In [ ]:

```
import pandas as pd
import matplotlib.pyplot as plt
import re
import time
import warnings
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.cross_validation 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
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
```

In [ ]:

```
#Creating db file from csv
if not os.path.isfile('train.db'):
    disk_engine = create_engine('sqlite:///train.db')
    start = dt.datetime.now()
    chunksize = 180000
    j = 0
    index_start = 1
    for df in pd.read_csv('final_features.csv', names=['Unnamed: 0','id','is_duplicate',
'cwc_min','cwc_max','csc_min','csc_max','ctc_min','ctc_max','last_word_eq','first_word_eq
','abs_len_diff','mean_len','token_set_ratio','token_sort_ratio','fuzz_ratio','fuzz_parti
al_ratio','longest_substr_ratio','freq_qid1','freq_qid2','q1len','q2len','q1_n_words','q
2_n_words','word_Common','word_Total','word_share','freq_q1+q2','freq_q1-q2','0_x','1_x',
'2_x','3_x','4_x','5_x','6_x','7_x','8_x','9_x','10_x','11_x','12_x','13_x','14_x','15_x
','16_x','17_x','18_x','19_x','20_x','21_x','22_x','23_x','24_x','25_x','26_x','27_x','2
8_x','29_x','30_x','31_x','32_x','33_x','34_x','35_x','36_x','37_x','38_x','39_x','40_x'
,'41_x','42_x','43_x','44_x','45_x','46_x','47_x','48_x','49_x','50_x','51_x','52_x','53
_x','54_x','55_x','56_x','57_x','58_x','59_x','60_x','61_x','62_x','63_x','64_x','65_x',
```

