3.6 Featurizing text data with tfidf

In [1]:

```
import pandas as pd
import matplotlib.pyplot as plt
import re
import time
import warnings
import numpy as np
from nltk.corpus import stopwords
from sklearn.preprocessing import normalize
from sklearn.feature_extraction.text import CountVectorizer
from sklearn.feature_extraction.text import TfidfVectorizer
warnings.filterwarnings("ignore")
import sys
import os
import pandas as pd
import numpy as np
from tqdm import tqdm
import datetime
import joblib

import pandas as pd
import matplotlib.pyplot as plt
import re
import time
import warnings
import datetime
import joblib
import sqlite3
from sqlalchemy import create_engine # database connection
import csv
import os
warnings.filterwarnings("ignore")
import datetime as dt
import numpy as np
from nltk.corpus import stopwords
from sklearn.decomposition import TruncatedSVD
from sklearn.preprocessing import normalize
from sklearn.feature_extraction.text import CountVectorizer
from sklearn.manifold import TSNE
import seaborn as sns
from sklearn.neighbors import KNeighborsClassifier
from sklearn.metrics import confusion_matrix
from sklearn.metrics.classification import accuracy_score, log_loss
from sklearn.feature_extraction.text import TfidfVectorizer
from collections import Counter
from scipy.sparse import hstack
from sklearn.multiclass import OneVsRestClassifier
from sklearn.svm import SVC
from sklearn.model_selection import StratifiedKFold
from collections import Counter, defaultdict
from sklearn.calibration import CalibratedClassifierCV
from sklearn.naive_bayes import MultinomialNB
from sklearn.naive_bayes import GaussianNB
from sklearn.model_selection import train_test_split
from sklearn.model_selection import GridSearchCV
import math
from sklearn.metrics import normalized_mutual_info_score
```

```python
from sklearn.ensemble import RandomForestClassifier



from sklearn.model_selection import cross_val_score
from sklearn.linear_model import SGDClassifier
from mlxtend.classifier import StackingClassifier

from sklearn import model_selection
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import precision_recall_curve, auc, roc_curve

# exctract word2vec vectors
# https://github.com/explosion/spaCy/issues/1721
# http://landinghub.visualstudio.com/visual-cpp-build-tools
#import spacy
```

In [2]:

```python
# avoid decoding problems
df = pd.read_csv("train.csv")

# encode questions to unicode
# https://stackoverflow.com/a/6812069
# ----------------- python 2 ---------------------
# df['question1'] = df['question1'].apply(lambda x: unicode(str(x),"utf-8"))
# df['question2'] = df['question2'].apply(lambda x: unicode(str(x),"utf-8"))
# ----------------- python 3 ---------------------
df['question1'] = df['question1'].apply(lambda x: str(x))
df['question2'] = df['question2'].apply(lambda x: str(x))
```

In [3]:

```python
from sklearn.feature_extraction.text import TfidfVectorizer
from sklearn.feature_extraction.text import CountVectorizer

startTime3 = datetime.datetime.now()
print("Current Time = ",startTime3)

ques_1_train = list(df['question1'][:70000])
ques_1_test = list(df['question1'][70000:100000])

ques_2_train = list(df['question2'][:70000])
ques_2_test = list(df['question2'][70000:100000])

tfidf = TfidfVectorizer(lowercase=False,max_features=384 )
ques_1_train_tfidf = tfidf.fit_transform(ques_1_train)
ques_1_test_tfidf = tfidf.transform(ques_1_test)

ques_2_train_tfidf = tfidf.fit_transform(ques_2_train)
ques_2_test_tfidf = tfidf.transform(ques_2_test)

print("Time taken to run this cell {}".format(datetime.datetime.now() - startTime
```

```
Current Time =  2019-05-15 15:29:07.249978
Time taken to run this cell 0:00:11.175635
```

In [4]:
```
ques_1_train_tfidf_df = pd.DataFrame(ques_1_train_tfidf.toarray())
ques_1_test_tfidf_df = pd.DataFrame(ques_1_test_tfidf.toarray())

ques_2_train_tfidf_df = pd.DataFrame(ques_2_train_tfidf.toarray())
ques_2_test_tfidf_df = pd.DataFrame(ques_2_test_tfidf.toarray())

ques_2_test_tfidf_df[:10]
```

Out[4]:
```
     0    1    2    3    4    5    6    7    8    9  ...  374  375  376  377  378  379  380  381  382
0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  ...  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
1  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  ...  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
2  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  ...  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
3  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  ...  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
4  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  ...  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
5  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  ...  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
6  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  ...  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
7  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  ...  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
8  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  ...  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
9  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  ...  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0

10 rows × 384 columns
```

