Spam filtering

Many of the e-mail services dedicate a special folder in their inboxes for the e-mails that are categorized as spams. The underlying mechanism that works behind the scenes is a text classification model which takes the content of the e-mail as input and returns a probability regarding this e-mail being a spam. This area of NLP is called **text classification** and we'll walk you through some applications of text categorization in the remainder of code.

In [1]:
```
import pandas as pd
```

Load and simplify the dataset

In [37]:
```
df = pd.read_csv(r'spam.csv',encoding='ISO-8859-1')

df.rename(columns = {'v1':'class_label', 'v2':'message'}, inplace = True)
df.drop(['Unnamed: 2', 'Unnamed: 3', 'Unnamed: 4'], axis = 1, inplace = True)

# notice your class_labels

df
```

Out[37]:

	class_label	message
0	ham	Go until jurong point, crazy.. Available only ...
1	ham	Ok lar... Joking wif u oni...
2	spam	Free entry in 2 a wkly comp to win FA Cup fina...
3	ham	U dun say so early hor... U c already then say...
4	ham	Nah I don't think he goes to usf, he lives aro...
...	...	...
5567	spam	This is the 2nd time we have tried 2 contact u...
5568	ham	Will Ì_ b going to esplanade fr home?
5569	ham	Pity, * was in mood for that. So...any other s...
5570	ham	The guy did some bitching but I acted like i'd...
5571	ham	Rofl. Its true to its name

5572 rows × 2 columns

In [38]:
```
# exploring the dataset. Have a look at your class counts.
# This will give you an idea whether you have an imbalanced
# dataset problem
df['class_label'].value_counts()
```

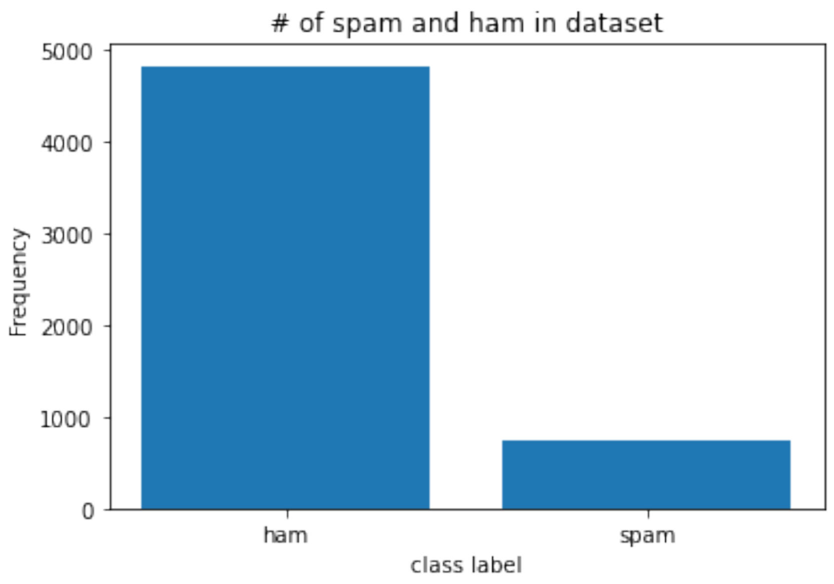
Out[38]:
```
ham     4825
spam     747
Name: class_label, dtype: int64
```

In [39]:
```
#exploratory data analysis
#bar chart for initial data
import matplotlib.pyplot as ab
import numpy as np

labels = ['ham', 'spam']
counts = [4825, 747]
ypos = np.arange(len(labels)) #converting text labels to numberic value, 0 an
ypos
```

Out[39]:
```
array([0, 1])
```

In [40]:
```
ab.xticks(ypos, labels)
ab.xlabel("class label")
ab.ylabel("Frequency")
ab.title("# of spam and ham in dataset")
ab.bar(ypos, counts)
```

Out[40]:
```
<BarContainer object of 2 artists>
```



In [41]:
```
df
```

Out[41]:

	class_label	message
0	ham	Go until jurong point, crazy.. Available only ...
1	ham	Ok lar... Joking wif u oni...
2	spam	Free entry in 2 a wkly comp to win FA Cup fina...
3	ham	U dun say so early hor... U c already then say...
4	ham	Nah I don't think he goes to usf, he lives aro...
...	...	...
5567	spam	This is the 2nd time we have tried 2 contact u...
5568	ham	Will Ì_ b going to esplanade fr home?
5569	ham	Pity, * was in mood for that. So...any other s...
5570	ham	The guy did some bitching but I acted like i'd...
5571	ham	Rofl. Its true to its name

