# To store the results
classifier_results={}

# using count vectorizer instead of tfidf
# tokenizing only alpha numeric
tokenPatt = '[A-Za-z0-9]+(?=\\s+)'

# pipeline which does two steps all together:
# (1) generate CountVector, and (2) train classifier
# each step is named, i.e. "vec", "clf"
pl_1 = Pipeline([
        ('tfidf', CountVectorizer(token_pattern = tokenPatt)),
        ('clf', LogisticRegression())])

pl_1.fit(X_train,y_train)

# accuracy
accuracy = pl_1.score(X_test,y_test)
print ("Untuned Accuracy of Logistic Regression using CountVectorizer: ", accuracy)

classifier_results["Untuned Accuracy of Logistic Regression using CountVectorizer"]=accuracy


# Parameters to be used for Tuning
parameters = {'tfidf__min_df':[2,3],
              'tfidf__token_pattern':['[A-Za-z0-9]+(?=\\s+)'],
              'tfidf__stop_words':[None,"english"],
              'clf__solver': ['newton-cg', 'lbfgs', 'liblinear', 'sag', 'saga']
}

# the metric used to select the best parameters
metric =  "f1_macro"

# GridSearch also uses cross validation
gs_clf = GridSearchCV(pl_1, param_grid=parameters, scoring=metric, cv=5)
gs_clf = gs_clf.fit(text, target)

# gs_clf.best_params_ returns a dictionary
# with parameter and its best value as an entry

for param_name in gs_clf.best_params_:
    print(param_name,": ",gs_clf.best_params_[param_name])

print("Best f1 score:", gs_clf.best_score_)
```

Out[13]:

```
Pipeline(memory=None,
     steps=[('tfidf', CountVectorizer(analyzer='word', binary=False, decode_error='strict',
        dtype=<class 'numpy.int64'>, encoding='utf-8', input='content',
        lowercase=True, max_df=1.0, max_features=None, min_df=1,
        ngram_range=(1, 1), preprocessor=None, stop_words=None,
        stri...penalty='l2', random_state=None, solver='warn',
          tol=0.0001, verbose=0, warm_start=False))])

Untuned Accuracy of Logistic Regression using CountVectorizer:  0.672544080604534
clf__solver :  newton-cg
tfidf__min_df :  3
tfidf__stop_words :  None
tfidf__token_pattern :  [A-Za-z0-9]+(?=\s+)
Best f1 score: 0.4268043195426816
```

In [14]:

```python
# Using Parameters from above GridSearch Result
p1_2 = Pipeline([
        ('tfidf', CountVectorizer(stop_words=None,token_pattern='[A-Za-z0-9]+(?=\\s+)',min_df=2)),
        ('clf', LogisticRegression(solver='sag'))
    ])

p1_2.fit(X_train,y_train)

# accuracy
accuracy = p1_2.score(X_test,y_test)
print("Tuned Accuracy of Logistic Regression using CountVectorizer: ", accuracy)

classifier_results["Tuned Accuracy of Logistic Regression using CountVectorizer"]=accuracy
```

Out[14]:

```
Pipeline(memory=None,
     steps=[('tfidf', CountVectorizer(analyzer='word', binary=False, decode_error='strict',
        dtype=<class 'numpy.int64'>, encoding='utf-8', input='content',
        lowercase=True, max_df=1.0, max_features=None, min_df=2,
        ngram_range=(1, 1), preprocessor=None, stop_words=None,
        stri... penalty='l2', random_state=None, solver='sag',
          tol=0.0001, verbose=0, warm_start=False))])
```

```
Tuned Accuracy of Logistic Regression using CountVectorizer:  0.6662468513853904
```

** ii. CountVectorizer + DecisionTreeClassifier **

In [15]:

```python
# importing required libraries
from sklearn.tree import DecisionTreeClassifier

p2_1 = Pipeline([
        ('tfidf', CountVectorizer(token_pattern = tokenPatt)),
        ('clf', DecisionTreeClassifier())
    ])

p2_1.fit(X_train,y_train)

