NLP Sentiment Analysis

The aiming of this analysis is to develop a tool to detect racist or sexist speech in tweets.

As a simple approach, this detection is done on a tweet that contains hate speech in it, related to raci sentiment associated.

Hence, the work is to clearly classify and predict racist or sexist tweets from other tweets.

Dataset

The dataset of tweets was split in the ratio of 65:35 into training and testing data. Out of the testing c public and the rest is private.

train.csv - For training the models, it is provided a labelled dataset of 31,962 tweets in the form of a c each line storing a tweet id, its label and the tweet.

test_tweets.csv - It contains the test data file with only tweet ids and the tweet text with each tweet ir line.

Importing the libraries

```
import re
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
import string
import nltk
import warnings
warnings.filterwarnings("ignore", category=DeprecationWarning)

%matplotlib inline
```

Importing the datasets

```
train  = pd.read_csv('train_tweets.csv')
test = pd.read_csv('test_tweets.csv')
```

Inspecting the datasets

```
train.head()
```

	id	label	tweet
0	1	0	@user when a father is dysfunctional and is s...
1	2	0	@user @user thanks for #lyft credit i can't us...
2	3	0	bihday your majesty
3	4	0	#model i love u take with u all the time in ...
4	5	0	factsguide: society now #motivation

```
train.describe
```

```
<bound method NDFrame.describe of            id  label
0          1      0   @user when a father is dysfunctional and is s...
1          2      0  @user @user thanks for #lyft credit i can't us...
2          3      0                                bihday your majesty
3          4      0  #model   i love u take with u all the time in ...
4          5      0             factsguide: society now    #motivation
...      ...    ...                                                ...
31957  31958      0  ate @user isz that youuu?ð□□□ð□□□ð□□□ð□□□ð□□□ð...
31958  31959      0    to see nina turner on the airwaves trying to...
31959  31960      0  listening to sad songs on a monday morning otw...
31960  31961      1  @user #sikh #temple vandalised in in #calgary,...
31961  31962      0                   thank you @user for you follow  

[31962 rows x 3 columns]>
```

```
train.count
```

```
print("Number of rows:", train.shape[0])
```

```
Number of rows: 31962
```

```
print("Number of colums:",train.shape[1])
```

```
Number of colums: 3
```

```
test.describe
```

```
<bound method NDFrame.describe of           id
0      31963  #studiolife #aislife #requires #passion #dedic...
1      31964   @user #white #supremacists want everyone to s...
2      31965  safe ways to heal your #acne!!    #altwaystohe...
3      31966  is the hp and the cursed child book up for res...
4      31967    3rd #bihday to my amazing, hilarious #nephew...
...      ...                                                ...
17192  49155  thought factory: left-right polarisation! #tru...
17193  49156  feeling like a mermaid ð #hairflip #neverre...
17194  49157  #hillary #campaigned today in #ohio((omg)) &am...
17195  49158  happy, at work conference: right mindset leads...
17196  49159  my   song "so glad" free download!  #shoegaze ...

[17197 rows x 2 columns]>
```

Cleaning the dataset

```
combi = train.append(test, ignore_index=True)
```

```
/usr/local/lib/python3.6/dist-packages/pandas/core/frame.py:7138: FutureWarning:
of pandas will change to not sort by default.

To accept the future behavior, pass 'sort=False'.

To retain the current behavior and silence the warning, pass 'sort=True'.

  sort=sort,
```

```
def remove_pattern(input_txt, pattern):
    r = re.findall(pattern, input_txt)
    for i in r:
        input_txt = re.sub(i, '', input_txt)

    return input_txt


# remove twitter handles (@user)
combi['tidy_tweet'] = np.vectorize(remove_pattern)(combi['tweet'], "@[\w]*")


# remove special characters, numbers, punctuations
combi['tidy_tweet'] = combi['tidy_tweet'].str.replace("[^a-zA-Z#]", " ")


 # Removing Short Words
combi['tidy_tweet'] = combi['tidy_tweet'].apply(lambda x: ' '.join([w for w in x.spli


combi.head()
```

	id	label	tweet	tidy_
0	1	0.0	@user when a father is dysfunctional and is s...	when father dysfunctional selfish drags l
1	2	0.0	@user @user thanks for #lyft credit i can't us...	thanks #lyft credit cause they offer whee
2	3	0.0	bihday your majesty	bihday your n
3	4	0.0	#model i love u take with u all the time in ...	#model love take wi
4	5	0.0	factsguide: society now #motivation	factsguide society #mot