In [5]:
```
#prepro_features_train.csv (Simple Preprocessing Feartures)
#nlp_features_train.csv (NLP Features)
if os.path.isfile('nlp_features_train.csv'):
    dfnlp = pd.read_csv("nlp_features_train.csv",encoding='latin-1')
else:
    print("download nlp_features_train.csv from drive or run previous notebook")

if os.path.isfile('df_fe_without_preprocessing_train.csv'):
    dfppro = pd.read_csv("df_fe_without_preprocessing_train.csv",encoding='latin-
else:
    print("download df_fe_without_preprocessing_train.csv from drive or run previ
```

In [6]:
```
df1 = dfnlp.drop(['qid1','qid2','question1','question2'],axis=1)
df2 = dfppro.drop(['qid1','qid2','question1','question2','is_duplicate'],axis=1)
df3 = df.drop(['qid1','qid2','question1','question2','is_duplicate'],axis=1)
```

In [7]:

```
# dataframe of nlp features
df1.head()
```

Out[7]:

	id	is_duplicate	cwc_min	cwc_max	csc_min	csc_max	ctc_min	ctc_max	last_word_eq	firs
0	0	0	0.999980	0.833319	0.999983	0.999983	0.916659	0.785709	0.0	
1	1	0	0.799984	0.399996	0.749981	0.599988	0.699993	0.466664	0.0	
2	2	0	0.399992	0.333328	0.399992	0.249997	0.399996	0.285712	0.0	
3	3	0	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.0	
4	4	0	0.399992	0.199998	0.999950	0.666644	0.571420	0.307690	0.0	

In [8]:

```
df1_train = df1[:70000]
df1_test = df1[70000:100000]
df1_test[:10]
```

Out[8]:

	id	is_duplicate	cwc_min	cwc_max	csc_min	csc_max	ctc_min	ctc_max	last_word_
70000	70000	1	0.666644	0.666644	0.999967	0.599988	0.833319	0.624992	
70001	70001	0	0.399992	0.249997	0.000000	0.000000	0.153845	0.133332	
70002	70002	0	0.666644	0.499988	0.666644	0.499988	0.571420	0.571420	
70003	70003	0	0.999967	0.749981	0.999975	0.799984	0.999986	0.777769	
70004	70004	0	0.249997	0.249997	0.142855	0.083333	0.187499	0.124999	
70005	70005	0	0.499988	0.499988	0.499975	0.199996	0.499992	0.333330	
70006	70006	1	0.999967	0.749981	0.666644	0.666644	0.833319	0.714276	
70007	70007	1	0.666656	0.571420	0.749981	0.599988	0.699993	0.583328	
70008	70008	0	0.000000	0.000000	0.666644	0.249997	0.249997	0.142856	
70009	70009	0	0.999967	0.999967	0.599988	0.374995	0.749991	0.461535	

In [9]:

```
# data before preprocessing
df2.head()
```

Out[9]:

	id	freq_qid1	freq_qid2	q1len	q2len	q1_n_words	q2_n_words	word_Common	word_Total	w
0	0	1	1	66	57	14	12	10.0	23.0	
1	1	4	1	51	88	8	13	4.0	20.0	
2	2	1	1	73	59	14	10	4.0	24.0	
3	3	1	1	50	65	11	9	0.0	19.0	
4	4	3	1	76	39	13	7	2.0	20.0	

In [10]:

```
df2_train = df2[:70000]
df2_test = df2[70000:100000]
df2_test[:10]
```

Out[10]:

	id	freq_qid1	freq_qid2	q1len	q2len	q1_n_words	q2_n_words	word_Common	word_
70000	70000	1	1	40	33	8	6	4.0	
70001	70001	1	1	77	76	12	14	1.0	
70002	70002	1	1	44	38	7	7	4.0	
70003	70003	1	1	45	35	8	6	5.0	
70004	70004	4	1	105	116	15	22	3.0	
70005	70005	1	1	47	38	9	6	2.0	
70006	70006	2	1	40	34	7	6	4.0	
70007	70007	1	1	56	69	10	12	7.0	
70008	70008	1	1	46	75	8	14	2.0	
70009	70009	1	1	54	40	12	8	6.0	

In [11]:

```
# dataframe of nlp features
df3.head()
```

Out[11]:

	id
0	0
1	1
2	2
3	3
4	4

In [12]:
```
df3_train = df3[:70000]
df3_test = df3[70000:100000]
df3_test[:10]
```