# accuracy
accuracy = p2_1.score(X_test,y_test)
print("Untuned Accuracy of Decision Tree using CountVectorizer: ", accuracy)

classifier_results["Untuned Accuracy of Decision Tree using CountVectorizer"]=accuracy

# Parameters to be used for Tuning
parameters = {'tfidf__min_df':[2,3],
              'tfidf__token_pattern':['[A-Za-z0-9]+(?=\\s+)'],
              'tfidf__stop_words':[None,"english"]
}

# the metric used to select the best parameters
metric =  "f1_macro"

# GridSearch also uses cross validation
gs_clf = GridSearchCV(p2_1, param_grid=parameters, scoring=metric, cv=5)
gs_clf = gs_clf.fit(text, target)

# gs_clf.best_params_ returns a dictionary
# with parameter and its best value as an entry

for param_name in gs_clf.best_params_:
    print(param_name,": ",gs_clf.best_params_[param_name])

print("Best f1 score:", gs_clf.best_score_)
```

Out[15]:

```
Pipeline(memory=None,
     steps=[('tfidf', CountVectorizer(analyzer='word', binary=False, decode_error='strict',
        dtype=<class 'numpy.int64'>, encoding='utf-8', input='content',
        lowercase=True, max_df=1.0, max_features=None, min_df=1,
        ngram_range=(1, 1), preprocessor=None, stop_words=None,
        stri...      min_weight_fraction_leaf=0.0, presort=False, random_state=None,
            splitter='best'))])

Untuned Accuracy of Decision Tree using CountVectorizer:  0.6158690176322418
tfidf__min_df :  2
tfidf__stop_words :  english
tfidf__token_pattern :  [A-Za-z0-9]+(?=\s+)
Best f1 score: 0.40682321943433036
```

In [52]:

```python
# Using Parameters from above GridSearch Result
p2_2 = Pipeline([
        ('tfidf', CountVectorizer(stop_words='english',token_pattern='[A-Za-z0-9]+(?=\\s+)',min_d
        ('clf', DecisionTreeClassifier())
    ])

p2_2.fit(X_train,y_train)

# accuracy
accuracy = p2_2.score(X_test,y_test)
print("Tuned Accuracy of Decision Tree using CountVectorizer: ", accuracy)

classifier_results["Tuned Accuracy of Decision Tree using CountVectorizer"]=accuracy
```

Out[52]:

```
Pipeline(memory=None,
     steps=[('tfidf', CountVectorizer(analyzer=u'word', binary=False, decode_error=u'strict',
        dtype=<type 'numpy.int64'>, encoding=u'utf-8', input=u'content',
        lowercase=True, max_df=1.0, max_features=None, min_df=3,
        ngram_range=(1, 1), preprocessor=None, stop_words='english',
    ...      min_weight_fraction_leaf=0.0, presort=False, random_state=None,
            splitter='best'))])
```

```
('Tuned Accuracy of Decision Tree using CountVectorizer: ', 0.5462012320328542)
```

** iii. CountVectorizer + MultinomialNB **

In [16]:

```python
# importing required libraries
from sklearn.naive_bayes import MultinomialNB

p3_1 = Pipeline([
        ('tfidf', CountVectorizer()),
        ('clf', MultinomialNB())
    ])

p3_1.fit(X_train,y_train)

# accuracy
accuracy = p3_1.score(X_test,y_test)
print("Untuned Accuracy of MultinomialNB using CountVectorizer: ", accuracy)

classifier_results["Untuned Accuracy of MultinomialNB using CountVectorizer"]=accuracy

# Parameters to be used for Tuning
parameters = {'tfidf__min_df':[2,3],
              'tfidf__token_pattern':['[A-Za-z0-9]+(?=\\s+)'],
              'tfidf__stop_words':[None,"english"],
              'clf__alpha': [0.5,1.0,2.0],
}