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'66_x','67_x','68_x','69_x','70_x','71_x','72_x','73_x','74_x','75_x','76_x','77_x','78_
x','79_x','80_x','81_x','82_x','83_x','84_x','85_x','86_x','87_x','88_x','89_x','90_x','
91_x','92_x','93_x','94_x','95_x','96_x','97_x','98_x','99_x','100_x','101_x','102_x','1
03_x','104_x','105_x','106_x','107_x','108_x','109_x','110_x','111_x','112_x','113_x','1
14_x','115_x','116_x','117_x','118_x','119_x','120_x','121_x','122_x','123_x','124_x','1
25_x','126_x','127_x','128_x','129_x','130_x','131_x','132_x','133_x','134_x','135_x','1
36_x','137_x','138_x','139_x','140_x','141_x','142_x','143_x','144_x','145_x','146_x','1
47_x','148_x','149_x','150_x','151_x','152_x','153_x','154_x','155_x','156_x','157_x','1
58_x','159_x','160_x','161_x','162_x','163_x','164_x','165_x','166_x','167_x','168_x','1
69_x','170_x','171_x','172_x','173_x','174_x','175_x','176_x','177_x','178_x','179_x','1
80_x','181_x','182_x','183_x','184_x','185_x','186_x','187_x','188_x','189_x','190_x','1
91_x','192_x','193_x','194_x','195_x','196_x','197_x','198_x','199_x','200_x','201_x','2
02_x','203_x','204_x','205_x','206_x','207_x','208_x','209_x','210_x','211_x','212_x','2
13_x','214_x','215_x','216_x','217_x','218_x','219_x','220_x','221_x','222_x','223_x','2
24_x','225_x','226_x','227_x','228_x','229_x','230_x','231_x','232_x','233_x','234_x','2
35_x','236_x','237_x','238_x','239_x','240_x','241_x','242_x','243_x','244_x','245_x','2
46_x','247_x','248_x','249_x','250_x','251_x','252_x','253_x','254_x','255_x','256_x','2
57_x','258_x','259_x','260_x','261_x','262_x','263_x','264_x','265_x','266_x','267_x','2
68_x','269_x','270_x','271_x','272_x','273_x','274_x','275_x','276_x','277_x','278_x','2
79_x','280_x','281_x','282_x','283_x','284_x','285_x','286_x','287_x','288_x','289_x','2
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67_x','368_x','369_x','370_x','371_x','372_x','373_x','374_x','375_x','376_x','377_x','3
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45_y','46_y','47_y','48_y','49_y','50_y','51_y','52_y','53_y','54_y','55_y','56_y','57_y
','58_y','59_y','60_y','61_y','62_y','63_y','64_y','65_y','66_y','67_y','68_y','69_y','7
0_y','71_y','72_y','73_y','74_y','75_y','76_y','77_y','78_y','79_y','80_y','81_y','82_y'
,'83_y','84_y','85_y','86_y','87_y','88_y','89_y','90_y','91_y','92_y','93_y','94_y','95
_y','96_y','97_y','98_y','99_y','100_y','101_y','102_y','103_y','104_y','105_y','106_y',
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'118_y','119_y','120_y','121_y','122_y','123_y','124_y','125_y','126_y','127_y','128_y',
'129_y','130_y','131_y','132_y','133_y','134_y','135_y','136_y','137_y','138_y','139_y',
'140_y','141_y','142_y','143_y','144_y','145_y','146_y','147_y','148_y','149_y','150_y',
'151_y','152_y','153_y','154_y','155_y','156_y','157_y','158_y','159_y','160_y','161_y',
'162_y','163_y','164_y','165_y','166_y','167_y','168_y','169_y','170_y','171_y','172_y',
'173_y','174_y','175_y','176_y','177_y','178_y','179_y','180_y','181_y','182_y','183_y',
'184_y','185_y','186_y','187_y','188_y','189_y','190_y','191_y','192_y','193_y','194_y',
'195_y','196_y','197_y','198_y','199_y','200_y','201_y','202_y','203_y','204_y','205_y',
'206_y','207_y','208_y','209_y','210_y','211_y','212_y','213_y','214_y','215_y','216_y',
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'239_y','240_y','241_y','242_y','243_y','244_y','245_y','246_y','247_y','248_y','249_y',
'250_y','251_y','252_y','253_y','254_y','255_y','256_y','257_y','258_y','259_y','260_y',
'261_y','262_y','263_y','264_y','265_y','266_y','267_y','268_y','269_y','270_y','271_y',
'272_y','273_y','274_y','275_y','276_y','277_y','278_y','279_y','280_y','281_y','282_y',
'283_y','284_y','285_y','286_y','287_y','288_y','289_y','290_y','291_y','292_y','293_y',
'294_y','295_y','296_y','297_y','298_y','299_y','300_y','301_y','302_y','303_y','304_y',
'305_y','306_y','307_y','308_y','309_y','310_y','311_y','312_y','313_y','314_y','315_y',
'316_y','317_y','318_y','319_y','320_y','321_y','322_y','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','343_y','344_y','345_y','346_y','347_y','348_y',
'349_y','350_y','351_y','352_y','353_y','354_y','355_y','356_y','357_y','358_y','359_y',
'360_y','361_y','362_y','363_y','364_y','365_y','366_y','367_y','368_y','369_y','370_y',
'371_y','372_y','373_y','374_y','375_y','376_y','377_y','378_y','379_y','380_y','381_y',
'382_y','383_y'], chunksize=chunksize, iterator=True, encoding='utf-8', ):
        df.index += index_start
        j+=1
        print('{} rows'.format(j*chunksize))
        df.to_sql('data', disk_engine, if_exists='append')
        index_start = df.index[-1] + 1
```

In [ ]:

```
def create_connection(db_file):
```

```
    """ create a database connection to the SQLite database
        specified by db_file
    :param db_file: database file
    :return: Connection object or None
    """
    try:
        conn = sqlite3.connect(db_file)
        return conn
    except Error as e:
        print(e)

    return None


def checkTableExists(dbcon):
    cursr = dbcon.cursor()
    str = "select name from sqlite_master where type='table'"
    table_names = cursr.execute(str)
    print("Tables in the databse:")
    tables =table_names.fetchall()
    print(tables[0][0])
    return(len(tables))
```

In [ ]:

```
read_db = 'train.db'
conn_r = create_connection(read_db)
checkTableExists(conn_r)
conn_r.close()
```

```
Tables in the databse:
data
```

In [ ]:

```
if os.path.isfile(read_db):
    conn_r = create_connection(read_db)
    if conn_r is not None:
        data = pd.read_sql_query("SELECT * From data ORDER BY RANDOM() LIMIT 100001;", c
onn_r)
        conn_r.commit()
        conn_r.close()
```

In [ ]:

```
data.drop(data.index[0], inplace=True)
y_true = data['is_duplicate']
data.drop(['Unnamed: 0', 'id','index','is_duplicate'], axis=1, inplace=True)
```

In [ ]:

```
data.head()
```

Out[ ]:

	cwc_min	cwc_max	csc_min	csc_max	ctc_min	ctc_max	la
1	0.199996000079998	0.166663888935184	0.0	0.0	0.14285510206997	0.0999990000099999	
2	0.399992000159997	0.399992000159997	0.499987500312492	0.499987500312492	0.444439506227709	0.444439506227709	
3	0.833319444675922	0.714275510349852	0.999983333611106	0.857130612419823	0.687495703151855	0.687495703151855	
4	0.0	0.0	0.599988000239995	0.499991666805553	0.249997916684028	0.230767455634957	
5	0.749981250468738	0.749981250468738	0.499987500312492	0.499987500312492	0.624992187597655	0.624992187597655	

5 rows × 794 columns

In [ ]:

```
cols = list(data.columns)
for i in cols:
    data[i] = data[i].apply(pd.to_numeric)
    print(i)
```

```
cwc_min
cwc_max
csc_min
csc_max
ctc_min
ctc_max
last_word_eq
first_word_eq
abs_len_diff
mean_len
token_set_ratio
token_sort_ratio
fuzz_ratio
fuzz_partial_ratio
longest_substr_ratio
freq_qid1
freq_qid2
q1len
q2len
q1_n_words
q2_n_words
word_Common
word_Total
word_share
freq_q1+q2
freq_q1-q2
0_x
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```

In [ ]:

```
y_true = list(map(int, y_true.values))
```

In [ ]:

```
X_train,X_test, y_train, y_test = train_test_split(data, y_true, stratify=y_true, test_s
ize=0.3)
```

In [ ]:

```
print("Number of data points in train data :",X_train.shape)
print("Number of data points in test data :",X_test.shape)
```

```
Number of data points in train data : (70000, 794)
Number of data points in test data : (30000, 794)
```

In [ ]:

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

```
---------- Distribution of output variable in train data ----------
Class 0:  0.6324857142857143 Class 1:  0.36751428571428574
---------- Distribution of output variable in train data ----------
Class 0:  0.3675 Class 1:  0.3675
```

In [ ]:

```
# 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)
    A =(((C.T)/(C.sum(axis=1))).T)

    B =(C/C.sum(axis=0))

    plt.figure(figsize=(20,4))

    labels = [1,2]
    cmap=sns.light_palette("blue")
    plt.subplot(1, 3, 1)
    sns.heatmap(C, annot=True, cmap=cmap, fmt=".3f", xticklabels=labels, yticklabels=lab
els)
    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, yticklabels=lab
els)
    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, yticklabels=labels)
    plt.xlabel('Predicted Class')
    plt.ylabel('Original Class')
    plt.title("Recall matrix")

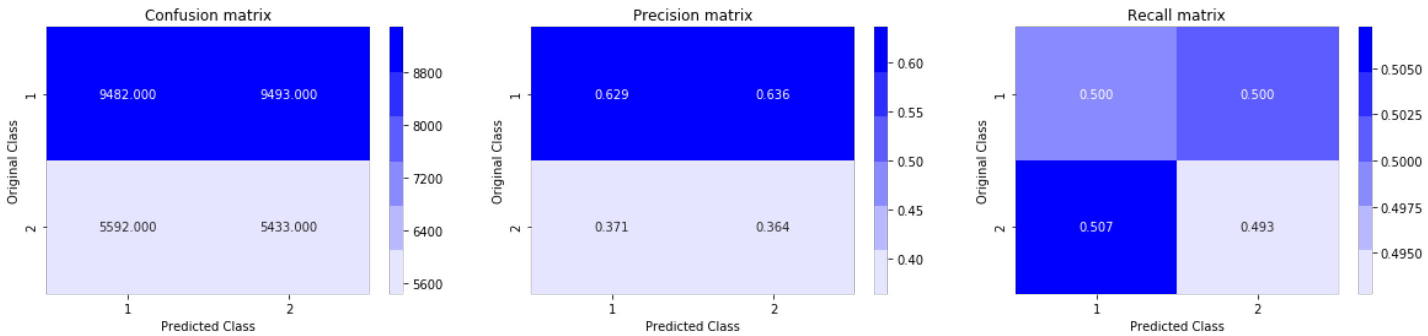
    plt.show()
```