Tokenization

```
tokenized_tweet = combi['tidy_tweet'].apply(lambda x: x.split())
tokenized_tweet.head()
```

```
0    [when, father, dysfunctional, selfish, drags, ...
1    [thanks, #lyft, credit, cause, they, offer, wh...
2                              [bihday, your, majesty]
3                     [#model, love, take, with, time]
4                   [factsguide, society, #motivation]
Name: tidy_tweet, dtype: object
```

Lemmatizing

```
nltk.download('wordnet')
from nltk.stem import WordNetLemmatizer
lemmatizer = WordNetLemmatizer()

#tokenized_tweet = tokenized_tweet.apply(lambda x: [stemmer.stem(i) for i in x]) # st
tokenized_tweet = tokenized_tweet.apply(lambda x: [lemmatizer.lemmatize(i) for i in x
tokenized_tweet.head()
```

```
[nltk_data] Downloading package wordnet to /root/nltk_data...
[nltk_data]   Package wordnet is already up-to-date!
0    [when, father, dysfunctional, selfish, drag, k...
1    [thanks, #lyft, credit, cause, they, offer, wh...
2                              [bihday, your, majesty]
3                     [#model, love, take, with, time]
4                   [factsguide, society, #motivation]
Name: tidy_tweet, dtype: object
```

```
# from nltk.stem.porter import *
# stemmer = PorterStemmer()

# tokenized_tweet = tokenized_tweet.apply(lambda x: [stemmer.stem(i) for i in x]) # s
# tokenized_tweet.head()
```

```
for i in range(len(tokenized_tweet)):
    tokenized_tweet[i] = ' '.join(tokenized_tweet[i])

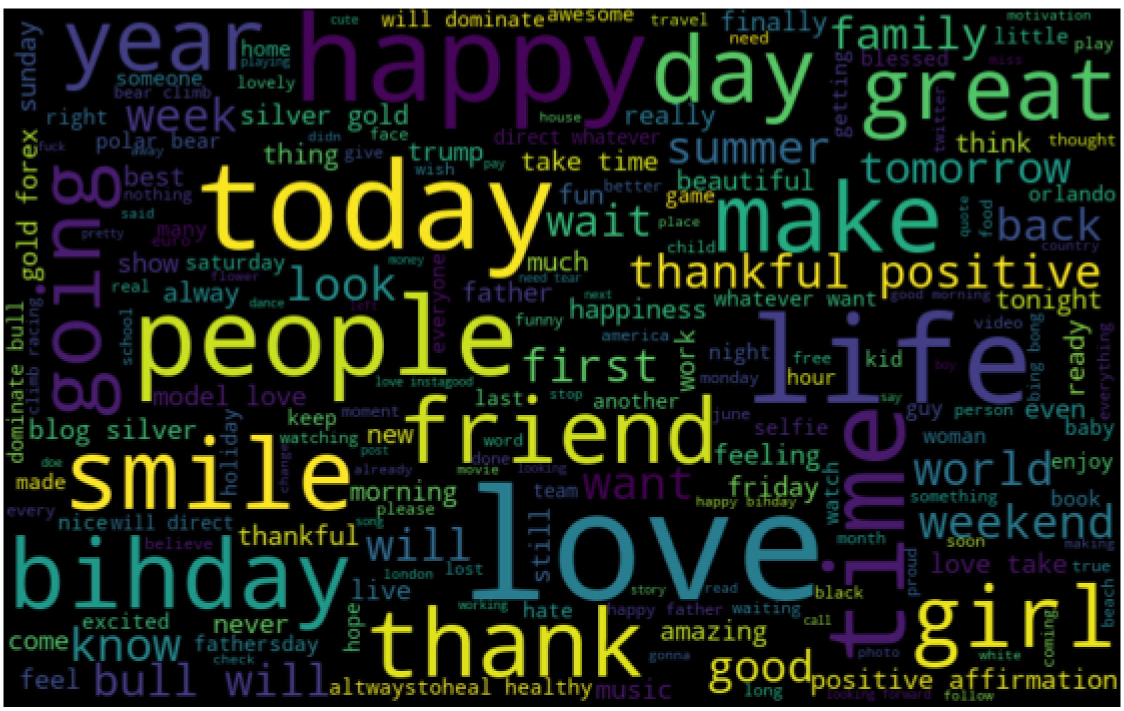
combi['tidy_tweet'] = tokenized_tweet
```

Visualization and Story Generation

```
all_words = ' '.join([text for text in combi['tidy_tweet']])
from wordcloud import WordCloud
wordcloud = WordCloud(width=800, height=500, random_state=21, max_font_size=110).gene

plt.figure(figsize=(10, 7))
plt.imshow(wordcloud, interpolation="bilinear")
plt.title('Words context in tweets')
plt.axis('off')
plt.show()
```