# the metric used to select the best parameters
metric =  "f1_macro"

# GridSearch also uses cross validation
gs_clf = GridSearchCV(p3_1, param_grid=parameters, scoring=metric, cv=5)
gs_clf = gs_clf.fit(text, target)

# gs_clf.best_params_ returns a dictionary
# with parameter and its best value as an entry

for param_name in gs_clf.best_params_:
    print(param_name,": ",gs_clf.best_params_[param_name])

print("Best f1 score:", gs_clf.best_score_)
```

Out[16]:

```
Pipeline(memory=None,
     steps=[('tfidf', CountVectorizer(analyzer='word', binary=False, decode_error='strict',
        dtype=<class 'numpy.int64'>, encoding='utf-8', input='content',
        lowercase=True, max_df=1.0, max_features=None, min_df=1,
        ngram_range=(1, 1), preprocessor=None, stop_words=None,
        strip_accents=None, token_pattern='(?u)\\b\\w\\w+\\b',
        tokenizer=None, vocabulary=None)), ('clf', MultinomialNB(alpha=1.0, class_prior=None, fit_p
rior=True))])

Untuned Accuracy of MultinomialNB using CountVectorizer:  0.6649874055415617
clf__alpha :  1.0
tfidf__min_df :  3
tfidf__stop_words :  None
tfidf__token_pattern :  [A-Za-z0-9]+(?=\s+)
Best f1 score: 0.4646847144630701
```

In [18]:

```python
# Using Parameters from above GridSearch Result
p3_2 = Pipeline([
        ('tfidf', CountVectorizer(stop_words=None,token_pattern='[A-Za-z0-9]+(?=\\s+)',min_df=2)),
        ('clf', MultinomialNB(alpha=0.5))
    ])

p3_2.fit(X_train,y_train)

# accuracy
accuracy = p3_2.score(X_test,y_test)
print("Tuned Accuracy of MultinomialNB using CountVectorizer: ", accuracy)

classifier_results["Tuned Accuracy of MultinomialNB using CountVectorizer"]=accuracy
```

Out[18]:

```
Pipeline(memory=None,
     steps=[('tfidf', CountVectorizer(analyzer='word', binary=False, decode_error='strict',
        dtype=<class 'numpy.int64'>, encoding='utf-8', input='content',
        lowercase=True, max_df=1.0, max_features=None, min_df=2,
        ngram_range=(1, 1), preprocessor=None, stop_words=None,
        strip_accents=None, token_pattern='[A-Za-z0-9]+(?=\\s+)',
        tokenizer=None, vocabulary=None)), ('clf', MultinomialNB(alpha=0.5, class_prior=None, fit_p
rior=True))])
```

```
Tuned Accuracy of MultinomialNB using CountVectorizer:  0.6435768261964736
```

iv. CountVectorizer + LinearSVC

In [19]:

```python
# importing required libraries
from sklearn.svm import LinearSVC

p4_1 = Pipeline([
        ('tfidf', CountVectorizer()),
        ('clf', LinearSVC())
    ])

p4_1.fit(X_train,y_train)

# accuracy
accuracy = p4_1.score(X_test,y_test)
print("Untuned Accuracy of LinearSVC using CountVectorizer: ", accuracy)

classifier_results["Untuned Accuracy of LinearSVC using CountVectorizer"]=accuracy

# Parameters to be used for Tuning
parameters = {'tfidf__min_df':[2,3],
              'tfidf__token_pattern':['[A-Za-z0-9]+(?=\\s+)'],
              'tfidf__stop_words':[None,"english"],
              'clf__loss':['hinge','squared_hinge']
}

# the metric used to select the best parameters
metric =  "f1_macro"

# GridSearch also uses cross validation
gs_clf = GridSearchCV(p4_1, param_grid=parameters, scoring=metric, cv=5)
gs_clf = gs_clf.fit(text, target)

# gs_clf.best_params_ returns a dictionary
# with parameter and its best value as an entry

for param_name in gs_clf.best_params_:
    print(param_name,": ",gs_clf.best_params_[param_name])

print("Best f1 score:", gs_clf.best_score_)
```

Out[19]:

```
Pipeline(memory=None,
     steps=[('tfidf', CountVectorizer(analyzer='word', binary=False, decode_error='strict',
        dtype=<class 'numpy.int64'>, encoding='utf-8', input='content',
        lowercase=True, max_df=1.0, max_features=None, min_df=1,
        ngram_range=(1, 1), preprocessor=None, stop_words=None,
        stri...ax_iter=1000,
     multi_class='ovr', penalty='l2', random_state=None, tol=0.0001,
     verbose=0))])

Untuned Accuracy of LinearSVC using CountVectorizer:  0.6511335012594458
clf__loss :  hinge
tfidf__min_df :  3
tfidf__stop_words :  english
tfidf__token_pattern :  [A-Za-z0-9]+(?=\s+)
Best f1 score: 0.43101033304838277
```

In [20]:

```python
# Using Parameters from above GridSearch Result
p4_2 = Pipeline([
        ('tfidf', CountVectorizer(stop_words=None,token_pattern='[A-Za-z0-9]+(?=\\s+)',min_df=2)),
        ('clf', LinearSVC(loss='hinge'))
    ])

p4_2.fit(X_train,y_train)

# accuracy
accuracy = p4_2.score(X_test,y_test)
print("Tuned Accuracy of LinearSVC using CountVectorizer: ", accuracy)

classifier_results["Tuned Accuracy of LinearSVC using CountVectorizer"]=accuracy
```

Out[20]:

```
Pipeline(memory=None,
     steps=[('tfidf', CountVectorizer(analyzer='word', binary=False, decode_error='strict',
        dtype=<class 'numpy.int64'>, encoding='utf-8', input='content',
        lowercase=True, max_df=1.0, max_features=None, min_df=2,
        ngram_range=(1, 1), preprocessor=None, stop_words=None,
        stri...e', max_iter=1000, multi_class='ovr',
     penalty='l2', random_state=None, tol=0.0001, verbose=0))])
```

```
Tuned Accuracy of LinearSVC using CountVectorizer:  0.6511335012594458
```

v. TfidfVectorizer + Logistic Regression

In [21]:
```
p5_1 = Pipeline([
        ('tfidf', TfidfVectorizer()),
        ('clf', LogisticRegression())
    ])

p5_1.fit(X_train,y_train)


# accuracy
accuracy = p5_1.score(X_test,y_test)
print ("Untuned Accuracy of Logistic Regression using TfidfVectorizer: ", accuracy)

classifier_results["Untuned Accuracy of Logistic Regression using TfidfVectorizer"]=accuracy

# Parameters to be used for Tuning
parameters = {'tfidf__min_df':[2,3],
              'tfidf__token_pattern':['[A-Za-z0-9]+(?=\\s+)'],
              'tfidf__stop_words':[None,"english"],
              'clf__solver': ['newton-cg', 'lbfgs', 'liblinear', 'sag', 'saga']
}

# the metric used to select the best parameters
metric =  "f1_macro"

# GridSearch also uses cross validation
gs_clf = GridSearchCV(p5_1, param_grid=parameters, scoring=metric, cv=5)
gs_clf = gs_clf.fit(text, target)

# gs_clf.best_params_ returns a dictionary
# with parameter and its best value as an entry

for param_name in gs_clf.best_params_:
    print(param_name,": ",gs_clf.best_params_[param_name])

print("Best f1 score:", gs_clf.best_score_)
```

Out[21]:
```
Pipeline(memory=None,
     steps=[('tfidf', TfidfVectorizer(analyzer='word', binary=False, decode_error='strict',
        dtype=<class 'numpy.float64'>, encoding='utf-8', input='content',
        lowercase=True, max_df=1.0, max_features=None, min_df=1,
        ngram_range=(1, 1), norm='l2', preprocessor=None, smooth_idf=True,...penalty='l2', random_s
tate=None, solver='warn',
          tol=0.0001, verbose=0, warm_start=False))])