Out[12]:

	id
70000	70000
70001	70001
70002	70002
70003	70003
70004	70004
70005	70005
70006	70006
70007	70007
70008	70008
70009	70009

In [13]:
```
df3_q1_train = pd.DataFrame(ques_1_train_tfidf_df, index= df3_train.index)
df3_q1_test = pd.DataFrame(ques_1_test_tfidf_df, index= df3_test.index)

df3_q2_train = pd.DataFrame(ques_2_train_tfidf_df, index= df3_train.index)
df3_q2_test = pd.DataFrame(ques_2_test_tfidf_df, index= df3_test.index)
```

In [14]:
```
print("Number of features in nlp dataframe :", df1.shape[1])
print("Number of features in preprocessed dataframe :", df2.shape[1])
print("Number of features in question1 w2v  dataframe :", ques_1_train_tfidf_df.s
print("Number of features in question2 w2v  dataframe :", ques_1_test_tfidf_df.sh
print("Number of features in final dataframe  :", df1.shape[1]+df2.shape[1]+ques_
```

```
Number of features in nlp dataframe : 17
Number of features in preprocessed dataframe : 12
Number of features in question1 w2v  dataframe : 384
Number of features in question2 w2v  dataframe : 384
Number of features in final dataframe  : 797
```

In [20]:

```
# storing the final features of train data to csv file
startTime3 = datetime.datetime.now()
print("Current Time = ",startTime3)

if not os.path.isfile('final_features_train_tfidf.csv'):
    df3_q1_train['id']=df1_train['id']
    df3_q2_train['id']=df1_train['id']
    df1_train  = df1_train.merge(df2_train, on='id',how='left')
    df2_train  = df3_q1_train.merge(df3_q2_train, on='id',how='left')
    result  = df1_train.merge(df2_train, on='id',how='left')
    result.to_csv('final_features_train_tfidf.csv')

print("Time taken to run this cell {}".format(datetime.datetime.now() - startTime
```

```
Current Time =  2019-05-13 15:24:37.252542
Time taken to run this cell 0:04:59.678311
```

In [15]:

```
final_features_train_tfidf = pd.read_csv("final_features_train_tfidf.csv")
final_features_train_tfidf[:5]
```

Out[15]:

	Unnamed: 0	id	is_duplicate	cwc_min	cwc_max	csc_min	csc_max	ctc_min	ctc_max	last_w
0	0	0	0	0.999980	0.833319	0.999983	0.999983	0.916659	0.785709	
1	1	1	0	0.799984	0.399996	0.749981	0.599988	0.699993	0.466664	
2	2	2	0	0.399992	0.333328	0.399992	0.249997	0.399996	0.285712	
3	3	3	0	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	
4	4	4	0	0.399992	0.199998	0.999950	0.666644	0.571420	0.307690	

5 rows × 797 columns

In [22]:

```
# storing the final features of test data to csv file
startTime = datetime.datetime.now()
print("Current Time = ",startTime)

if not os.path.isfile('final_features_test_tfidf.csv'):
    df3_q1_test['id']=df1_test['id']
    df3_q2_test['id']=df1_test['id']
    df1_test  = df1_test.merge(df2_test, on='id',how='left')
    df2_test  = df3_q1_test.merge(df3_q2_test, on='id',how='left')
    result_test  = df1_test.merge(df2_test, on='id',how='left')
    result_test.to_csv('final_features_test_tfidf.csv')

print("Time taken to run this cell {}".format(datetime.datetime.now() - startTime
```

```
Current Time =  2019-05-13 15:30:34.551741
Time taken to run this cell 0:01:49.072173
```

In [16]:
```
final_features_test_tfidf = pd.read_csv("final_features_test_tfidf.csv")
final_features_test_tfidf[:5]
```

Out[16]:

	Unnamed: 0	id	is_duplicate	cwc_min	cwc_max	csc_min	csc_max	ctc_min	ctc_max	las
0	0	70000	1	0.666644	0.666644	0.999967	0.599988	0.833319	0.624992	
1	1	70001	0	0.399992	0.249997	0.000000	0.000000	0.153845	0.133332	
2	2	70002	0	0.666644	0.499988	0.666644	0.499988	0.571420	0.571420	
3	3	70003	0	0.999967	0.749981	0.999975	0.799984	0.999986	0.777769	
4	4	70004	0	0.249997	0.249997	0.142855	0.083333	0.187499	0.124999	