5572 rows × 2 columns

In [42]:
```
#separate both classes
df_ham = df[df.class_label=='ham']
df_spam = df[df.class_label=='spam']

#convert the dataframe to a list. This is how you will print the wordcloud.
ham_list=df_ham['message'].tolist()
spam_list= df_spam['message'].tolist()
#spam_list
```

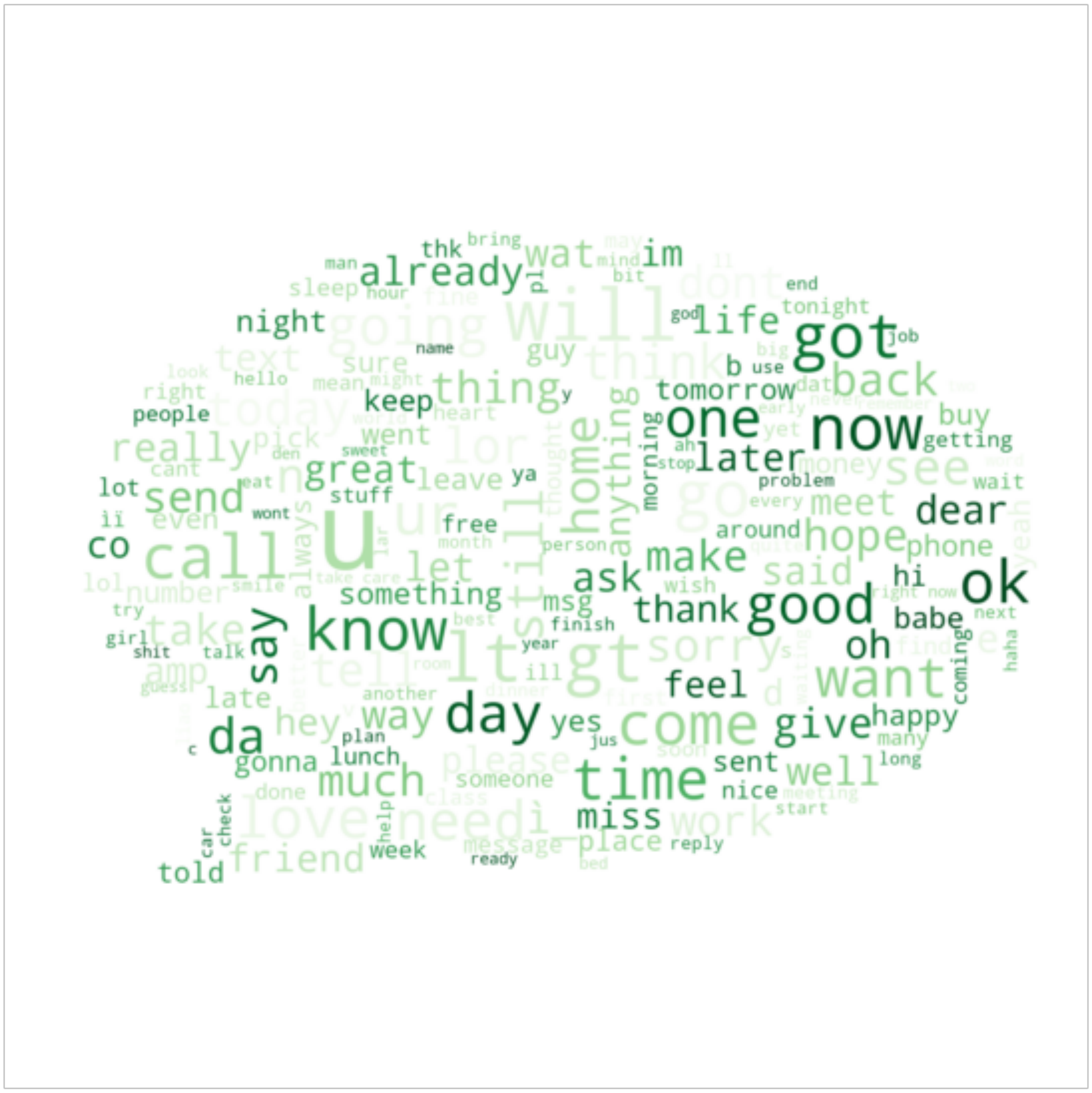
In [43]:
```
filtered_spam = ("").join(spam_list) #convert the list into a string of spam
filtered_spam = filtered_spam.lower()

filtered_ham = ("").join(ham_list) #convert the list into a string of ham
filtered_ham = filtered_ham.lower()
#filtered_spam
```