In [ ]:

```
predicted_y = np.zeros((test_len,2))
for i in range(test_len):
    rand_probs = np.random.rand(1,2)
    predicted_y[i] = ((rand_probs/sum(sum(rand_probs)))[0])
print("Log loss on Test Data using Random Model",log_loss(y_test, predicted_y, eps=1e-15))

predicted_y =np.argmax(predicted_y, axis=1)
plot_confusion_matrix(y_test, predicted_y)
```

```
Log loss on Test Data using Random Model 0.887242646958
```



In [ ]:

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



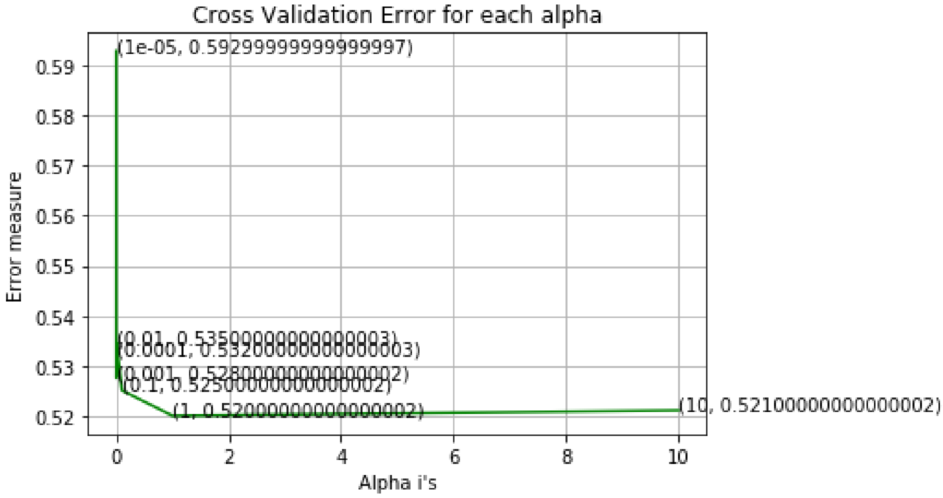
log_error_array=[]
for i in alpha:
    clf = SGDClassifier(alpha=i, penalty='l2', loss='log', random_state=42)
    clf.fit(X_train, y_train)
    sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
    sig_clf.fit(X_train, y_train)
    predict_y = sig_clf.predict_proba(X_test)
    log_error_array.append(log_loss(y_test, predict_y, labels=clf.classes_, eps=1e-15))
    print('For values of alpha = ', i, "The log loss is:",log_loss(y_test, predict_y, labels=clf.classes_, eps=1e-15))

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()

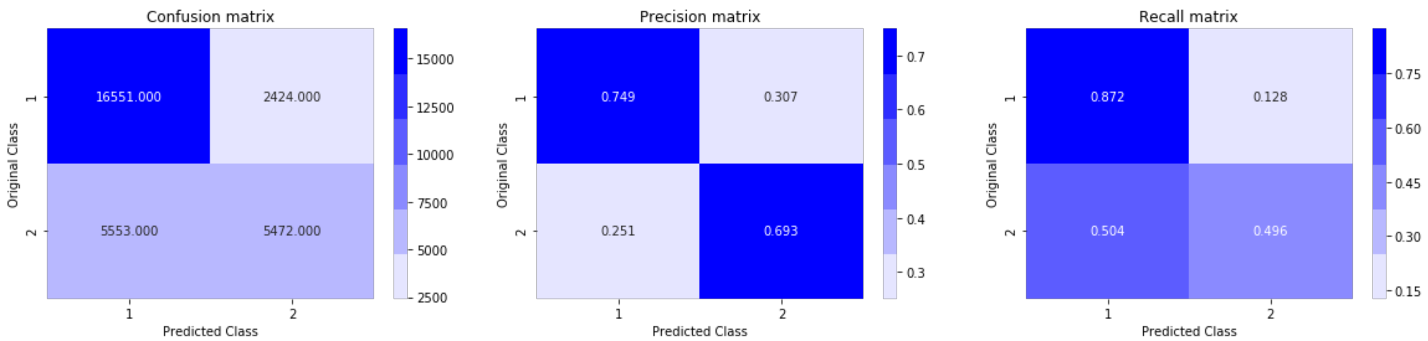

best_alpha = np.argmin(log_error_array)
clf = SGDClassifier(alpha=alpha[best_alpha], penalty='l2', loss='log', random_state=42)
clf.fit(X_train, y_train)
sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
sig_clf.fit(X_train, y_train)
```