5 rows × 797 columns

In [17]:
```
# remove the first row
start = datetime.datetime.now()
print("Current Time = ",start)

final_features_train_tfidf.drop(final_features_train_tfidf.index[0], inplace=True
y_true_train = final_features_train_tfidf['is_duplicate']
final_features_train_tfidf.drop(['Unnamed: 0', 'id','is_duplicate'], axis=1, inpl

final_features_test_tfidf.drop(final_features_test_tfidf.index[0], inplace=True)
y_true_test = final_features_test_tfidf['is_duplicate']
final_features_test_tfidf.drop(['Unnamed: 0', 'id','is_duplicate'], axis=1, inpla

current_time = datetime.datetime.now()
print("Time taken to run this cell: ",current_time-start)
```

```
Current Time =  2019-05-15 15:33:21.426267
Time taken to run this cell:  0:00:02.787742
```

In [18]:
```
final_features_train_tfidf.head()
```

Out[18]:

	cwc_min	cwc_max	csc_min	csc_max	ctc_min	ctc_max	last_word_eq	first_word_eq	abs_le
1	0.799984	0.399996	0.749981	0.599988	0.699993	0.466664	0.0	1.0	
2	0.399992	0.333328	0.399992	0.249997	0.399996	0.285712	0.0	1.0	
3	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.0	0.0	
4	0.399992	0.199998	0.999950	0.666644	0.571420	0.307690	0.0	1.0	
5	0.666656	0.571420	0.888879	0.799992	0.705878	0.705878	1.0	0.0	

5 rows × 794 columns

In [19]:
```
final_features_test_tfidf.head()
```

Out[19]:

	cwc_min	cwc_max	csc_min	csc_max	ctc_min	ctc_max	last_word_eq	first_word_eq	abs_le
1	0.399992	0.249997	0.000000	0.000000	0.153845	0.133332	0.0	0.0	
2	0.666644	0.499988	0.666644	0.499988	0.571420	0.571420	0.0	0.0	
3	0.999967	0.749981	0.999975	0.799984	0.999986	0.777769	0.0	1.0	
4	0.249997	0.249997	0.142855	0.083333	0.187499	0.124999	0.0	0.0	
5	0.499988	0.499988	0.499975	0.199996	0.499992	0.333330	0.0	0.0	

5 rows × 794 columns

In [ ]:
```
# resetting index
def reset_index(data_frame):
    data_frame = data_frame.reset_index()
    data_frame['index_col'] = data_frame.index

    data_frame = data_frame.drop("index", axis=1)
    data_frame = data_frame.drop("index_col", axis=1)
    return(data_frame)
```

In [ ]:
```
final_features_train_tfidf = reset_index(final_features_train_tfidf)
final_features_test_tfidf = reset_index(final_features_test_tfidf)
```

In [20]:
```
# https://stackoverflow.com/questions/7368789/convert-all-strings-in-a-list-to-in
y_true_train = list(map(int, y_true_train.values))
y_true_test = list(map(int, y_true_test.values))
```

In [21]:
```
print(np.shape(y_true_train))
print(np.shape(y_true_test))
```

```
(69999,)
(29999,)
```

Converting strings to numerics

In [22]:

```
# after we read from sql table each entry was read it as a string
# we convert all the features into numaric before we apply any model
start = datetime.datetime.now()
print("Current Time = ",start)

cols = list(final_features_train_tfidf.columns)
for i in cols:
    final_features_train_tfidf[i] = final_features_train_tfidf[i].apply(pd.to_num
    print(i)

current_time = datetime.datetime.now()
print("Time taken to run this cell: ",current_time-start)

start2 = datetime.datetime.now()
print("Current Time = ",start2)

cols = list(final_features_test_tfidf.columns)
for i in cols:
    final_features_test_tfidf[i] = final_features_test_tfidf[i].apply(pd.to_numer
    print(i)

current_time = datetime.datetime.now()
print("Time taken to run this cell: ",current_time-start2)
```

```
323_y
324_y
325_y
326_y
327_y
328_y
329_y
330_y
331_y
332_y
333_y
334_y
335_y
336_y
337_y
338_y

339_y
340_y
341_y
342_y
```

In [23]:

```
X_train_tfidf = final_features_train_tfidf
X_test_tfidf = final_features_test_tfidf

y_train_tfidf = y_true_train
y_test_tfidf = y_true_test

print("Number of data points in train data :",X_train_tfidf.shape)
print("Number of data points in test data :",X_test_tfidf.shape)

import joblib                                       #   * DO NOT RUN *
joblib.dump(X_train_tfidf,"X_train_tfidf.pkl")
joblib.dump(X_test_tfidf,"X_test_tfidf.pkl")
joblib.dump(y_train_tfidf,"y_train_tfidf.pkl")
joblib.dump(y_test_tfidf,"y_test_tfidf.pkl")
```

```
Number of data points in train data : (69999, 794)
Number of data points in test data : (29999, 794)
```