Words context in tweets




```
combi['label'].count
```

```
<bound method Series.count of 0        0.0
1        0.0
2        0.0
3        0.0
4        0.0
        ...
49154    NaN
49155    NaN
49156    NaN
49157    NaN
49158    NaN
Name: label, Length: 49159, dtype: float64>
```

```
print('Total number of classified Tweets (0 or 1):', combi['label'].count())
```

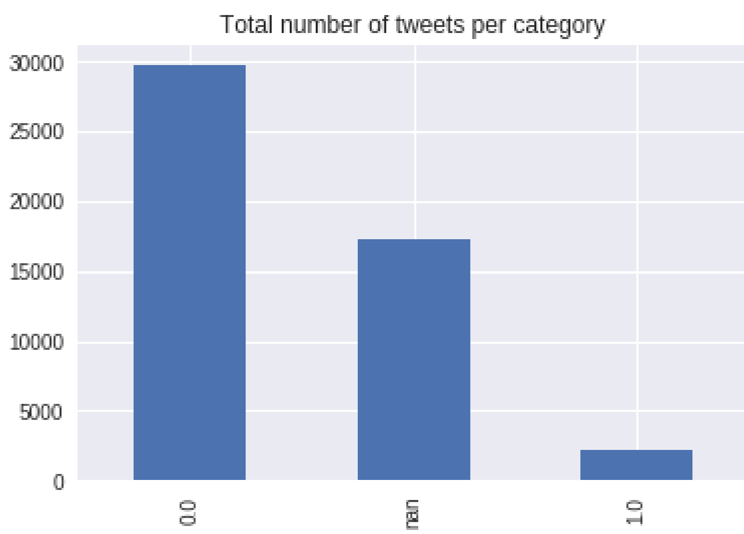
```
Total number of classified Tweets (0 or 1): 31962
```

```
print('Total number of not classified Tweets (NaN):', combi['label'].isna().sum())
```

```
Total number of not classified Tweets (NaN): 17197
```

```
counts = combi['label'].value_counts(dropna=False)
counts.plot.bar(title = "Total number of tweets per category", grid=True)
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f3b06f26be0>
```



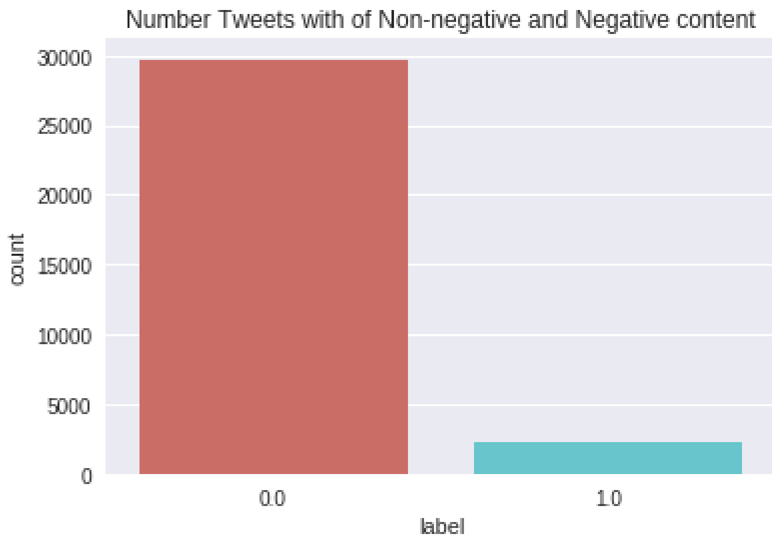
Distribution of the classified Tweets

```
combi['label'].value_counts()
```

```
0.0    29720
1.0     2242
Name: label, dtype: int64
```

```
sns.countplot(x='label', data=combi, palette='hls')
```

```
plt.title("Number Tweets with of Non-negative and Negative content")
plt.show()
plt.savefig('count_plot')
```




```
<Figure size 432x288 with 0 Axes>
```

Taking into account the labels with 0 and 1 (not including the NaNs)