```
predict_y = sig_clf.predict_proba(X_train)
print('For values of best alpha = ', alpha[best_alpha], "The train log loss is:",log_loss
(y_train, predict_y, labels=clf.classes_, eps=1e-15))
predict_y = sig_clf.predict_proba(X_test)
print('For values of best alpha = ', alpha[best_alpha], "The test log loss is:",log_loss(
y_test, predict_y, labels=clf.classes_, eps=1e-15))
predicted_y =np.argmax(predict_y,axis=1)
print("Total number of data points :", len(predicted_y))
plot_confusion_matrix(y_test, predicted_y)
```

```
For values of alpha =  1e-05 The log loss is: 0.592800211149
For values of alpha =  0.0001 The log loss is: 0.532351700629
For values of alpha =  0.001 The log loss is: 0.527562275995
For values of alpha =  0.01 The log loss is: 0.534535408885
For values of alpha =  0.1 The log loss is: 0.525117052926
For values of alpha =  1 The log loss is: 0.520035530431
For values of alpha =  10 The log loss is: 0.521097925307
```




```
For values of best alpha =  1 The train log loss is: 0.513842874233
For values of best alpha =  1 The test log loss is: 0.520035530431
Total number of data points : 30000
```



In [ ]:

```
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, y_train)
    sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
    sig_clf.fit(X_train, y_train)
    predict_y = sig_clf.predict_proba(X_test)
    log_error_array.append(log_loss(y_test, predict_y, labels=clf.classes_, eps=1e-15))
    print('For values of alpha = ', i, "The log loss is:",log_loss(y_test, predict_y, la
bels=clf.classes_, eps=1e-15))

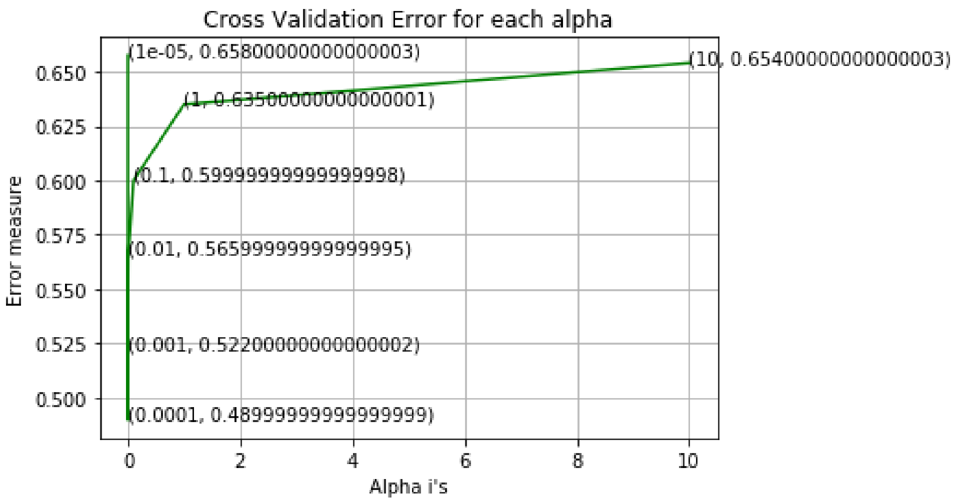
fig, ax = plt.subplots()
ax.plot(alpha, log_error_array,c='g')
for i, txt in enumerate(np.round(log_error_array,3)):
    ax.annotate((alpha[i],np.round(txt,3)), (alpha[i],log_error_array[i]))
```

```
plt.grid()
plt.title("Cross Validation Error for each alpha")
plt.xlabel("Alpha i's")
plt.ylabel("Error measure")
plt.show()