In [44]:
```
import os
from wordcloud import WordCloud
from PIL import Image
comment_mask = np.array(Image.open("comment.png"))
```

In [45]:
```
# Create and generate a word cloud image:
wordcloud = WordCloud(max_font_size = 160, margin=0, mask = comment_mask, bac

# Display the generated image

ab.figure(figsize=[20,10])
ab.imshow(wordcloud, interpolation='bilinear')
ab.axis("off")

ab.margins(x=0, y=0)

ab.show()
```

free
mobile
text
txt
call
claim
reply
stop
now
won
will
tone
win
â prize
â cash
message
contact u
please call
new
landline
receive
customer service
ringtone
150p
chat
u
t c
poly
urgent
identifier code
send stop
suite342 2lands
prize guaranteed
account statement
co uk
po box
call identifier
call mobileupd8
collect
go
phone
guaranteed call

In [46]:
```
# Create and generate a word cloud image:
wordcloud = WordCloud(max_font_size = 160, margin=0, mask = comment_mask, bac

# Display the generated image

ab.figure(figsize=[20,10])
ab.imshow(wordcloud, interpolation='bilinear')
ab.axis("off")

ab.margins(x=0, y=0)

ab.show()
```



In [47]:
```
# since class labels are strings, convert them to numbers: 1 for spam
df['class_label'] = df['class_label'].apply(lambda x: 1 if x == 'spam' else 0
```

In [48]:
```
from sklearn.model_selection import train_test_split
# 30% test, 70% train split
# split the dataset
x_train, x_test, y_train, y_test = train_test_split(df['message'], df['class_

print('rows in test set: ' + str(x_test.shape))
print('rows in train set: ' + str(x_train.shape))
type(x_train)
```

```
rows in test set: (1672,)
rows in train set: (3900,)
```

Out[48]:
```
pandas.core.series.Series
```

tfidf Vectorizer cell

In [49]:
```
from sklearn.feature_extraction.text import TfidfVectorizer

# Fitting of the CountVectorizer consists of tokenization of the training dat
# and building the vocabulary
# Transforming the CountVectorizer creates the bag-of-words representation
# of the train data.
# the bow is stored in a SciPy sparse matrix that only stores the nonzero
# entries.
# to look at the actual content of the sparse matrix, convert it to dense
# array using numpy.toarray() method

# vectorize email text into tfidf matrix
# TfidfVectorizer converts collection of raw documents to a matrix of TF-IDF
# It's equivalent to CountVectorizer followed by TfidfTransformer.
list = x_train.tolist()
vectorizer = TfidfVectorizer(
    input= list ,  # input is actual text
    lowercase=True,      # convert to lower case before tokenizing
    stop_words='english' # remove stop words
)
features_train_transformed = vectorizer.fit_transform(list) #gives tf idf vec
features_test_transformed  = vectorizer.transform(x_test) #gives tf idf vecto
# after transform, boW with tfidf values are calculated.
```

In [50]:
```
from sklearn.naive_bayes import MultinomialNB

# train a classifier
classifier = MultinomialNB()
classifier.fit(features_train_transformed, y_train)
```

Out[50]:
```
MultinomialNB()
```

In [51]:
```
# review the classifier accuracy
print("classifier accuracy {:.2f}%".format(classifier.score(features_test_tra
classifier accuracy 96.41%
```