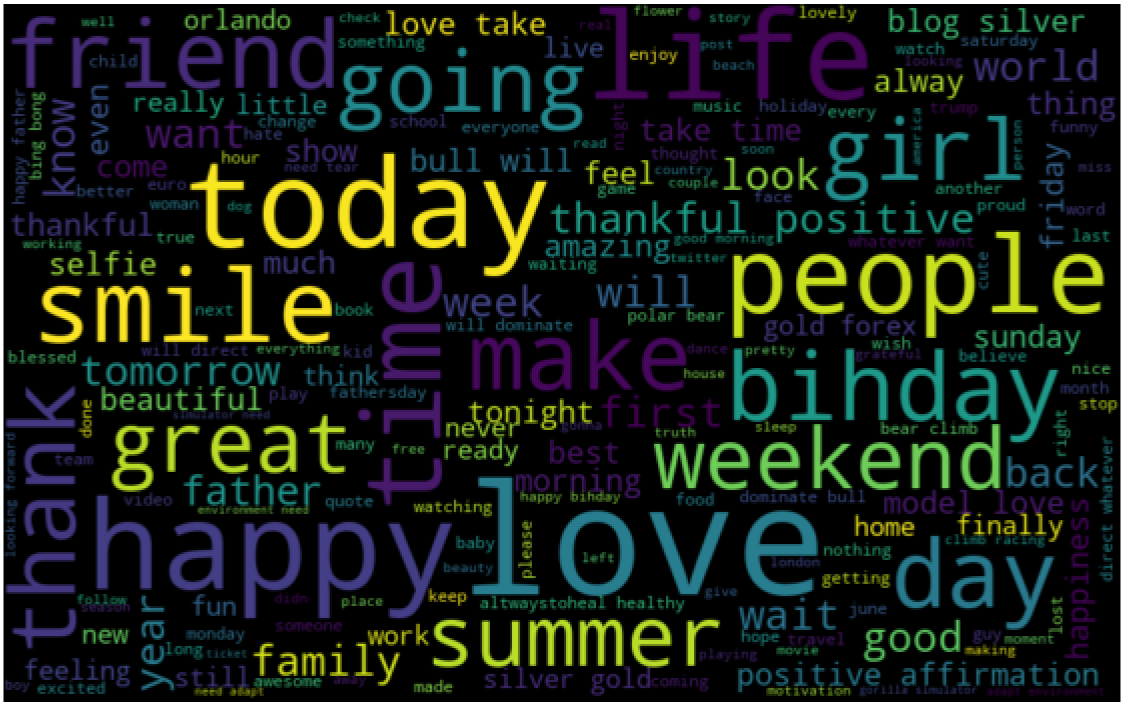
```
count_non_negative = len(combi[combi['label']==0])
#print("Number of non negative tweets is:", count_non_negative)
count_negative = len(combi[combi['label']==1])
#print("Number of negative tweets is:", count_negative)
pct_of_non_negative = count_non_negative/(count_non_negative+count_negative)
print("Percentage of non negative tweets is:", round(pct_of_non_negative*100,2),"% ("
pct_of_negative = count_negative/(count_non_negative+count_negative)
print("Percentage of negative tweets is:", round(pct_of_negative*100,2),"% (", count_
```

```
Percentage of non negative tweets is: 92.99 % ( 29720 )
Percentage of negative tweets is: 7.01 % ( 2242 )
```

```
# Words in non racist/sexist tweets
normal_words =' '.join([text for text in combi['tidy_tweet'][combi['label'] == 0]])

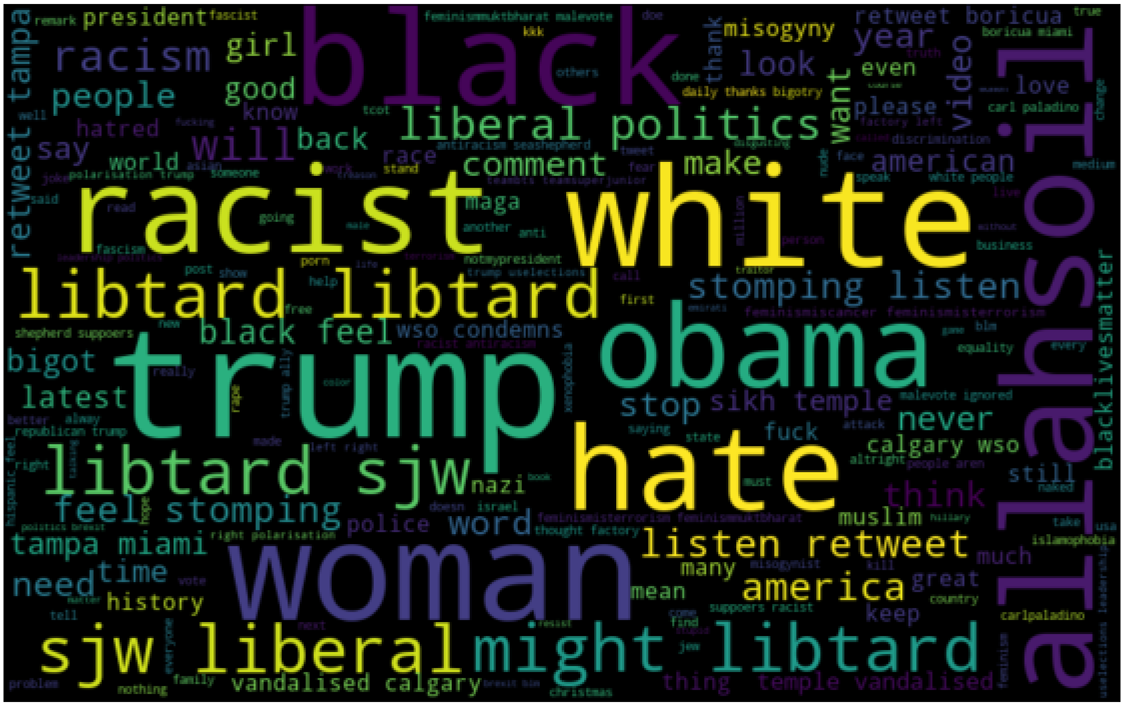
wordcloud = WordCloud(width=800, height=500, random_state=21, max_font_size=110).gene
plt.figure(figsize=(10, 7))
plt.imshow(wordcloud, interpolation="bilinear")
plt.title('Words in non racist/sexist tweets')
plt.axis('off')
plt.show()
```