Out[23]:

```
['y_test_tfidf.pkl']
```

In [ ]:

```
#Loading the saved Train data frame
X_train_tfidf = joblib.load("X_train_tfidf.pkl")
X_test_tfidf = joblib.load("X_test_tfidf.pkl")

y_train_tfidf = joblib.load("y_train_tfidf.pkl")
y_test_tfidf = joblib.load("y_test_tfidf.pkl")
```

In [24]:

```
# Standardizing the data
from sklearn.preprocessing import StandardScaler
std_scal = StandardScaler(with_mean=False)
std_scal.fit(X_train_tfidf)
X_train_tfidf = std_scal.transform(X_train_tfidf)
X_test_tfidf = std_scal.transform(X_test_tfidf)
```

```
C:\Anaconda3\lib\site-packages\sklearn\preprocessing\data.py:645: DataConversio
nWarning: Data with input dtype int64, float64 were all converted to float64 by
StandardScaler.
  return self.partial_fit(X, y)
C:\Anaconda3\lib\site-packages\ipykernel_launcher.py:5: DataConversionWarning:
Data with input dtype int64, float64 were all converted to float64 by StandardS
caler.
  """
C:\Anaconda3\lib\site-packages\ipykernel_launcher.py:6: DataConversionWarning:
Data with input dtype int64, float64 were all converted to float64 by StandardS
caler.
```

In [25]:

```
print("-"*10, "Distribution of output variable in train data", "-"*10)
train_distr = Counter(y_train_tfidf)
train_len = len(y_train_tfidf)
print("Class 0: ",int(train_distr[0])/train_len,"Class 1: ", int(train_distr[1])/
print("-"*10, "Distribution of output variable in train data", "-"*10)
test_distr = Counter(y_test_tfidf)
test_len = len(y_test_tfidf)
print("Class 0: ",int(test_distr[1])/test_len, "Class 1: ",int(test_distr[1])/tes
```

```
---------- Distribution of output variable in train data ----------
Class 0:  0.6275375362505179 Class 1:  0.3724624637494821
---------- Distribution of output variable in train data ----------
Class 0:  0.3727124237474582 Class 1:  0.3727124237474582
```

In [26]:
```
# This function plots the confusion matrices given y_i, y_i_hat.
def plot_confusion_matrix(test_y, predict_y):
    C = confusion_matrix(test_y, predict_y)
    # C = 9,9 matrix, each cell (i,j) represents number of points of class i are

    A =(((C.T)/(C.sum(axis=1))).T)
    #divid each element of the confusion matrix with the sum of elements in that

    # C = [[1, 2],
    #     [3, 4]]
    # C.T = [[1, 3],
    #        [2, 4]]
    # C.sum(axis = 1)  axis=0 corresonds to columns and axis=1 corresponds to row
    # C.sum(axix =1) = [[3, 7]]
    # ((C.T)/(C.sum(axis=1))) = [[1/3, 3/7]
    #                            [2/3, 4/7]]

    # ((C.T)/(C.sum(axis=1))).T = [[1/3, 2/3]
    #                            [3/7, 4/7]]
    # sum of row elements = 1

    B =(C/C.sum(axis=0))
    #divid each element of the confusion matrix with the sum of elements in that
    # C = [[1, 2],
    #     [3, 4]]
    # C.sum(axis = 0)  axis=0 corresonds to columns and axis=1 corresponds to row
    # C.sum(axix =0) = [[4, 6]]
    # (C/C.sum(axis=0)) = [[1/4, 2/6],
    #                       [3/4, 4/6]]
    plt.figure(figsize=(20,4))

    labels = [1,2]
    # representing A in heatmap format
    cmap=sns.light_palette("blue")
    plt.subplot(1, 3, 1)
    sns.heatmap(C, annot=True, cmap=cmap, fmt=".3f", xticklabels=labels, yticklab
    plt.xlabel('Predicted Class')
    plt.ylabel('Original Class')
    plt.title("Confusion matrix")

    plt.subplot(1, 3, 2)
    sns.heatmap(B, annot=True, cmap=cmap, fmt=".3f", xticklabels=labels, yticklab
    plt.xlabel('Predicted Class')
    plt.ylabel('Original Class')
    plt.title("Precision matrix")

    plt.subplot(1, 3, 3)
    # representing B in heatmap format
    sns.heatmap(A, annot=True, cmap=cmap, fmt=".3f", xticklabels=labels, yticklab
    plt.xlabel('Predicted Class')
    plt.ylabel('Original Class')
    plt.title("Recall matrix")

    plt.show()
```