Untuned Accuracy of Logistic Regression using TfidfVectorizer:  0.672544080604534
clf__solver :  saga
tfidf__min_df :  3
tfidf__stop_words :  None
tfidf__token_pattern :  [A-Za-z0-9]+(?=\s+)
Best f1 score: 0.3880592998717089
```

In [22]:

```python
# Using Parameters from above GridSearch Result
p5_2 = Pipeline([
        ('tfidf', TfidfVectorizer(stop_words=None,token_pattern='[A-Za-z0-9]+(?=\\s+)',min_df=2)),
        ('clf', LogisticRegression(solver='newton-cg'))
    ])

p5_2.fit(X_train,y_train)

# accuracy
accuracy = p5_2.score(X_test,y_test)
print("Tuned Accuracy of Logistic Regression using TfidfVectorizer: ", accuracy)

classifier_results["Tuned Accuracy of Logistic Regression using TfidfVectorizer"]=accuracy
```

Out[22]:

```
Pipeline(memory=None,
     steps=[('tfidf', TfidfVectorizer(analyzer='word', binary=False, decode_error='strict',
        dtype=<class 'numpy.float64'>, encoding='utf-8', input='content',
        lowercase=True, max_df=1.0, max_features=None, min_df=2,
        ngram_range=(1, 1), norm='l2', preprocessor=None, smooth_idf=True,...ty='l2', random_state=
None, solver='newton-cg',
          tol=0.0001, verbose=0, warm_start=False))])
```

```
Tuned Accuracy of Logistic Regression using TfidfVectorizer:  0.6700251889168766
```

vi. TfidfVectorizer + DecisionTreeClassifier

In [23]:

```python
p6_1 = Pipeline([
        ('tfidf', TfidfVectorizer()),
        ('clf', DecisionTreeClassifier())
    ])

p6_1.fit(X_train,y_train)

# accuracy
accuracy = p6_1.score(X_test,y_test)
print("Untuned Accuracy of Decision Tree using TfidfVectorizer: ", accuracy)

classifier_results["Untuned Accuracy of Decision Tree using TfidfVectorizer"]=accuracy

# Parameters to be used for Tuning
parameters = {'tfidf__min_df':[2,3],
              'tfidf__token_pattern':['[A-Za-z0-9]+(?=\\s+)'],
              'tfidf__stop_words':[None,"english"]
}

# the metric used to select the best parameters
metric =  "f1_macro"

# GridSearch also uses cross validation
gs_clf = GridSearchCV(p6_1, param_grid=parameters, scoring=metric, cv=5)
gs_clf = gs_clf.fit(text, target)

# gs_clf.best_params_ returns a dictionary
# with parameter and its best value as an entry

for param_name in gs_clf.best_params_:
    print(param_name,": ",gs_clf.best_params_[param_name])

print("Best f1 score:", gs_clf.best_score_)
```

Out[23]:

```
Pipeline(memory=None,
     steps=[('tfidf', TfidfVectorizer(analyzer='word', binary=False, decode_error='strict',
        dtype=<class 'numpy.float64'>, encoding='utf-8', input='content',
        lowercase=True, max_df=1.0, max_features=None, min_df=1,
        ngram_range=(1, 1), norm='l2', preprocessor=None, smooth_idf=True,...      min_weight_fract
ion_leaf=0.0, presort=False, random_state=None,
            splitter='best'))])

Untuned Accuracy of Decision Tree using TfidfVectorizer:  0.6246851385390428
tfidf__min_df :  2
tfidf__stop_words :  english
tfidf__token_pattern :  [A-Za-z0-9]+(?=\s+)
Best f1 score: 0.40299918571643156
```

In [24]:

```python
# Using Parameters from above GridSearch Result
p6_2 = Pipeline([
        ('tfidf', TfidfVectorizer(stop_words='english',token_pattern='[A-Za-z0-9]+(?=\\s+)',min_d
        ('clf', DecisionTreeClassifier())
    ])

p6_2.fit(X_train,y_train)