Words in non racist/sexist tweets




```
# Words in racist/sexist tweets
negative_words = ' '.join([text for text in combi['tidy_tweet'][combi['label'] == 1]])
wordcloud = WordCloud(width=800, height=500,
random_state=21, max_font_size=110).generate(negative_words)
plt.figure(figsize=(10, 7))
plt.imshow(wordcloud, interpolation="bilinear")
plt.title('Words in racist/sexist tweets')
plt.axis('off')
plt.show()
```

Words in racist/sexist tweets



Hashtags on tweets sentiment impact

```
# Function to collect hashtags
def hashtag_extract(x):
    hashtags = []
    # Loop over the words in the tweet
    for i in x:
        ht = re.findall(r"#(\w+)", i)
        hashtags.append(ht)

    return hashtags

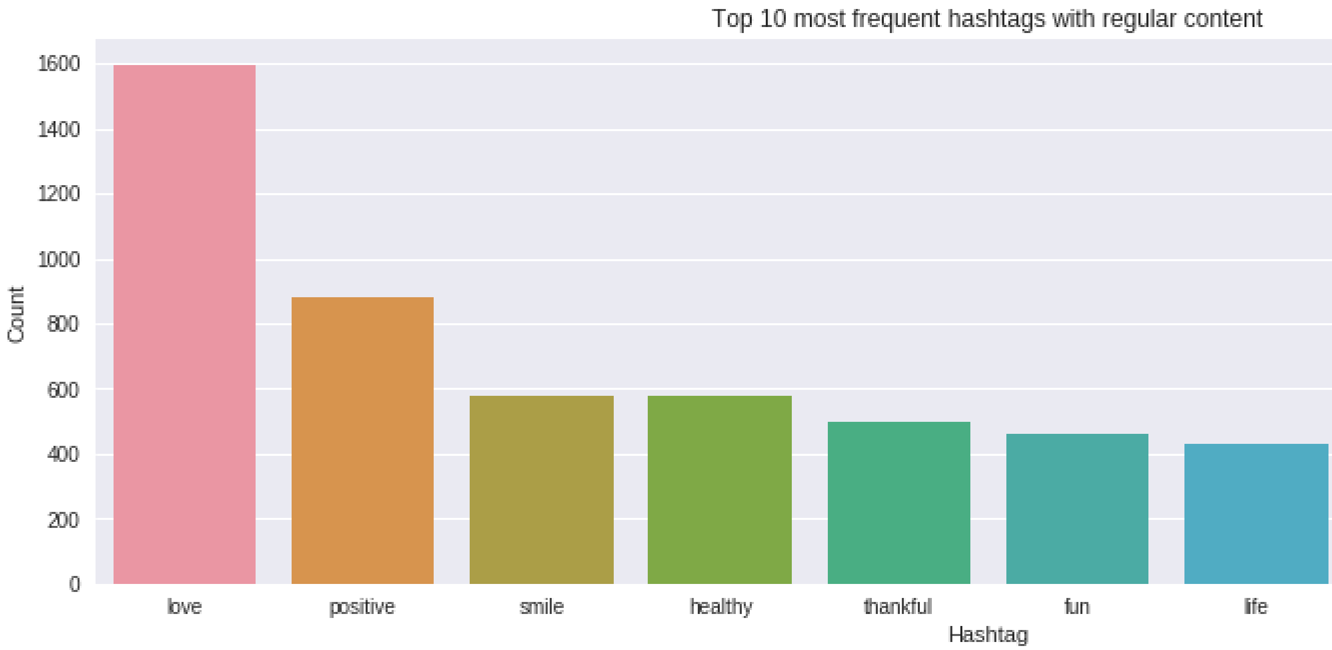

# Extracting hashtags from non racist/sexist tweets
HT_regular = hashtag_extract(combi['tidy_tweet'][combi['label'] == 0])


# Extracting hashtags from racist/sexist tweets
HT_negative = hashtag_extract(combi['tidy_tweet'][combi['label'] == 1])