In [27]:

```python
print(np.shape(X_train_tfidf))
print(np.shape(y_train_tfidf))
```

```
(69999, 794)
(69999,)
```

In [28]:

```python
# checking for NaN values
def NaN_values(data_frame):
    bool_series = pd.isnull(data_frame)

    # displayind data only with team = NaN
    print("Number of rows with NaN values = ",len(data_frame[bool_series]))
    return (data_frame[bool_series][:10])
```

In [29]:

```python
x = NaN_values(X_train_tfidf)
x
```

```
Number of rows with NaN values =  0
```

Out[29]:

```
array([], dtype=float64)
```

In [ ]:

```python
X_train_tfidf = np.nan_to_num(X_train_tfidf)   #Not required if there are no Null
```

In [30]:

```python
x = NaN_values(X_test_tfidf)
x
```

```
Number of rows with NaN values =  23039232
```

Out[30]:

```
array([nan, nan, nan, nan, nan, nan, nan, nan, nan, nan])
```

In [31]:

```python
X_test_tfidf = np.nan_to_num(X_test_tfidf)
```

In [32]:

```python
x = NaN_values(X_test_tfidf)
x
```

```
Number of rows with NaN values =  0
```

Out[32]:

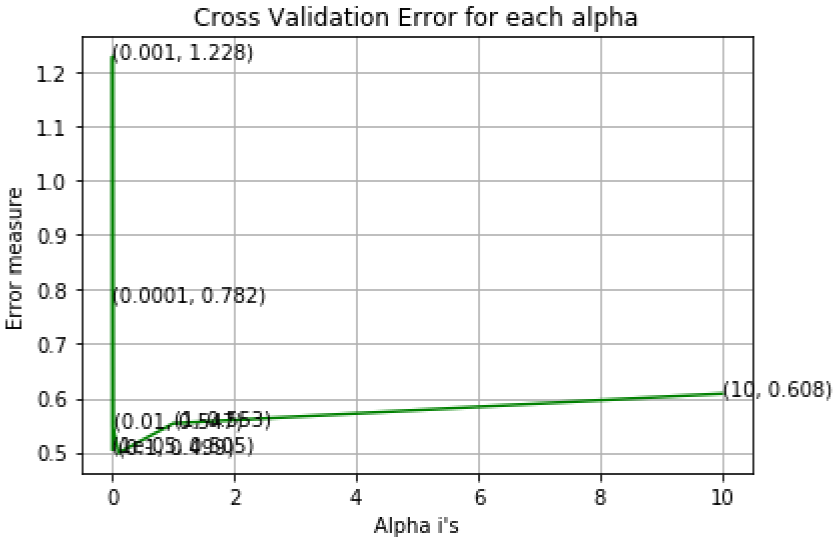
```
array([], dtype=float64)
```

Logistic Regression with hyperparameter tuning

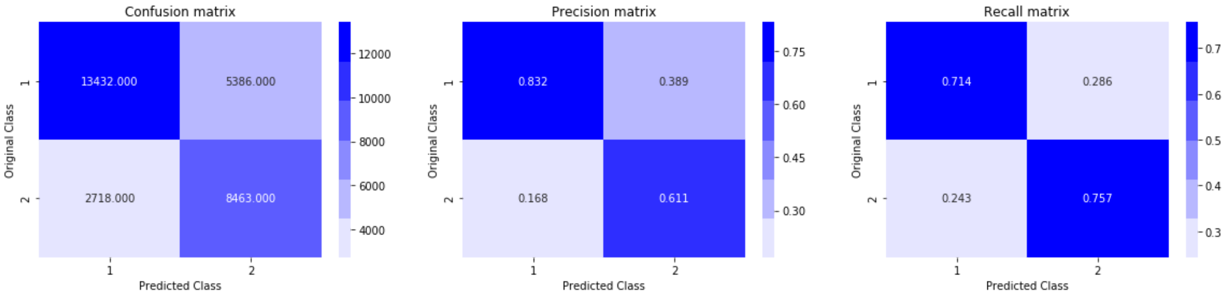
In [33]:

```
startTime = datetime.datetime.now()
print("Current Time = ",startTime)

alpha = [10 ** x for x in range(-5, 2)] # hyperparam for SGD classifier.

log_error_array=[]
for i in alpha:
    clf = SGDClassifier(alpha=i, penalty='l2', loss='log', random_state=42)
    clf.fit(X_train_tfidf, y_train_tfidf)
    sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
    sig_clf.fit(X_train_tfidf, y_train_tfidf)
    predict_y = sig_clf.predict_proba(X_test_tfidf)
    log_error_array.append(log_loss(y_test_tfidf, predict_y, labels=clf.classes_,
    print('For values of alpha = ', i, "The log loss is:",log_loss(y_test_tfidf,

fig, ax = plt.subplots()