# accuracy
accuracy = p6_2.score(X_test,y_test)
print("Tuned Accuracy of Decision Tree using TfidfVectorizer: ", accuracy)

classifier_results["Tuned Accuracy of Decision Tree using TfidfVectorizer"]=accuracy
```

Out[24]:

```
Pipeline(memory=None,
     steps=[('tfidf', TfidfVectorizer(analyzer='word', binary=False, decode_error='strict',
        dtype=<class 'numpy.float64'>, encoding='utf-8', input='content',
        lowercase=True, max_df=1.0, max_features=None, min_df=3,
        ngram_range=(1, 1), norm='l2', preprocessor=None, smooth_idf=True,...      min_weight_fract
ion_leaf=0.0, presort=False, random_state=None,
            splitter='best'))])

Tuned Accuracy of Decision Tree using TfidfVectorizer:  0.628463476070529
```

** vii. TfidfVectorizer + MultinomialNB**

In [25]:

```
p7_1 = Pipeline([
        ('tfidf', TfidfVectorizer()),
        ('clf', MultinomialNB())
    ])

p7_1.fit(X_train,y_train)

# accuracy without parameter tuning
accuracy = p7_1.score(X_test,y_test)
print("Untuned Accuracy of MultinomialNB using TfidfVectorizer: ", accuracy)

classifier_results["Untuned Accuracy of MultinomialNB using TfidfVectorizer"]=accuracy

# Parameters to be used for Tuning
parameters = {'tfidf__min_df':[2,3],
              'tfidf__token_pattern':['[A-Za-z0-9]+(?=\\s+)'],
              'tfidf__stop_words':[None,"english"],
              'clf__alpha': [0.5,1.0,2.0],
}

# the metric used to select the best parameters
metric =  "f1_macro"

# GridSearch also uses cross validation
gs_clf = GridSearchCV(p7_1, param_grid=parameters, scoring=metric, cv=5)
gs_clf = gs_clf.fit(text, target)

# gs_clf.best_params_ returns a dictionary
# with parameter and its best value as an entry

for param_name in gs_clf.best_params_:
    print(param_name,": ",gs_clf.best_params_[param_name])

print("Best f1 score:", gs_clf.best_score_)
```

Out[25]:

```
Pipeline(memory=None,
     steps=[('tfidf', TfidfVectorizer(analyzer='word', binary=False, decode_error='strict',
        dtype=<class 'numpy.float64'>, encoding='utf-8', input='content',
        lowercase=True, max_df=1.0, max_features=None, min_df=1,
        ngram_range=(1, 1), norm='l2', preprocessor=None, smooth_idf=True,...rue,
        vocabulary=None)), ('clf', MultinomialNB(alpha=1.0, class_prior=None, fit_prior=True))])

Untuned Accuracy of MultinomialNB using TfidfVectorizer:  0.6599496221662469
clf__alpha :  0.5
tfidf__min_df :  3
tfidf__stop_words :  english
tfidf__token_pattern :  [A-Za-z0-9]+(?=\s+)
Best f1 score: 0.40078895416122884
```

In [26]:
```
# Using Parameters from above GridSearch Result
p7_2 = Pipeline([
        ('tfidf', TfidfVectorizer(stop_words='english', token_pattern='[A-Za-z0-9]+(?=\\s+)',min_
        ('clf', MultinomialNB(alpha=0.5))
    ])

p7_2.fit(X_train,y_train)

# accuracy
accuracy = p7_2.score(X_test,y_test)
print("Tuned Accuracy of MultinomialNB using TfidfVectorizer: ", accuracy)

classifier_results["Tuned Accuracy of MultinomialNB using TfidfVectorizer"]=accuracy
```

Out[26]:
```
Pipeline(memory=None,
     steps=[('tfidf', TfidfVectorizer(analyzer='word', binary=False, decode_error='strict',
        dtype=<class 'numpy.float64'>, encoding='utf-8', input='content',
        lowercase=True, max_df=1.0, max_features=None, min_df=3,
        ngram_range=(1, 1), norm='l2', preprocessor=None, smooth_idf=True,...rue,
        vocabulary=None)), ('clf', MultinomialNB(alpha=0.5, class_prior=None, fit_prior=True))])
```