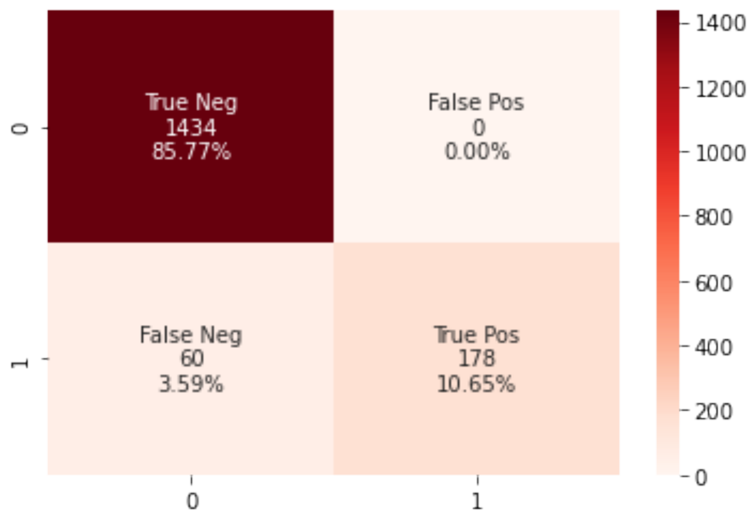
In [52]:
```
# accuracy looks good but  it is not a good indicator
# for imbalanced datasets.
```

In [53]:
```
labels = classifier.predict(features_test_transformed)
from sklearn.metrics import f1_score
from sklearn.metrics import confusion_matrix
from sklearn.metrics import accuracy_score
from sklearn.metrics import classification_report

actual = y_test.tolist()
predicted = labels
results = confusion_matrix(actual, predicted)

print('Confusion Matrix :')
print(results)
print ('Accuracy Score :',accuracy_score(actual, predicted))
print ('Report : ')
print (classification_report(actual, predicted) )

score_2 = f1_score(actual, predicted, average = 'binary')
print('F-Measure: %.3f' % score_2)
```

```
Confusion Matrix :
[[1434    0]
 [  60  178]]
Accuracy Score : 0.9641148325358851
Report :
              precision    recall  f1-score   support

           0       0.96      1.00      0.98      1434
           1       1.00      0.75      0.86       238

    accuracy                           0.96      1672
   macro avg       0.98      0.87      0.92      1672
weighted avg       0.97      0.96      0.96      1672

F-Measure: 0.856
```

In [54]:
```
#heatmap for confusion matrix
import seaborn as sns
group_names = ['True Neg','False Pos','False Neg','True Pos']
group_counts = ["{0:0.0f}".format(value) for value in
                results.flatten()]
group_percentages = ["{0:.2%}".format(value) for value in
                     results.flatten()/np.sum(results)]
labels = [f"{v1}\n{v2}\n{v3}" for v1, v2, v3 in
          zip(group_names,group_counts,group_percentages)]
labels = np.asarray(labels).reshape(2,2)
sns.heatmap(results, annot=labels, fmt='', cmap='Reds')
```

```
Out[54]: <AxesSubplot:>
```



count vectorizer cell

```
In [55]: list = x_train.tolist()
         from sklearn.feature_extraction.text import CountVectorizer
         cv = CountVectorizer(strip_accents = ascii) #initialize countVectorizer.
         word_count_vector=cv.fit_transform(list) #get the document-term matrix.
         print(word_count_vector.shape) #see the rows and columns of this matrix

         (3900, 7127)
```

```
In [ ]: #cv.vocabulary_
```

```
In [57]: x_test_vector = cv.transform(x_test)
```

```
In [58]: # train a classifier
         classifier = MultinomialNB()
         classifier.fit(word_count_vector, y_train)

Out[58]: MultinomialNB()
```

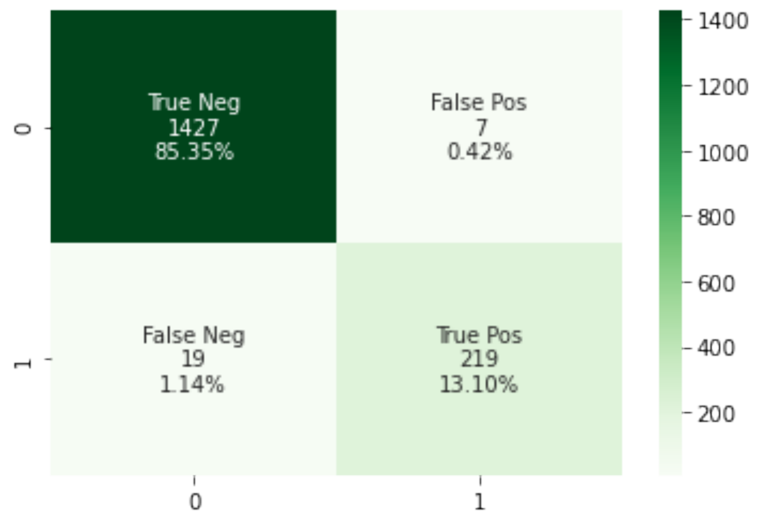
```
In [59]: # review the classifier accuracy
         print("classifier accuracy {:.2f}%".format(classifier.score(x_test_vector, y_

         classifier accuracy 98.44%
```