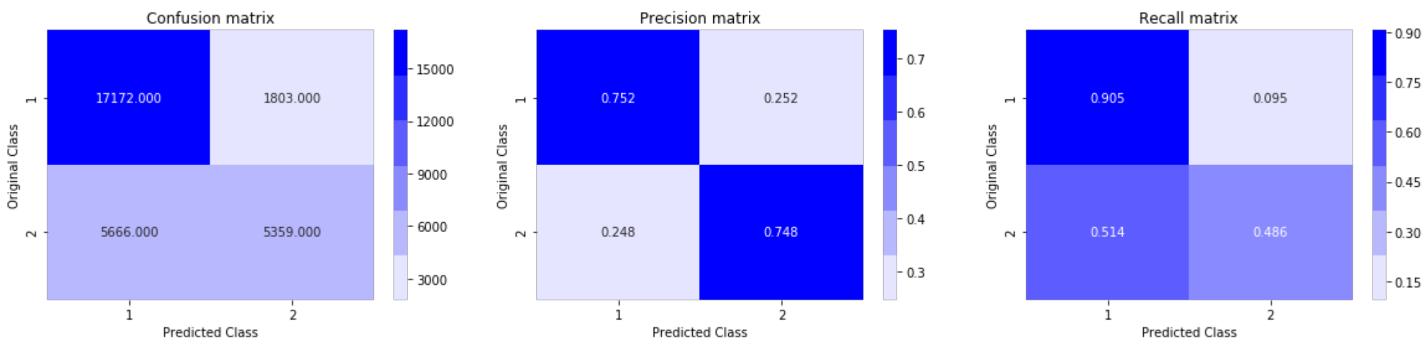

best_alpha = np.argmin(log_error_array)
clf = SGDClassifier(alpha=alpha[best_alpha], penalty='l1', loss='hinge', random_state=42
)
clf.fit(X_train, y_train)
sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
sig_clf.fit(X_train, y_train)

predict_y = sig_clf.predict_proba(X_train)
print('For values of best alpha = ', alpha[best_alpha], "The train log loss is:",log_loss
(y_train, predict_y, labels=clf.classes_, eps=1e-15))
predict_y = sig_clf.predict_proba(X_test)
print('For values of best alpha = ', alpha[best_alpha], "The test log loss is:",log_loss(
y_test, predict_y, labels=clf.classes_, eps=1e-15))
predicted_y =np.argmax(predict_y,axis=1)
print("Total number of data points :", len(predicted_y))
plot_confusion_matrix(y_test, predicted_y)
```

```
For values of alpha =  1e-05 The log loss is: 0.657611721261
For values of alpha =  0.0001 The log loss is: 0.489669093534
For values of alpha =  0.001 The log loss is: 0.521829068562
For values of alpha =  0.01 The log loss is: 0.566295616914
For values of alpha =  0.1 The log loss is: 0.599957866217
For values of alpha =  1 The log loss is: 0.635059427016
For values of alpha =  10 The log loss is: 0.654159467907
```




```
For values of best alpha =  0.0001 The train log loss is: 0.478054677285
For values of best alpha =  0.0001 The test log loss is: 0.489669093534
Total number of data points : 30000
```



In [ ]:

```
import xgboost as xgb
params = {}
params['objective'] = 'binary:logistic'
params['eval_metric'] = 'logloss'
params['eta'] = 0.02
```

```
params['max_depth'] = 4

d_train = xgb.DMatrix(X_train, label=y_train)
d_test = xgb.DMatrix(X_test, label=y_test)

watchlist = [(d_train, 'train'), (d_test, 'valid')]

bst = xgb.train(params, d_train, 400, watchlist, early_stopping_rounds=20, verbose_eval=
10)

xgdmat = xgb.DMatrix(X_train,y_train)
predict_y = bst.predict(d_test)
print("The test log loss is:",log_loss(y_test, predict_y, labels=clf.classes_, eps=1e-15)
)
```

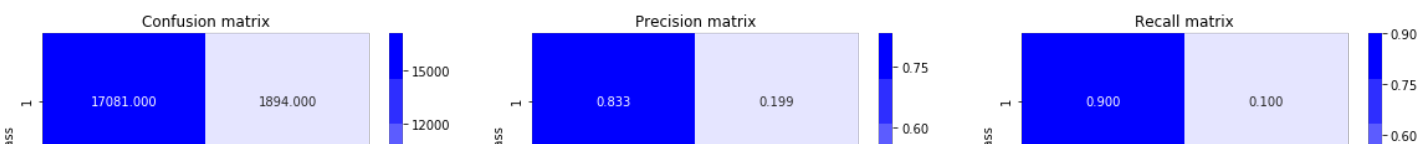
```
[0] train-logloss:0.684819 valid-logloss:0.684845
Multiple eval metrics have been passed: 'valid-logloss' will be used for early stopping.

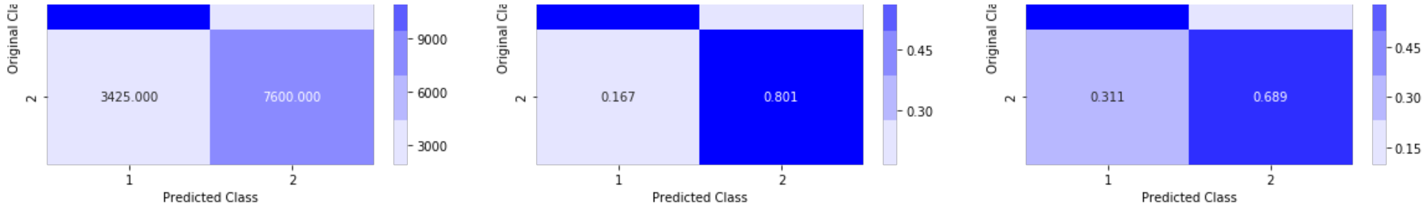
Will train until valid-logloss hasn't improved in 20 rounds.
[10] train-logloss:0.61583 valid-logloss:0.616104
[20] train-logloss:0.564616 valid-logloss:0.565273
[30] train-logloss:0.525758 valid-logloss:0.52679
[40] train-logloss:0.496661 valid-logloss:0.498021
[50] train-logloss:0.473563 valid-logloss:0.475182
[60] train-logloss:0.455315 valid-logloss:0.457186
[70] train-logloss:0.440442 valid-logloss:0.442482
[80] train-logloss:0.428424 valid-logloss:0.430795
[90] train-logloss:0.418803 valid-logloss:0.421447
[100] train-logloss:0.41069 valid-logloss:0.413583
[110] train-logloss:0.403831 valid-logloss:0.40693
[120] train-logloss:0.398076 valid-logloss:0.401402
[130] train-logloss:0.393305 valid-logloss:0.396851
[140] train-logloss:0.38913 valid-logloss:0.392952
[150] train-logloss:0.385469 valid-logloss:0.389521
[160] train-logloss:0.382327 valid-logloss:0.386667
[170] train-logloss:0.379541 valid-logloss:0.384148
[180] train-logloss:0.377014 valid-logloss:0.381932
[190] train-logloss:0.374687 valid-logloss:0.379883
[200] train-logloss:0.372585 valid-logloss:0.378068
[210] train-logloss:0.370615 valid-logloss:0.376367
[220] train-logloss:0.368559 valid-logloss:0.374595
[230] train-logloss:0.366545 valid-logloss:0.372847
[240] train-logloss:0.364708 valid-logloss:0.371311
[250] train-logloss:0.363021 valid-logloss:0.369886
[260] train-logloss:0.36144 valid-logloss:0.368673
[270] train-logloss:0.359899 valid-logloss:0.367421
[280] train-logloss:0.358465 valid-logloss:0.366395
[290] train-logloss:0.357128 valid-logloss:0.365361
[300] train-logloss:0.355716 valid-logloss:0.364315
[310] train-logloss:0.354425 valid-logloss:0.363403
[320] train-logloss:0.353276 valid-logloss:0.362595
[330] train-logloss:0.352084 valid-logloss:0.361823
[340] train-logloss:0.351051 valid-logloss:0.361167
[350] train-logloss:0.349867 valid-logloss:0.36043
[360] train-logloss:0.348829 valid-logloss:0.359773
[370] train-logloss:0.347689 valid-logloss:0.359019
[380] train-logloss:0.346607 valid-logloss:0.358311
[390] train-logloss:0.345568 valid-logloss:0.357674
The test log loss is: 0.357054433715
```

In [ ]:

```
predicted_y =np.array(predict_y>0.5,dtype=int)
print("Total number of data points :", len(predicted_y))
plot_confusion_matrix(y_test, predicted_y)
```

```
Total number of data points : 30000
```

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2
3425.000
7600.000
9000
6000
3000
1
2
Predicted Class
Original Cla
2
0.167
0.801
0.45
0.30
1
2
Predicted Class
Original Cla
2
0.311
0.689
0.45
0.30
0.15
1
2
Predicted Class