```
Tuned Accuracy of MultinomialNB using TfidfVectorizer:  0.6662468513853904
```

viii. TfidfVectorizer + LinearSVC

In [27]:

```python
p8_1 = Pipeline([
        ('tfidf', TfidfVectorizer()),
        ('clf', LinearSVC())
    ])

p8_1.fit(X_train,y_train)

# accuracy
accuracy = p8_1.score(X_test,y_test)
print("Untuned Accuracy of LinearSVC using TfidfVectorizer: ", accuracy)

classifier_results["Untuned Accuracy of LinearSVC using TfidfVectorizer"]=accuracy

# Parameters to be used for Tuning
parameters = {'tfidf__min_df':[2,3],
              'tfidf__token_pattern':['[A-Za-z0-9]+(?=\\s+)'],
              'tfidf__stop_words':[None,"english"],
              'clf__loss':['hinge','squared_hinge']
}

# the metric used to select the best parameters
metric =  "f1_macro"

# GridSearch also uses cross validation
gs_clf = GridSearchCV(p8_1, param_grid=parameters, scoring=metric, cv=5)
gs_clf = gs_clf.fit(text, target)

# gs_clf.best_params_ returns a dictionary
# with parameter and its best value as an entry

for param_name in gs_clf.best_params_:
    print(param_name,": ",gs_clf.best_params_[param_name])

print("Best f1 score:", gs_clf.best_score_)
```

Out[27]:

```
Pipeline(memory=None,
     steps=[('tfidf', TfidfVectorizer(analyzer='word', binary=False, decode_error='strict',
        dtype=<class 'numpy.float64'>, encoding='utf-8', input='content',
        lowercase=True, max_df=1.0, max_features=None, min_df=1,
        ngram_range=(1, 1), norm='l2', preprocessor=None, smooth_idf=True,...ax_iter=1000,
     multi_class='ovr', penalty='l2', random_state=None, tol=0.0001,
     verbose=0))])

Untuned Accuracy of LinearSVC using TfidfVectorizer:  0.6687657430730478
clf__loss :  squared_hinge
tfidf__min_df :  3
tfidf__stop_words :  english
tfidf__token_pattern :  [A-Za-z0-9]+(?=\s+)
Best f1 score: 0.4317829573509598
```

In [28]:

```
# Using Parameters from above GridSearch Result
p8_2 = Pipeline([
        ('tfidf', TfidfVectorizer(stop_words=None,token_pattern='[A-Za-z0-9]+(?=\\s+)',min_df=2)),
        ('clf', LinearSVC(loss='hinge'))
    ])

p8_2.fit(X_train,y_train)

# accuracy
accuracy = p8_2.score(X_test,y_test)
print("Tuned Accuracy of LinearSVC using TfidfVectorizer: ", accuracy)

classifier_results["Tuned Accuracy of LinearSVC using TfidfVectorizer"]=accuracy
```

Out[28]:

```
Pipeline(memory=None,
     steps=[('tfidf', TfidfVectorizer(analyzer='word', binary=False, decode_error='strict',
        dtype=<class 'numpy.float64'>, encoding='utf-8', input='content',
        lowercase=True, max_df=1.0, max_features=None, min_df=2,
        ngram_range=(1, 1), norm='l2', preprocessor=None, smooth_idf=True,...e', max_iter=1000, mul
ti_class='ovr',
     penalty='l2', random_state=None, tol=0.0001, verbose=0))])

Tuned Accuracy of LinearSVC using TfidfVectorizer:  0.6738035264483627
```

A2. Supervised Learning - Model Comparison Analysis

In [30]:

```
for key in classifier_results:
    print('{}={}'.format(key,classifier_results[key]))
```