In [60]:
```
labels = classifier.predict(x_test_vector)



actual = y_test
predicted = labels
results = confusion_matrix(actual, predicted)

print('Confusion Matrix :')
print(results)
print ('Accuracy Score :',accuracy_score(actual, predicted))
print ('Report : ')
print (classification_report(actual, predicted) )
score_2 = f1_score(actual, predicted, average = 'binary')
print('F-Measure: %.3f' % score_2)
```

```
Confusion Matrix :
[[1427    7]
 [  19  219]]
Accuracy Score : 0.9844497607655502
Report :
              precision    recall  f1-score   support

           0       0.99      1.00      0.99      1434
           1       0.97      0.92      0.94       238

    accuracy                           0.98      1672
   macro avg       0.98      0.96      0.97      1672
weighted avg       0.98      0.98      0.98      1672

F-Measure: 0.944
```

In [61]:
```
#heatmap for confusion matrix

group_names = ['True Neg','False Pos','False Neg','True Pos']
group_counts = ["{0:0.0f}".format(value) for value in
               results.flatten()]
group_percentages = ["{0:.2%}".format(value) for value in
                    results.flatten()/np.sum(results)]
labels = [f"{v1}\n{v2}\n{v3}" for v1, v2, v3 in
          zip(group_names,group_counts,group_percentages)]
labels = np.asarray(labels).reshape(2,2)
sns.heatmap(results, annot=labels, fmt='', cmap='Greens')
```

```
Out[61]: <AxesSubplot:>
```



```
In [62]: #Implementing cross validation on both the models

         #THIS CELL USES CROSS VALIDATION FOR COUNT VECTORIZER

         #%pip install scikit-learn

         #%conda upgrade scikit-learn


         from sklearn.model_selection import cross_val_score

         X=df["message"].tolist()
         Y=df["class_label"].tolist()
         df

         classifier = MultinomialNB()

         cv = CountVectorizer(strip_accents = ascii) #initialize countVectorizer.
         word_count_vector=cv.fit_transform(X) #get the document-term matrix.
         #print(word_count_vector.shape) #see the rows and columns of this matrix

         scores=cross_val_score(classifier,word_count_vector,Y,cv=10,scoring='accuracy

         print(scores)

         print(scores.mean())
```

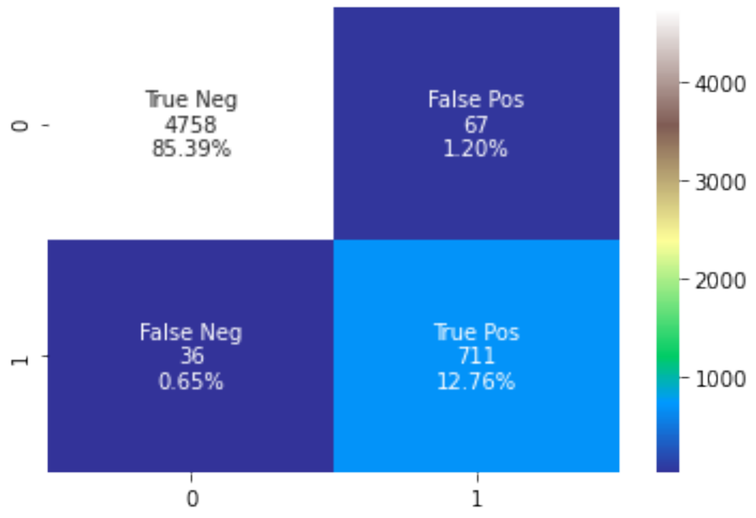
```
[0.98387097 0.98028674 0.98025135 0.98384201 0.98025135 0.98025135
 0.98204668 0.98384201 0.97127469 0.98922801]
0.9815145138768233
```