ax.plot(alpha, log_error_array,c='g')
for i, txt in enumerate(np.round(log_error_array,3)):
    ax.annotate((alpha[i],np.round(txt,3)), (alpha[i],log_error_array[i]))
plt.grid()
plt.title("Cross Validation Error for each alpha")
plt.xlabel("Alpha i's")
plt.ylabel("Error measure")
plt.show()


best_alpha = np.argmin(log_error_array)
clf = SGDClassifier(alpha=alpha[best_alpha], penalty='l2', loss='log', random_sta
clf.fit(X_train_tfidf, y_train_tfidf)
sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
sig_clf.fit(X_train_tfidf, y_train_tfidf)

predict_y = sig_clf.predict_proba(X_train_tfidf)
print('For values of best alpha = ', alpha[best_alpha], "The train log loss is:",
predict_y = sig_clf.predict_proba(X_test_tfidf)
print('For values of best alpha = ', alpha[best_alpha], "The test log loss is:",l
predicted_y =np.argmax(predict_y,axis=1)
print("Total number of data points :", len(predicted_y))
plot_confusion_matrix(y_test_tfidf, predicted_y)

print("Time taken for creation of dataframe is {}".format(datetime.datetime.now()
```

```
Current Time =  2019-05-15 15:59:24.949789
For values of alpha =  1e-05 The log loss is: 0.5051989387640091
For values of alpha =  0.0001 The log loss is: 0.782082306689474
For values of alpha =  0.001 The log loss is: 1.228487817527734
For values of alpha =  0.01 The log loss is: 0.5466074154614651
For values of alpha =  0.1 The log loss is: 0.49895200560259007
For values of alpha =  1 The log loss is: 0.5533644643462943
For values of alpha =  10 The log loss is: 0.6081851595597474
```



```
For values of best alpha =  0.1 The train log loss is: 0.43116409874272005
For values of best alpha =  0.1 The test log loss is: 0.49895200560259007
Total number of data points : 29999
```

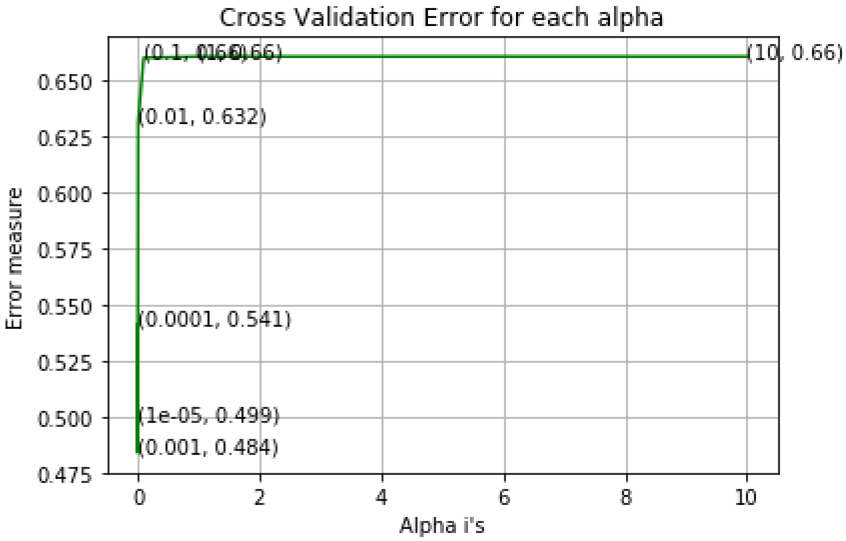


```
Time taken for creation of dataframe is 0:02:35.046433
```