```
Untuned Accuracy of Logistic Regression using CountVectorizer=0.672544080604534
Tuned Accuracy of Logistic Regression using CountVectorizer=0.6662468513853904
Untuned Accuracy of Decision Tree using CountVectorizer=0.6158690176322418
Untuned Accuracy of MultinomialNB using CountVectorizer=0.6649874055415617
Tuned Accuracy of MultinomialNB using CountVectorizer=0.6435768261964736
Untuned Accuracy of LinearSVC using CountVectorizer=0.6511335012594458
Tuned Accuracy of LinearSVC using CountVectorizer=0.6511335012594458
Untuned Accuracy of Logistic Regression using TfidfVectorizer=0.672544080604534
Tuned Accuracy of Logistic Regression using TfidfVectorizer=0.6700251889168766
Untuned Accuracy of Decision Tree using TfidfVectorizer=0.6246851385390428
Tuned Accuracy of Decision Tree using TfidfVectorizer=0.628463476070529
Untuned Accuracy of MultinomialNB using TfidfVectorizer=0.6599496221662469
Tuned Accuracy of MultinomialNB using TfidfVectorizer=0.6662468513853904
Untuned Accuracy of LinearSVC using TfidfVectorizer=0.6687657430730478
Tuned Accuracy of LinearSVC using TfidfVectorizer=0.6738035264483627
```

B. Unsupervised Learning

** Unsupervised Sentiment Classification using NLTK Vader**

*** Step B1: Analyze Sentiments***

In [33]:

```python
import pandas as pd
from nltk.sentiment.vader import SentimentIntensityAnalyzer

def sentiment_analysis_vader_validation(df, filepath):
    sid = SentimentIntensityAnalyzer()
    # print df.head()
    d = []
    sentiment_map = {'pos': 4, 'neg': 0, 'neu': 2}
    for index, tweet in df.iterrows():

        if len(str(tweet['text']).split()) > 4:
            tweet_txt = tweet['text']
            tweet_date = tweet['date']
            tweet_manual_label = tweet['sentiment']

            ss = sid.polarity_scores(tweet_txt)

            '''MAX LOGIC'''
            score_sentiment = max(ss['neg'], ss['neu'], ss['pos'])

            '''
            # COMPLEX LOGIC
            if ss['neg']>0 and ss['pos']>0 and ss['neu']>0:
                score_sentiment = max(ss['neg'], ss['neu'], ss['pos'])
            elif ss['neg']==0 and ss['pos']>0 and ss['neu']>0:
                score_sentiment = ss['pos']
            elif ss['pos'] == 0 and ss['neg'] > 0 and ss['neu'] > 0:
                score_sentiment = ss['neg']
            elif ss['pos'] == 0 and ss['neg'] == 0 and ss['neu'] > 0:
                score_sentiment = ss['neu']
            '''
            sentiment = [k for k, v in ss.items() if v == score_sentiment][0]
            sentiment_mapping = sentiment_map[sentiment]
            if tweet_manual_label == sentiment_mapping:
                validation_result='Match'
            else:
                validation_result='Mismatch'

            d.append({'date': tweet_date, 'text': tweet_txt, 'polarity_score_neg':ss['neg'], 'pol

    df_processed = pd.DataFrame(d)
    #df_processed.to_csv(filepath, index=False)
    print(df_processed.groupby(['validation_result'])['validation_result'].count())


# Using merged_df created in Step A1
# merged_df has all the labelled tweets for MSFT and AAPL
output_file = 'vader_predictions.csv'
sentiment_analysis_vader_validation(aapl, output_file)
```

```
validation_result
Match       2269
Mismatch    1389
Name: validation_result, dtype: int64
```

OUTCOME OF THE SELECTION PROCESS

For our project, it is important to achieve the highest accuracy in classifying the tweet sentiments. With the results of the above analysis, we observed that LinearSVC alongwith TfidfVectorizer gave the best accuracy of 60.99%.

Therefore, we have selected the untuned LinearSVC alongwith TfidfVectorizer for the tweet sentiment classification.

title

In [ ]:

```python

```