In [63]:
```
from sklearn.model_selection import cross_val_predict

y_pred = cross_val_predict(classifier,word_count_vector, Y, cv=10)
conf_mat = confusion_matrix(Y, y_pred)
conf_mat
```

Out[63]:
```
array([[4758,   67],
       [  36,  711]])
```

In [64]:
```
#heatmap for confusion matrix

group_names = ['True Neg','False Pos','False Neg','True Pos']
group_counts = ["{0:0.0f}".format(value) for value in
                conf_mat.flatten()]
group_percentages = ["{0:.2%}".format(value) for value in
                     conf_mat.flatten()/np.sum(conf_mat)]
labels = [f"{v1}\n{v2}\n{v3}" for v1, v2, v3 in
          zip(group_names,group_counts,group_percentages)]
labels = np.asarray(labels).reshape(2,2)
sns.heatmap(conf_mat, annot=labels, fmt='', cmap='terrain')
```

Out[64]:
```
<AxesSubplot:>
```



In [65]:
```
vectorizer = TfidfVectorizer(
    input= list ,  # input is actual text
    lowercase=True,      # convert to lower case before tokenizing
    stop_words='english' # remove stop words
)
features_train_transformed = vectorizer.fit_transform(X) #gives tf idf vector
#features_test_transformed  = vectorizer.transform(x_test) #gives tf idf vect

classifier = MultinomialNB()

scores=cross_val_score(classifier,features_train_transformed,Y,cv=10,scoring=

print(scores)

print(scores.mean())
```

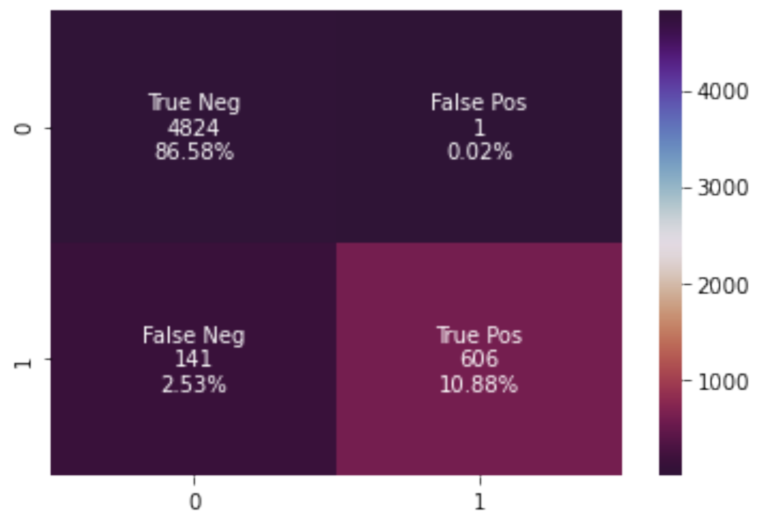
```
[0.98387097 0.97849462 0.96947935 0.97845601 0.96947935 0.96768402
 0.97127469 0.97307002 0.97307002 0.98025135]
0.9745130402887975
```

In [66]:
```
y_pred = cross_val_predict(classifier,features_train_transformed, Y, cv=10)
conf_mat = confusion_matrix(Y, y_pred)
conf_mat
```

Out[66]:
```
array([[4824,    1],
       [ 141,  606]])
```

In [67]:
```
#heatmap for confusion matrix

group_names = ['True Neg','False Pos','False Neg','True Pos']
group_counts = ["{0:0.0f}".format(value) for value in
                conf_mat.flatten()]
group_percentages = ["{0:.2%}".format(value) for value in
                     conf_mat.flatten()/np.sum(conf_mat)]
labels = [f"{v1}\n{v2}\n{v3}" for v1, v2, v3 in
          zip(group_names,group_counts,group_percentages)]
labels = np.asarray(labels).reshape(2,2)
sns.heatmap(conf_mat, annot=labels, fmt='', cmap='twilight_shifted_r')
```

```
Out[67]: <AxesSubplot:>
```


True Neg
4824
86.58%
False Pos
1
0.02%
False Neg
141
2.53%
True Pos
606
10.88%
0
1
0
1
4000
3000
2000
1000

```
In [ ]:
```

```
In [ ]:
```