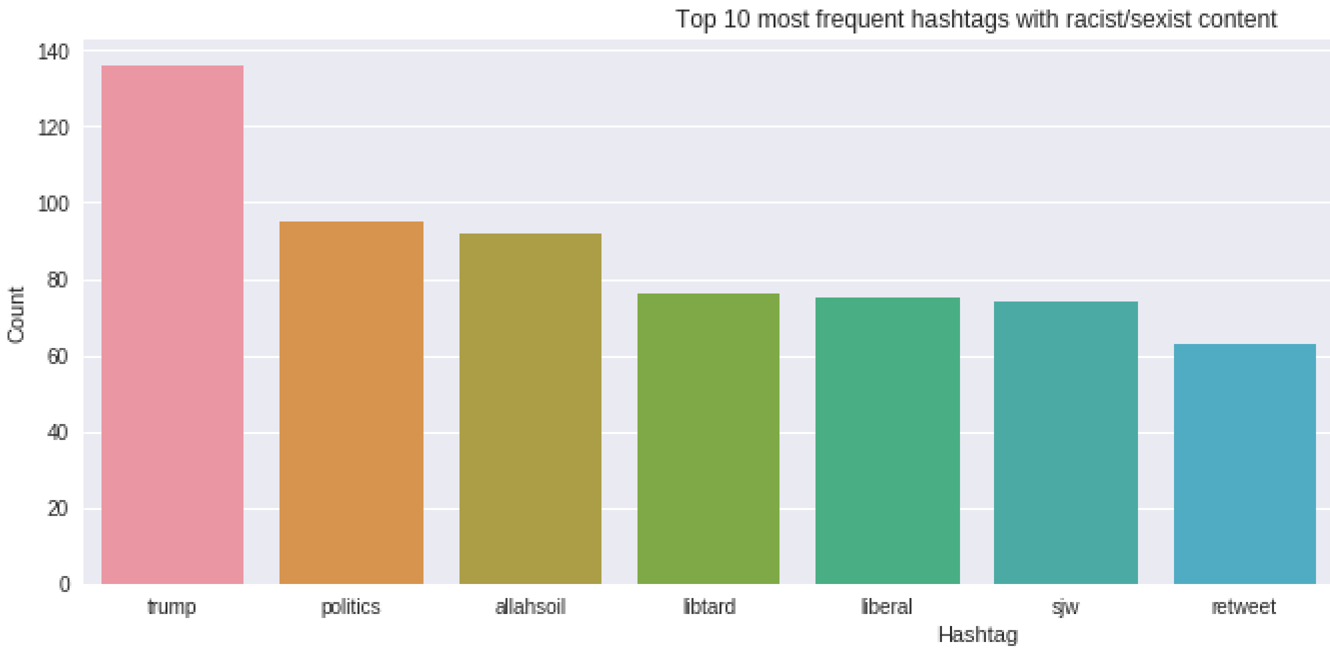

# Unnesting list
HT_regular = sum(HT_regular,[])
HT_negative = sum(HT_negative,[])


# Selecting top 10 most frequent hashtags
a = nltk.FreqDist(HT_regular)
d = pd.DataFrame({'Hashtag': list(a.keys()),
```

```
                    'Count': list(a.values())})
d = d.nlargest(columns="Count", n = 10)
plt.figure(figsize=(16,5))
ax = sns.barplot(data=d, x= "Hashtag", y = "Count")
ax.set(ylabel = 'Count')
plt.title("Top 10 most frequent hashtags with regular content")
plt.show()
```




```
# Selecting top 10 most frequent hashtags
b = nltk.FreqDist(HT_negative)
e = pd.DataFrame({'Hashtag': list(b.keys()), 'Count': list(b.values())})
e = e.nlargest(columns="Count", n = 10)
plt.figure(figsize=(16,5))
ax = sns.barplot(data=e, x= "Hashtag", y = "Count")
ax.set(ylabel = 'Count')
plt.title("Top 10 most frequent hashtags with racist/sexist content")
plt.show()
```



Feature extraction (Cleaned Tweets)

```
# Bag of Words
from sklearn.feature_extraction.text import CountVectorizer
bow_vectorizer = CountVectorizer(max_df=0.90, min_df=2, max_features=1000, stop_words
# bag-of-words feature matrix
bow = bow_vectorizer.fit_transform(combi['tidy_tweet'])


# TF-IDF
from sklearn.feature_extraction.text import TfidfVectorizer
tfidf_vectorizer = TfidfVectorizer(max_df=0.90, min_df=2, max_features=1000, stop_wor
# TF-IDF feature matrix
tfidf = tfidf_vectorizer.fit_transform(combi['tidy_tweet'])
```

Model building

```
from sklearn.linear_model import LogisticRegression
from sklearn.model_selection import train_test_split
from sklearn.metrics import f1_score


# Building model using TF-IDF features
train_bow = bow[:train.shape[0],:]
test_bow = bow[train.shape[0]:,:]

# splitting data into training and validation set
X_train, X_test, y_train, y_test = train_test_split(train_bow, train['label'], random
```

```
X_train, X_test, y_train, y_test = train_test_split(train_bow, train['label'], random

lreg = LogisticRegression()
lreg.fit(X_train, y_train) # training the model

prediction = lreg.predict_proba(X_test) # predicting on the validation set

prediction_int = prediction[:,1] >= 0.3 # if prediction is greater than or equal to 0

prediction_int = prediction_int.astype(np.int)

f1 = f1_score(y_test, prediction_int) # calculating f1 score
print("f1-score (Bag Of Words): %.2f" % f1)
```

```
f1-score (Bag Of Words): 0.50
```

```
# Accuracy of the classifier
print('Accuracy of logistic regression classifier on test set: {:.2f}%'.format(lreg.s
```

```
Accuracy of logistic regression classifier on test set: 94.40%
```

```
test_pred = lreg.predict_proba(test_bow)
test_pred_int = test_pred[:,1] >= 0.3
test_pred_int = test_pred_int.astype(np.int)
test['label'] = test_pred_int
submission = test[['id','label']]
submission.to_csv('lreg_model_bow.csv', index=False) # writing data to a CSV file
```

```
# Building model using TF-IDF features

train_tfidf = tfidf[:train.shape[0],:]
test_tfidf = tfidf[train.shape[0]:,:]

xtrain_tfidf = train_tfidf[y_train.index]
xvalid_tfidf = train_tfidf[y_test.index]

# splitting data into training and validation set
X_train, X_test, y_train, y_test = train_test_split(train_tfidf, train['label'], ranc


lreg.fit(X_train, y_train)

prediction = lreg.predict_proba(xvalid_tfidf)
prediction_int = prediction[:,1] >= 0.3
prediction_int = prediction_int.astype(np.int)

f1 = f1_score(y_test, prediction_int)
print("f1-score (TF-IDF): {0:.2f}".format(round(f1,2)))
```

```
f1-score (TF-IDF): 0.51
```

```
# Accuracy of the classifier
print('Accuracy of logistic regression classifier on test set: {:.2f}%'.format(lreg.s
```

```
Accuracy of logistic regression classifier on test set: 94.45%
```

Hyperparameters tunning

```
# Grid Search Cross Validation
# GridSearchCV
def myGSCV(X_train, y_train, hyperparameters):
    from sklearn.model_selection import GridSearchCV

    lreg_model = LogisticRegression()
    clf = GridSearchCV(lreg_model, hyperparameters, cv=10, verbose=0)

    # Fit grid search
    best_model = clf.fit(X_train, y_train)
    return best_model
```

```
# Create regularization penalty space
penalty = ['l1', 'l2']
# Create regularization hyperparameter space
C = np.logspace(0, 4, 10)
# Create hyperparameter options
hyperparameters = dict(C=C, penalty=penalty)
```

```
best_model = myGSCV(X_train,y_train,hyperparameters)
```

```
#Training Score
print('Training score: ', round(best_model.best_score_,2)*100,"%")
```

```
Training score:  95.0 %
```

```
print('Best parameters: ', best_model.best_params_)
```

```
Best parameters:  {'C': 2.7825594022071245, 'penalty': 'l2'}
```

```
# View best hyperparameters
print('Best Penalty:', best_model.best_estimator_.get_params()['penalty'])
print('Best C:', best_model.best_estimator_.get_params()['C'])
```

```
Best Penalty: l2
Best C: 2.7825594022071245
```

Final Evaluation

```
# ROC Curve

from sklearn.metrics import roc_curve,auc

lm = LogisticRegression(solver='lbfgs', max_iter=1000)
best_model.fit(X_train, y_train)
lm.fit(X_test, y_test)

y_pred = best_model.predict_proba(X_test)[:, 1]
fpr_lm, tpr_lm, _ = roc_curve(y_test, y_pred)
roc_auc = auc(fpr_lm, tpr_lm)
```

```
/usr/local/lib/python3.6/dist-packages/sklearn/model_selection/_validation.py:53
ValueError: Solver lbfgs supports only 'l2' or 'none' penalties, got l1 penalty.

  FitFailedWarning)
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  FitFailedWarning)
/usr/local/lib/python3.6/dist-packages/sklearn/linear_model/_logistic.py:940: Co
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as shown in:
    https://scikit-learn.org/stable/modules/preprocessing.html
Please also refer to the documentation for alternative solver options:
    https://scikit-learn.org/stable/modules/linear_model.html#logistic-regressio
  extra_warning_msg=_LOGISTIC_SOLVER_CONVERGENCE_MSG)
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```

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```

Making predictions

```
# Making predictions
print('Prediction:', y_pred)
```

```
Prediction: [0.00946957 0.01852425 0.04342106 ... 0.01830569 0.05225327 0.011267
```

Accuracy of the classifier

```
# Accuracy of the classifier
print('Accuracy of logistic regression classifier on test set: {:.2f}%'.format(best_m
```

```
Accuracy of logistic regression classifier on test set: 94.55%
```

```
prediction = best_model.predict_proba(X_test) # predicting on the validation set

prediction_int = prediction[:,1] >= 0.3 # if prediction is greater than or equal to 0

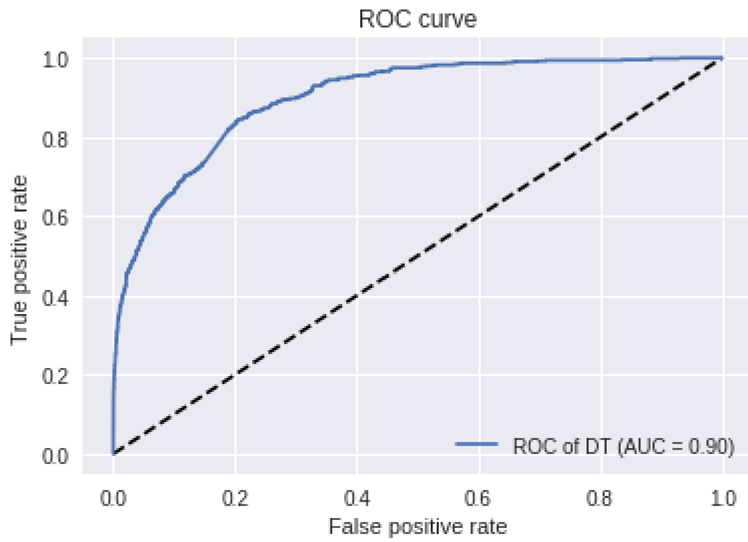
prediction_int = prediction_int.astype(np.int)

f1 = f1_score(y_test, prediction_int) # calculating f1 score
print("f1-score (Bag Of Words): %.2f" % f1)
```

```
f1-score (Bag Of Words): 0.51
```

Plotting the ROC curve

```
plt.figure(1)
plt.plot([0, 1], [0, 1], 'k--')
plt.plot(fpr_lm, tpr_lm, label='ROC of DT (AUC = %0.2f)' % roc_auc)
plt.xlabel('False positive rate')
plt.ylabel('True positive rate')
plt.title('ROC curve')
plt.legend(loc='best')
plt.show()
```




```
# Loading model to compare the results
model = pickle.load(open('lreg_model.pkl','rb'))

#from sklearn.externals import joblib
# model = joblib.load('dt_model.pkl')
y_pred = model.predict_proba(X_test)[:, 1]

y_pred
```

```
array([0.00946957, 0.01852425, 0.04342106, ..., 0.01830569, 0.05225327,
       0.01126769])
```

```
print('Prediction:', y_pred)
```

```
Prediction: [0.00946957 0.01852425 0.04342106 ... 0.01830569 0.05225327 0.011267
```

```
print('Accuracy of logistic regression classifier on test set: {:.2f}%'.format(model.
```

```
Accuracy of logistic regression classifier on test set: 94.55%
```

Conclusion

The logistic regression model worked in this kernel, once done the featured engir and tunned is able to predict the content (sentiment involved) from a regular twe opposition to a racist/sexist one and viceversa with an accuracy of 95.0%