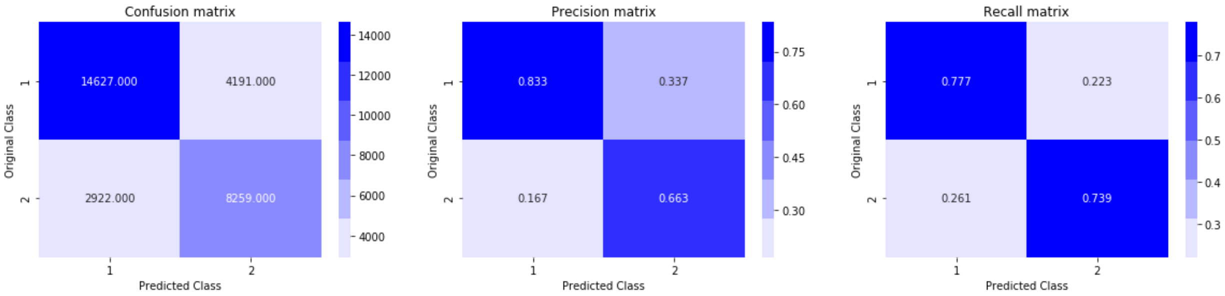
Linear SVM with hyperparameter tuning

In [34]:
```
startTime = datetime.datetime.now()
print("Current Time = ",startTime)

alpha = [10 ** x for x in range(-5, 2)] # hyperparam for SGD classifier.


log_error_array=[]
for i in alpha:
    clf = SGDClassifier(alpha=i, penalty='l1', loss='hinge', random_state=42)
    clf.fit(X_train_tfidf, y_train_tfidf)
    sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
    sig_clf.fit(X_train_tfidf, y_train_tfidf)
    predict_y = sig_clf.predict_proba(X_test_tfidf)
    log_error_array.append(log_loss(y_test_tfidf, predict_y, labels=clf.classes_,
    print('For values of alpha = ', i, "The log loss is:",log_loss(y_test_tfidf,

fig, ax = plt.subplots()
ax.plot(alpha, log_error_array,c='g')
for i, txt in enumerate(np.round(log_error_array,3)):
    ax.annotate((alpha[i],np.round(txt,3)), (alpha[i],log_error_array[i]))
plt.grid()
plt.title("Cross Validation Error for each alpha")
plt.xlabel("Alpha i's")
plt.ylabel("Error measure")
plt.show()


best_alpha = np.argmin(log_error_array)
clf = SGDClassifier(alpha=alpha[best_alpha], penalty='l1', loss='hinge', random_s
clf.fit(X_train_tfidf, y_train_tfidf)
sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
sig_clf.fit(X_train_tfidf, y_train_tfidf)

predict_y = sig_clf.predict_proba(X_train_tfidf)
print('For values of best alpha = ', alpha[best_alpha], "The train log loss is:",
predict_y = sig_clf.predict_proba(X_test_tfidf)
print('For values of best alpha = ', alpha[best_alpha], "The test log loss is:",l
predicted_y =np.argmax(predict_y,axis=1)
print("Total number of data points :", len(predicted_y))
plot_confusion_matrix(y_test_tfidf, predicted_y)

print("Time taken for creation of dataframe is {}".format(datetime.datetime.now()
```

```
Current Time =  2019-05-15 16:02:00.070589
For values of alpha =  1e-05 The log loss is: 0.49856494173314964
For values of alpha =  0.0001 The log loss is: 0.541283329412915
For values of alpha =  0.001 The log loss is: 0.48380995234132207
For values of alpha =  0.01 The log loss is: 0.6316405940658874
For values of alpha =  0.1 The log loss is: 0.6598254626208729
For values of alpha =  1 The log loss is: 0.6603846901367277
For values of alpha =  10 The log loss is: 0.6603836463545636
```



```
For values of best alpha =  0.001 The train log loss is: 0.4381700544187956
For values of best alpha =  0.001 The test log loss is: 0.48380995234132207
Total number of data points : 29999
```



```
Time taken for creation of dataframe is 0:04:08.140769
```

In [42]:

```
from prettytable import PrettyTable
x = PrettyTable()
x.field_names = ["Paramters/Models","Logistic Regression", "SVM"]

x.add_row(["train log loss (tfidf): ", "0.43116409874272005", "0.4381700544187956
x.add_row(["test log loss (tfidf) : ", "0.49895200560259007", "0.4838099523413220

print(x)
```

```
+--------------------------+---------------------+---------------------+
|     Paramters/Models     | Logistic Regression |         SVM         |
+--------------------------+---------------------+---------------------+
| train log loss (tfidf):  | 0.43116409874272005 |  0.4381700544187956 |
| test log loss (tfidf) :  | 0.49895200560259007 | 0.48380995234132207 |
+--------------------------+---------------------+---------------------+
```

In [ ]: