In [2]:
```
from google.colab import drive
drive.mount('/content/drive/')
```

```
Go to this URL in a browser: https://acco
unts.google.com/o/oauth2/auth?client_id=9
47318989803-6bn6qk8qdgf4n4g3pfee6491hc0br
c4i.apps.googleusercontent.com&redirect_u
ri=urn%3aietf%3awg%3aoauth%3a2.0%3aoob&re
sponse_type=code&scope=email%20https%3a%2
f%2fwww.googleapis.com%2fauth%2fdocs.tes
t%20https%3a%2f%2fwww.googleapis.com%2fau
th%2fdrive%20https%3a%2f%2fwww.googleapi
s.com%2fauth%2fdrive.photos.readonly%20ht
tps%3a%2f%2fwww.googleapis.com%2fauth%2fp
eopleapi.readonly

Enter your authorization code:
··········
Mounted at /content/drive/
```

In [3]:
```
%cd /content/drive/My Drive
```

```
/content/drive/My Drive
```

In [0]:
```
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 Cou
ntVectorizer
from sklearn.manifold import TSNE
import seaborn as sns
from sklearn.neighbors import KNeighborsClassif
ier
from sklearn.metrics import confusion_matrix
from sklearn.metrics.classification import accu
racy_score, log_loss
from sklearn.feature_extraction.text import Tfi
dfVectorizer
from collections import Counter
from scipy.sparse import hstack
from sklearn.multiclass import OneVsRestClassif
ier
from sklearn.svm import SVC
from collections import Counter, defaultdict
from sklearn.calibration import CalibratedClass
ifierCV
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 GridSearchC
V
import math
from sklearn.metrics import normalized_mutual_i
nfo_score
from sklearn.ensemble import RandomForestClassi
```

```
fier



from sklearn.model_selection import cross_val_s
core
from sklearn.linear_model import SGDClassifier
from mlxtend.classifier import StackingClassifi
er

from sklearn import model_selection
from sklearn.linear_model import LogisticRegres
sion
from sklearn.metrics import precision_recall_cu
rve, auc, roc_curve
```

# 4. Machine Learning Models

## 4.1 Reading data from file and storing into sql table

In [0]:
```
import os
```

In [0]:
```
#Creating db file from csv
if not os.path.isfile('Quora/train.db'):
    disk_engine = create_engine('sqlite:///trai
n.db')
    start = dt.datetime.now()
    chunksize = 180000
    j = 0
    index_start = 1
```

```
    for df in pd.read_csv('Quora/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_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','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','28_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','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','103_x','104_x','105_x','106_x','107_x','108_x','109_x','110_x','111_x','112_x','113_x','114_x','115_x','116_x','117_x','118_x','119_x','120_x','121_x','122_x','123_x','124_x','125_x','126_x','127_x','128_x','129_x','130_x','131_x','132_x','133_x','134_x','135_x','136_x','137_x','138_x','139_x','140_x','141_x','142_x','143_x','144_x','145_x','146_x','147_x','148_x','149_x','150_x','151_x','152_x','153_x','154_x','155_x','156_x','157_x','158_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','180_x'
,'181_x','182_x','183_x','184_x','185_x','186_
x','187_x','188_x','189_x','190_x','191_x','192
_x','193_x','194_x','195_x','196_x','197_x','19
8_x','199_x','200_x','201_x','202_x','203_x','2
04_x','205_x','206_x','207_x','208_x','209_x',
'210_x','211_x','212_x','213_x','214_x','215_x'
,'216_x','217_x','218_x','219_x','220_x','221_
x','222_x','223_x','224_x','225_x','226_x','227
_x','228_x','229_x','230_x','231_x','232_x','23
3_x','234_x','235_x','236_x','237_x','238_x','2
39_x','240_x','241_x','242_x','243_x','244_x',
'245_x','246_x','247_x','248_x','249_x','250_x'
,'251_x','252_x','253_x','254_x','255_x','256_
x','257_x','258_x','259_x','260_x','261_x','262
_x','263_x','264_x','265_x','266_x','267_x','26
8_x','269_x','270_x','271_x','272_x','273_x','2
74_x','275_x','276_x','277_x','278_x','279_x',
'280_x','281_x','282_x','283_x','284_x','285_x'
,'286_x','287_x','288_x','289_x','290_x','291_
x','292_x','293_x','294_x','295_x','296_x','297
_x','298_x','299_x','300_x','301_x','302_x','30
3_x','304_x','305_x','306_x','307_x','308_x','3
09_x','310_x','311_x','312_x','313_x','314_x',
'315_x','316_x','317_x','318_x','319_x','320_x'
,'321_x','322_x','323_x','324_x','325_x','326_
x','327_x','328_x','329_x','330_x','331_x','332
_x','333_x','334_x','335_x','336_x','337_x','33
8_x','339_x','340_x','341_x','342_x','343_x','3
44_x','345_x','346_x','347_x','348_x','349_x',
'350_x','351_x','352_x','353_x','354_x','355_x'
,'356_x','357_x','358_x','359_x','360_x','361_
x','362_x','363_x','364_x','365_x','366_x','367
_x','368_x','369_x','370_x','371_x','372_x','37
3_x','374_x','375_x','376_x','377_x','378_x','3
```

```
79_x','380_x','381_x','382_x','383_x','0_y','1_
y','2_y','3_y','4_y','5_y','6_y','7_y','8_y','9
_y','10_y','11_y','12_y','13_y','14_y','15_y',
'16_y','17_y','18_y','19_y','20_y','21_y','22_
y','23_y','24_y','25_y','26_y','27_y','28_y','2
9_y','30_y','31_y','32_y','33_y','34_y','35_y',
'36_y','37_y','38_y','39_y','40_y','41_y','42_
y','43_y','44_y','45_y','46_y','47_y','48_y','4
9_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','6
9_y','70_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','8
9_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','10
2_y','103_y','104_y','105_y','106_y','107_y','1
08_y','109_y','110_y','111_y','112_y','113_y',
'114_y','115_y','116_y','117_y','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','13
7_y','138_y','139_y','140_y','141_y','142_y','1
43_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','17
2_y','173_y','174_y','175_y','176_y','177_y','1
78_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','20
7_y','208_y','209_y','210_y','211_y','212_y','2
13_y','214_y','215_y','216_y','217_y','218_y',
```

```
'219_y','220_y','221_y','222_y','223_y','224_y'
,'225_y','226_y','227_y','228_y','229_y','230_
y','231_y','232_y','233_y','234_y','235_y','236
_y','237_y','238_y','239_y','240_y','241_y','24
2_y','243_y','244_y','245_y','246_y','247_y','2
48_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','27
7_y','278_y','279_y','280_y','281_y','282_y','2
83_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','31
2_y','313_y','314_y','315_y','316_y','317_y','3
18_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','34
7_y','348_y','349_y','350_y','351_y','352_y','3
53_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','38
2_y','383_y'], chunksize=chunksize, iterator=Tr
ue, encoding='utf-8', ):
        df.index += index_start
        j+=1
        print('{} rows'.format(j*chunksize))
        df.to_sql('data', disk_engine, if_exist
s='append')
        index_start = df.index[-1] + 1
```

In [0]:
```
#http://www.sqlitetutorial.net/sqlite-python/create-tables/
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 [37]:
```
read_db = 'Quora/train.db'
conn_r = create_connection(read_db)
checkTableExists(conn_r)
conn_r.close()
```

```
Tables in the databse:
```

```
data
```

In [0]:
```
# try to sample data according to the computing power you have
if os.path.isfile(read_db):
    conn_r = create_connection(read_db)
    if conn_r is not None:
        # for selecting first 1M rows
        # data = pd.read_sql_query("""SELECT * FROM data LIMIT 100001;""", conn_r)

        # for selecting random points
        data = pd.read_sql_query("SELECT * From data ORDER BY RANDOM() LIMIT 100001;", conn_r)
        conn_r.commit()
        conn_r.close()
```

In [0]:
```
# remove the first row
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 [0]:
```
data.head()
```

Out[0]:

| | cwc_min | cwc_max | |
|---|---|---|---|
| **1** | 0.749981250468738 | 0.599988000239995 | 0.8333194 |
| **2** | 0.0 | 0.0 | |
| **3** | 0.499991666805553 | 0.499991666805553 | 0.3333277 |
| **4** | 0.999975000624984 | 0.799984000319994 | 0.6249921 |
| **5** | 0.999950002499875 | 0.66664444518516 | 0.9999500 |

5 rows × 794 columns

# 4.2 Converting strings to numerics

In [0]:
```
# after we read from sql table each entry was r
ead it as a string
# we convert all the features into numaric befo
re we apply any model
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
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
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379_x
380_x
381_x
382_x
383_x
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1_y
2_y
3_y
4_y

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```

In [0]:
```
# https://stackoverflow.com/questions/7368789/convert-all-strings-in-a-list-to-int
y_true = list(map(int, y_true.values))
```

## 4.3 Random train test split( 70:30)

In [0]:
```
X_train,X_test, y_train, y_test = train_test_split(data, y_true, stratify=y_true, test_size=0.3)
```

In [0]:
```
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 : (70
000, 794)
Number of data points in test data : (300
00, 794)
```

In [0]:

```
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_len)
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 variabl
e in train data ----------
Class 0:  0.6330857142857143 Class 1:  0.
3669142857142857
---------- Distribution of output variabl
e in train data ----------
Class 0:  0.36693333333333333 Class 1:
0.36693333333333333
```

In [0]:

```
# This function plots the confusion matrices gi
ven 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) represent
s number of points of class i are predicted cla
```

```
ss j

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

    # C = [[1, 2],
    #     [3, 4]]
    # C.T = [[1, 3],
    #        [2, 4]]
    # C.sum(axis = 1)  axis=0 corresonds to col
umns and axis=1 corresponds to rows in two diam
ensional array
    # 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 row
    # C = [[1, 2],
    #     [3, 4]]
    # C.sum(axis = 0)  axis=0 corresonds to col
umns and axis=1 corresponds to rows in two diam
ensional array
    # 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, yticklabels=labels)
    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=labels)
    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()
```

## 4.4 Building a random model (Finding worst-case log-loss)

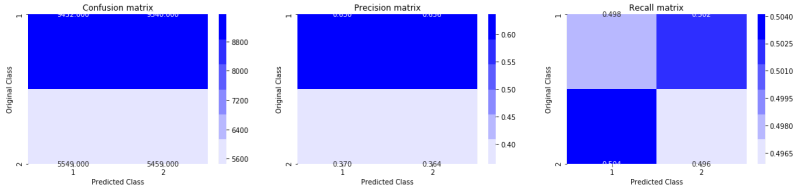
In [0]:

```
# we need to generate 9 numbers and the sum of
 numbers should be 1
# one solution is to genarate 9 numbers and div
ide each of the numbers by their sum
# ref: https://stackoverflow.com/a/18662466/408
```

```
4039
# we create a output array that has exactly sam
e size as the CV data
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 Mode
l",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
0.8913124204874303
```




# 4.4 Logistic Regression with hyperparameter tuning

In [0]:

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

# read more about SGDClassifier() at http://sci
kit-learn.org/stable/modules/generated/sklearn.
linear_model.SGDClassifier.html
# ------------------------------
# default parameters
# SGDClassifier(loss='hinge', penalty='l2', alp
```

```
ha=0.0001, l1_ratio=0.15, fit_intercept=True, m
ax_iter=None, tol=None,
# shuffle=True, verbose=0, epsilon=0.1, n_jobs=
1, random_state=None, learning_rate='optimal',
 eta0=0.0, power_t=0.5,
# class_weight=None, warm_start=False, average=
False, n_iter=None)

# some of methods
# fit(X, y[, coef_init, intercept_init, …])
Fit linear model with Stochastic Gradient Desce
nt.
# predict(X)    Predict class labels for sample
s in X.

#------------------------------
# video link:
#------------------------------


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, metho
d="sigmoid")
    sig_clf.fit(X_train, y_train)
    predict_y = sig_clf.predict_proba(X_test)
    log_error_array.append(log_loss(y_test, pre
dict_y, labels=clf.classes_, eps=1e-15))
    print('For values of alpha = ', i, "The log
loss is:",log_loss(y_test, predict_y, labels=cl
f.classes_, eps=1e-15))

fig, ax = plt.subplots()
```

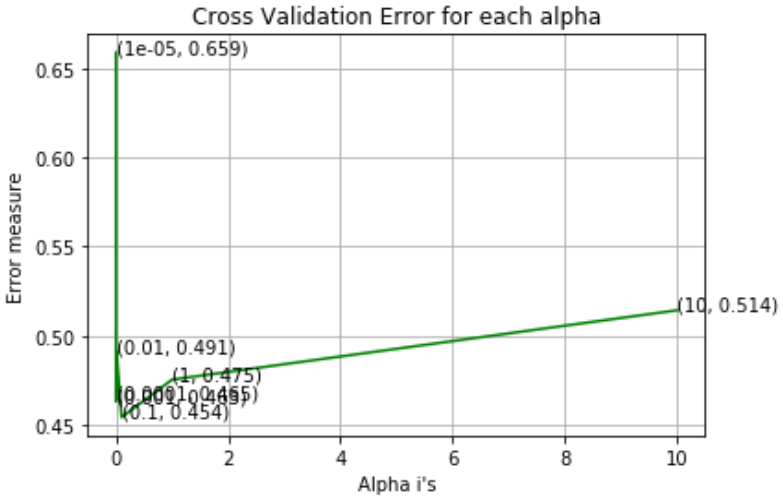
```
ax.plot(alpha, log_error_array,c='g')
for i, txt in enumerate(np.round(log_error_arra
y,3)):
    ax.annotate((alpha[i],np.round(txt,3)), (al
pha[i],log_error_array[i]))
plt.grid()
plt.title("Cross Validation Error for each alph
a")
plt.xlabel("Alpha i's")
plt.ylabel("Error measure")
plt.show()


best_alpha = np.argmin(log_error_array)
clf = SGDClassifier(alpha=alpha[best_alpha], pe
nalty='l2', loss='log', random_state=42)
clf.fit(X_train, y_train)
sig_clf = CalibratedClassifierCV(clf, method="s
igmoid")
sig_clf.fit(X_train, y_train)

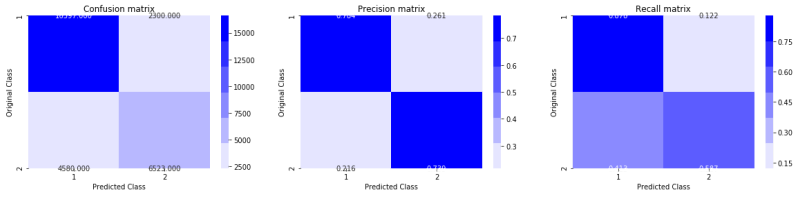
predict_y = sig_clf.predict_proba(X_train)
print('For values of best alpha = ', alpha[best
_alpha], "The train log loss is:",log_loss(y_tr
ain, predict_y, labels=clf.classes_, eps=1e-15
))
predict_y = sig_clf.predict_proba(X_test)
print('For values of best alpha = ', alpha[best
_alpha], "The test log loss is:",log_loss(y_tes
t, predict_y, labels=clf.classes_, eps=1e-15))
predicted_y =np.argmax(predict_y,axis=1)
print("Total number of data points :", len(pred
icted_y))
plot_confusion_matrix(y_test, predicted_y)
```

```
For values of alpha =  1e-05 The log loss
```

```
For values of alpha =  0.0001 The log loss is: 0.6590088823008615
For values of alpha =  0.0001 The log los
s is: 0.4651504759119351
For values of alpha =  0.001 The log loss
is: 0.46315322183816376
For values of alpha =  0.01 The log loss
is: 0.49118624271412314
For values of alpha =  0.1 The log loss i
s: 0.4541760157156937
For values of alpha =  1 The log loss is:
0.47532071098189277
For values of alpha =  10 The log loss i
s: 0.5142369430998964
```




```
For values of best alpha =  0.1 The train
log loss is: 0.44387313274681317
For values of best alpha =  0.1 The test
log loss is: 0.4541760157156937
Total number of data points : 30000
```



# 4.5 Linear SVM with hyperparameter tuning

In [0]:

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

# read more about SGDClassifier() at http://sci
kit-learn.org/stable/modules/generated/sklearn.
linear_model.SGDClassifier.html
# ------------------------------
# default parameters
# SGDClassifier(loss='hinge', penalty='l2', alp
ha=0.0001, l1_ratio=0.15, fit_intercept=True, m
ax_iter=None, tol=None,
# shuffle=True, verbose=0, epsilon=0.1, n_jobs=
1, random_state=None, learning_rate='optimal',
 eta0=0.0, power_t=0.5,
# class_weight=None, warm_start=False, average=
False, n_iter=None)

# some of methods
# fit(X, y[, coef_init, intercept_init, …])
Fit linear model with Stochastic Gradient Desce
nt.
# predict(X)    Predict class labels for sample
s in X.

#------------------------------
# video link:
#------------------------------


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, metho
d="sigmoid")
    sig_clf.fit(X_train, y_train)
    predict_y = sig_clf.predict_proba(X_test)
    log_error_array.append(log_loss(y_test, pre
dict_y, labels=clf.classes_, eps=1e-15))
    print('For values of alpha = ', i, "The log
loss is:",log_loss(y_test, predict_y, labels=cl
f.classes_, eps=1e-15))

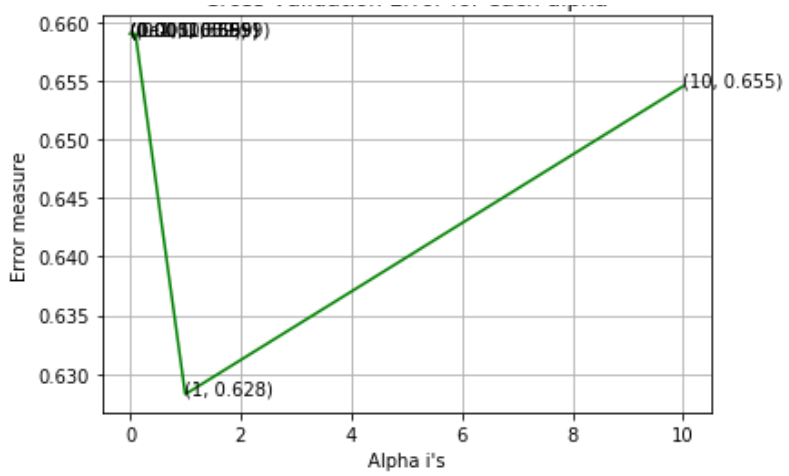
fig, ax = plt.subplots()
ax.plot(alpha, log_error_array,c='g')
for i, txt in enumerate(np.round(log_error_arra
y,3)):
    ax.annotate((alpha[i],np.round(txt,3)), (al
pha[i],log_error_array[i]))
plt.grid()
plt.title("Cross Validation Error for each alph
a")
plt.xlabel("Alpha i's")
plt.ylabel("Error measure")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


best_alpha = np.argmin(log_error_array)
clf = SGDClassifier(alpha=alpha[best_alpha], pe
nalty='l1', loss='hinge', random_state=42)
clf.fit(X_train, y_train)
sig_clf = CalibratedClassifierCV(clf, method="s
igmoid")
sig_clf.fit(X_train, y_train)
```

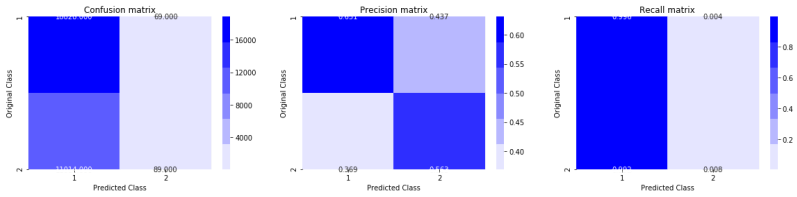
```
predict_y = sig_clf.predict_proba(X_train)
print('For values of best alpha = ', alpha[best
_alpha], "The train log loss is:",log_loss(y_tr
ain, predict_y, labels=clf.classes_, eps=1e-15
))
predict_y = sig_clf.predict_proba(X_test)
print('For values of best alpha = ', alpha[best
_alpha], "The test log loss is:",log_loss(y_tes
t, predict_y, labels=clf.classes_, eps=1e-15))
predicted_y =np.argmax(predict_y,axis=1)
print("Total number of data points :", len(pred
icted_y))
plot_confusion_matrix(y_test, predicted_y)
```

```
For values of alpha =  1e-05 The log loss
is: 0.6590088823008615
For values of alpha =  0.0001 The log los
s is: 0.6590088823008615
For values of alpha =  0.001 The log loss
is: 0.6590088823008615
For values of alpha =  0.01 The log loss
is: 0.6590088823008615
For values of alpha =  0.1 The log loss i
s: 0.6590088823008615
For values of alpha =  1 The log loss is:
0.6282544209648048
For values of alpha =  10 The log loss i
s: 0.6545352066543368
```

Cross Validation Error for each alpha




```
For values of best alpha =  1 The train l
og loss is: 0.6290317900094735
For values of best alpha =  1 The test lo
g loss is: 0.6282544209648048
Total number of data points : 30000
```




# 4.6 XGBoost

In [0]:

```
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, 'vali
d')]

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:0.684823  valid-log
loss:0.684868
Multiple eval metrics have been passed:
'valid-logloss' will be used for early st
opping.

Will train until valid-logloss hasn't imp
roved in 20 rounds.
[10]    train-logloss:0.615177  valid-log
loss:0.615789
[20]    train-logloss:0.564106  valid-log
loss:0.565148
[30]    train-logloss:0.525468  valid-log
loss:0.526875
[40]    train-logloss:0.495816  valid-log
loss:0.497425
[50]    train-logloss:0.472475  valid-log
loss:0.474235
[60]    train-logloss:0.454237  valid-log
loss:0.456248
[70]    train-logloss:0.439451  valid-log
loss:0.441755
[80]    train-logloss:0.427301  valid-log
```

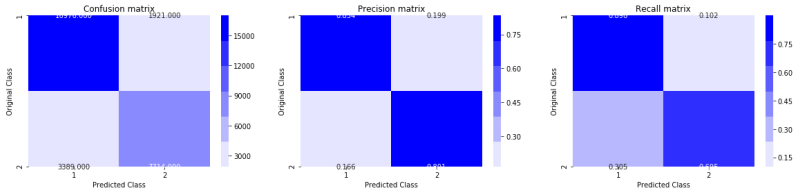
```
loss:0.429771
[90]    train-logloss:0.417757  valid-log
loss:0.420442
[100]   train-logloss:0.40965   valid-log
loss:0.412456
[110]   train-logloss:0.402834  valid-log
loss:0.405848
[120]   train-logloss:0.397128  valid-log
loss:0.400366
[130]   train-logloss:0.392339  valid-log
loss:0.395784
[140]   train-logloss:0.388492  valid-log
loss:0.392155
[150]   train-logloss:0.384839  valid-log
loss:0.388657
[160]   train-logloss:0.381794  valid-log
loss:0.385797
[170]   train-logloss:0.378903  valid-log
loss:0.383084
[180]   train-logloss:0.376388  valid-log
loss:0.380762
[190]   train-logloss:0.374098  valid-log
loss:0.378652
[200]   train-logloss:0.372121  valid-log
loss:0.376933
[210]   train-logloss:0.370196  valid-log
loss:0.375221
[220]   train-logloss:0.368447  valid-log
loss:0.373672
[230]   train-logloss:0.366677  valid-log
loss:0.37212
[240]   train-logloss:0.364875  valid-log
loss:0.370534
[250]   train-logloss:0.363291  valid-log
loss:0.36924
[260]   train-logloss:0.361679  valid-log
```

```
loss:0.367817
[270]   train-logloss:0.360073  valid-log
loss:0.366429
[280]   train-logloss:0.358652  valid-log
loss:0.365213
[290]   train-logloss:0.357247  valid-log
loss:0.364032
[300]   train-logloss:0.355973  valid-log
loss:0.362989
[310]   train-logloss:0.354757  valid-log
loss:0.362065
[320]   train-logloss:0.353537  valid-log
loss:0.361123
[330]   train-logloss:0.352386  valid-log
loss:0.360178
[340]   train-logloss:0.351129  valid-log
loss:0.359216
[350]   train-logloss:0.349967  valid-log
loss:0.358308
[360]   train-logloss:0.348892  valid-log
loss:0.357558
[370]   train-logloss:0.347832  valid-log
loss:0.356814
[380]   train-logloss:0.346877  valid-log
loss:0.356152
[390]   train-logloss:0.345805  valid-log
loss:0.355388
[399]   train-logloss:0.344998  valid-log
loss:0.354849
The test log loss is: 0.35484948327301147
```

In [0]:

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

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




# 5. Assignments

1. Try out models (Logistic regression, Linear-SVM) with simple TF-IDF vectors instead of TD_IDF weighted word2Vec.
2. Hyperparameter tune XgBoost using RandomSearch to reduce the log-loss.

# TFIDF Feature

In [0]:
```
#nlp_features_train.csv (NLP Features)
if os.path.isfile('Quora/nlp_features_train.csv'):
    dfnlp = pd.read_csv("Quora/nlp_features_train.csv",encoding='latin-1')
else:
    print("download nlp_features_train.csv from drive or run previous notebook")

if os.path.isfile('Quora/df_fe_without_preprocessing_train.csv'):
    dfppro = pd.read_csv("Quora/df_fe_without_preprocessing_train.csv",encoding='latin-1')
else:
    print("download df_fe_without_preprocessing
```

```
_train.csv from drive or run previous notebook"
)
```

In [0]:
```
# dropping only qid1, qid1 from the advanced features
df1 = dfnlp.drop(['qid1','qid2',],axis=1)
# dropping only qid1 , qid2, question1, question2 from the advanced features
df2 = dfppro.drop(['qid1','qid2','question1','question2','is_duplicate'],axis=1)

# so finaldf_all = 19columns(df1) + 12columns(df2) = 31 columns
```

In [0]:
```
df1.head(2)
```

Out[0]:

| | id | question1 | question2 | is_duplicate | cwc_min |
|---|---|---|---|---|---|
| **0** | 0 | what is the step by step guide to invest in sh... | what is the step by step guide to invest in sh... | 0 | 0.999980 |
| **1** | 1 | what is the story of kohinoor koh i noor dia... | what would happen if the indian government sto... | 0 | 0.799984 |

In [0]:
```
df2.head(2)
```

Out[0]:

| | id | freq_qid1 | freq_qid2 | q1len | q2len | q1_n_wor |
|---|---|---|---|---|---|---|
| **0** | 0 | 1 | 1 | 66 | 57 | |

| | id | freq_qid1 | freq_qid2 | q1len | q2len | q1_n_wor |
|---|---|---|---|---|---|---|
| **1** | 1 | 4 | 1 | 51 | 88 | |

In [0]:
```
# joining advancedfeatures(df1) and normalfeatures(df2) taking index in common id
finaldf_all = df1.join(df2.set_index('id'), on='id')
```

In [0]:
```
finaldf_all.shape
```

Out[0]:
```
(404290, 30)
```

In [0]:
```
finaldf_all.head(2)
```

Out[0]:

| | id | question1 | question2 | is_duplicate | cwc_min |
|---|---|---|---|---|---|
| **0** | 0 | what is the step by step guide to invest in sh... | what is the step by step guide to invest in sh... | 0 | 0.999980 |
| **1** | 1 | what is the story of kohinoor koh i noor dia... | what would happen if the indian government sto... | 0 | 0.799984 |

In [0]:
```
finaldf_all['question1'] = finaldf_all['question1'].apply(lambda x: str(x))
finaldf_all['question2'] = finaldf_all['question2'].apply(lambda x: str(x))
```

In [0]:
```
# Sampling 100k data points for the model
finaldf_100k = finaldf_all.sample(n=100000,rand
om_state = 1)
print(finaldf_100k.shape)
```

```
(100000, 30)
```

In [0]:
```
# taking actual label from dataset(100k)
y_true = finaldf_100k['is_duplicate']
```

In [0]:
```
# randomly sampling 70% to train and 30% to tes
t dataset
X_train,X_test, y_train, y_test = train_test_sp
lit(finaldf_100k, y_true, stratify=y_true, test
_size=0.3)
```

# TFIDF

In [0]:
```
from sklearn.preprocessing import StandardScale
r
```

In [0]:
```
# storing length of actual label from train and
test dataset
test_len = len(y_test)
train_len = len(y_train)
```

In [0]:
```
# converting our test and train data questions
 1 into tfidf vec
tfidf_vectorizer_qs1 = TfidfVectorizer(lowercas
e=False)
tfidf_qs1_train = tfidf_vectorizer_qs1.fit_tran
sform(X_train['question1'])
tfidf_qs1_test  = tfidf_vectorizer_qs1.transfor
```

```
m(X_test['question1'])

print(tfidf_qs1_train.shape)
print(tfidf_qs1_test.shape)
```

```
(70000, 31004)
(30000, 31004)
```

In [0]:

```
# converting our test and train data questions
 2 into tfidf vec
tfidf_vectorizer_qs2 = TfidfVectorizer(lowercas
e=False)
tfidf_qs2_train = tfidf_vectorizer_qs2.fit_tran
sform(X_train['question2'])
tfidf_qs2_test  = tfidf_vectorizer_qs2.transfor
m(X_test['question2'])

print(tfidf_qs2_train.shape)
print(tfidf_qs2_test.shape)
```

```
(70000, 29039)
(30000, 29039)
```

In [0]:

```
#Combining the two dataframe

train_tfidf = hstack((tfidf_qs1_train,tfidf_qs2
_train))
test_tfidf = hstack((tfidf_qs1_test,tfidf_qs2_t
est))

print("train data shape",train_tfidf.shape)
print("Test data shape ",test_tfidf.shape)
```

```
train data shape (70000, 60043)
Test data shape  (30000, 60043)
```

In [0]:
```
X_train.head(1)
```

Out[0]:

| | id | question1 | question2 | is_duplicate | c |
|---|---|---|---|---|---|
| **56942** | 56942 | what are the best ways for passing time during... | what are some ways to pass time during boring ... | 1 | 0 |

In [0]:
```
# Dropping id and questions from the dataset af
ter tfidf vectorizing the data
train_feature_df = X_train.drop(['id','question
1','question2','is_duplicate'], axis=1, inplace
=False)
test_feature_df = X_test.drop(['id','question1'
,'question2','is_duplicate'], axis=1, inplace=F
alse)
```

In [0]:
```
train_feature_df.head(1)
```

Out[0]:

| | cwc_min | cwc_max | csc_min | csc_max | ct |
|---|---|---|---|---|---|
| **56942** | 0.599988 | 0.499992 | 0.599988 | 0.599988 | 0.5 |

In [0]:
```
print(type(train_tfidf))
print(type(test_tfidf))
```

```
<class 'scipy.sparse.coo.coo_matrix'>
<class 'scipy.sparse.coo.coo_matrix'>
```

In [0]:
```
# since both the data is sparse matrix to we ne
ed to convert the dataframe to sparse before co
```

```
mbining them
import scipy
train_sparse = scipy.sparse.csr_matrix(train_fe
ature_df)
test_sparse = scipy.sparse.csr_matrix(test_feat
ure_df)

print("TRAIN data Shape = ",train_sparse.shape,
" Type is",type(train_sparse))
print("TEST data shape = ",test_sparse.shape, "
Type is", type(test_sparse))
```

```
TRAIN data Shape =  (70000, 26)  Type is
<class 'scipy.sparse.csr.csr_matrix'>
TEST data shape =  (30000, 26)  Type is <
class 'scipy.sparse.csr.csr_matrix'>
```

In [0]:

```
# Combining tfidf features of question 1 and qu
estion 2 to the original test and train dataset
train_data_final = hstack((train_tfidf,train_sp
arse))
test_data_final = hstack((test_tfidf,test_spars
e))

print("train data shape",train_data_final.shape
)
print("Test data shape ",test_data_final.shape)
```

```
train data shape (70000, 60069)
Test data shape  (30000, 60069)
```

In [0]:

```
scaler = StandardScaler(with_mean=False)
standardized_data_train = scaler.fit_transform(
train_data_final)
standardized_data_test = scaler.transform(test_
data_final)
```

```
print("train data shape",standardized_data_train.shape)
print("Test data shape ",standardized_data_test.shape)
```

```
train data shape (70000, 60069)
Test data shape  (30000, 60069)
```

In [0]:
```
X_train = standardized_data_train
X_test = standardized_data_test
```

# Logistic Regression

In [0]:
```
alpha = [10 ** x for x in range(-5, 2)] # hyper param for SGD classifier.

log_error_array=[]
for i in alpha:
    clf = SGDClassifier(alpha=i, penalty='l2', loss='log', random_state=1,class_weight='balanced')
    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))

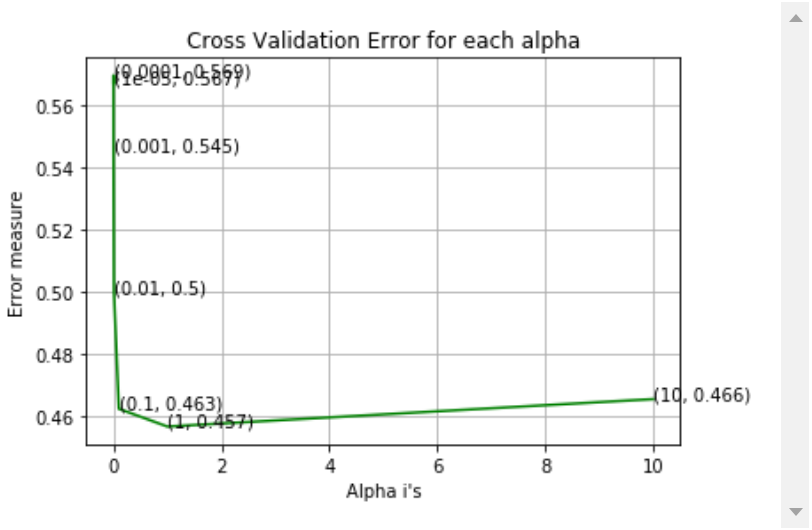
fig, ax = plt.subplots()
```

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

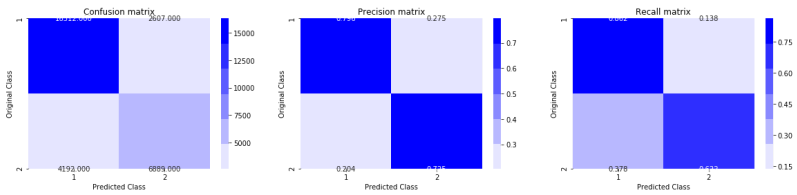

best_alpha = np.argmin(log_error_array)
clf = SGDClassifier(alpha=alpha[best_alpha], pe
nalty='l2', loss='log', random_state=1,class_we
ight='balanced')
clf.fit(X_train, y_train)
sig_clf = CalibratedClassifierCV(clf, method="s
igmoid")
sig_clf.fit(X_train, y_train)

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_tr
ain, 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_tes
t, predict_y, labels=clf.classes_, eps=1e-15))
predicted_y =np.argmax(predict_y,axis=1)
print("Total number of data points :", len(pred
icted_y))
plot_confusion_matrix(y_test, predicted_y)
```

```
For values of alpha =  1e-05 The log loss is: 0.566998893974907
For values of alpha =  0.0001 The log loss is: 0.5694428306768418
For values of alpha =  0.001 The log loss is: 0.545024717898796
For values of alpha =  0.01 The log loss is: 0.49986564086795404
For values of alpha =  0.1 The log loss is: 0.4625312509498126
For values of alpha =  1 The log loss is: 0.456833942091159
For values of alpha =  10 The log loss is: 0.4656292591942041
```




```
For values of best alpha =  1 The train log loss is: 0.33190088730471434
For values of best alpha =  1 The test log loss is: 0.456833942091159
Total number of data points : 30000
```



# Linear SVM

In [0]:

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

log_error_array=[]
for i in alpha:
    clf = SGDClassifier(alpha=i, penalty='l1',
loss='hinge', random_state=1,class_weight='bala
nced')
    clf.fit(X_train, y_train)
    sig_clf = CalibratedClassifierCV(clf, metho
d="sigmoid")
    sig_clf.fit(X_train, y_train)
    predict_y = sig_clf.predict_proba(X_test)
    log_error_array.append(log_loss(y_test, pre
dict_y, labels=clf.classes_, eps=1e-15))
    print('For values of alpha = ', i, "The log
loss is:",log_loss(y_test, predict_y, labels=cl
f.classes_, eps=1e-15))

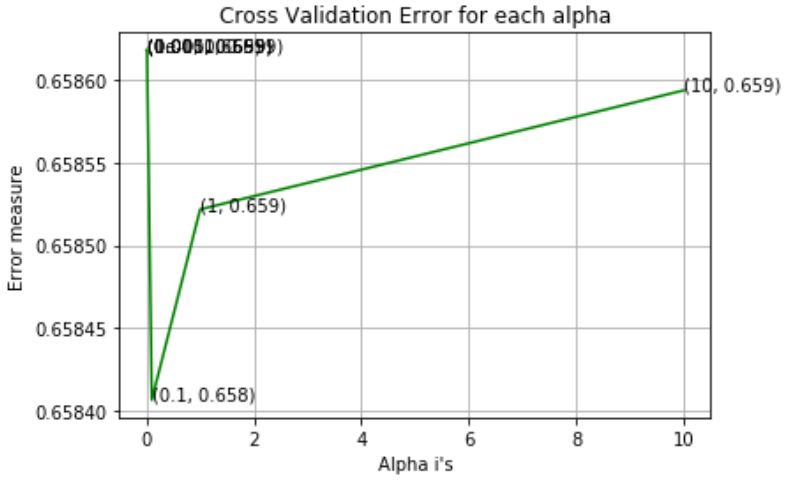
fig, ax = plt.subplots()
ax.plot(alpha, log_error_array,c='g')
for i, txt in enumerate(np.round(log_error_arra
y,3)):
    ax.annotate((alpha[i],np.round(txt,3)), (al
pha[i],log_error_array[i]))
plt.grid()
plt.title("Cross Validation Error for each alph
a")
plt.xlabel("Alpha i's")
plt.ylabel("Error measure")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

```
best_alpha = np.argmin(log_error_array)
clf = SGDClassifier(alpha=alpha[best_alpha], penalty='l1', loss='hinge', random_state=1,class_weight='balanced')
clf.fit(X_train, y_train)
sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
sig_clf.fit(X_train, y_train)

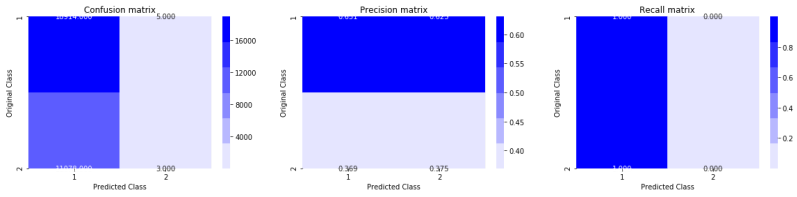
predict_y = sig_clf.predict_proba(X_train)
print('For values of best alpha = ', alpha[best_alpha], "The train log loss is:",log_loss(y_train, predict_y, labels=clf.classes_, eps=1e-15))
predict_y = sig_clf.predict_proba(X_test)
print('For values of best alpha = ', alpha[best_alpha], "The test log loss 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: 0.6586177514104066
For values of alpha =  0.0001 The log loss is: 0.6586177514104066
For values of alpha =  0.001 The log loss is: 0.6586177514104066
For values of alpha =  0.01 The log loss is: 0.6586177514104066
For values of alpha =  0.1 The log loss is: 0.6584066520829768
For values of alpha =  1 The log loss is:
```

```
0.6585216118390109
For values of alpha =  10 The log loss i
s: 0.6585934323140507
```




```
For values of best alpha =  0.1 The train
log loss is: 0.6583917657563423
For values of best alpha =  0.1 The test
log loss is: 0.6584066520829768
Total number of data points : 30000
```




# XGBOOST with Hyperparameter

# tuning

In [0]:
```
import xgboost as xgb
```

In [0]:
```
n_estimators = [50,100,150,200,300,400,500]
test_scores = []
train_scores = []
for i in n_estimators:
    clf = xgb.XGBClassifier(learning_rate=0.1,n
_estimators=i,n_jobs=-1)
    clf.fit(X_train,y_train)
    y_pred = clf.predict_proba(X_train)
    log_loss_train = log_loss(y_train, y_pred,
eps=1e-15)
    train_scores.append(log_loss_train)
    y_pred = clf.predict_proba(X_test)
    log_loss_test = log_loss(y_test, y_pred, ep
s=1e-15)
    test_scores.append(log_loss_test)
    print('For n_estimators = ',i,'Train Log Lo
ss ',log_loss_train,'Test Log Loss ',log_loss_t
est)
```

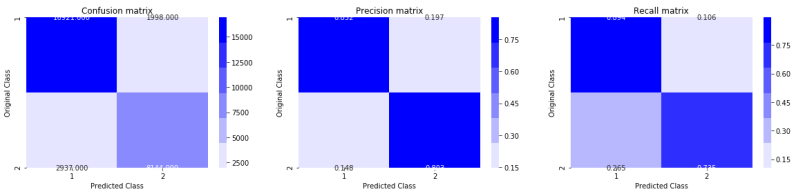
```
For n_estimators =  50 Train Log Loss  0.
37776845560689853 Test Log Loss  0.381401
0509262482
For n_estimators =  100 Train Log Loss
0.3572491313563236 Test Log Loss  0.36326
10291531397
For n_estimators =  150 Train Log Loss
0.3455091178805006 Test Log Loss  0.35356
09471881418
For n_estimators =  200 Train Log Loss
0.3377292008635845 Test Log Loss  0.34810
381124947937
```

```
For n_estimators =  300 Train Log Loss
0.3272940655662297 Test Log Loss  0.34207
568189851423
For n_estimators =  400 Train Log Loss
0.3196578887048417 Test Log Loss  0.33817
445826356435
For n_estimators =  500 Train Log Loss
0.3135746392374123 Test Log Loss  0.33589
88578589735
```

In [0]:

```
clf=xgb.XGBClassifier(learning_rate=0.1,n_estim
ators=500,n_jobs=-1)
clf.fit(X_train,y_train)
y_pred=clf.predict_proba(X_test)
print("The test log loss is:",log_loss(y_test,
y_pred, eps=1e-15))
predicted_y =np.argmax(y_pred,axis=1)
plot_confusion_matrix(y_test, predicted_y)
```

```
The test log loss is: 0.3358988578589735
```




In [0]:

```
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 Cou
ntVectorizer
```

```
from sklearn.feature_extraction.text import Tfi
dfVectorizer
warnings.filterwarnings("ignore")
import sys
import os
import pandas as pd
import numpy as np
from tqdm import tqdm

# exctract word2vec vectors
# https://github.com/explosion/spaCy/issues/172
1
# http://landinghub.visualstudio.com/visual-cpp
-build-tools
import spacy
```

In [5]:

```
# avoid decoding problems
df = pd.read_csv("Quora/train.csv")# encode que
stions to unicode
# https://stackoverflow.com/a/6812069
# ----------------- python 2 ------------------
---
# df['question1'] = df['question1'].apply(lambd
a x: unicode(str(x),"utf-8"))
# df['question2'] = df['question2'].apply(lambd
a 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))
df.head()
```

Out[5]:

| | id | qid1 | qid2 | question1 | question2 | is_dupli |
|---|---|---|---|---|---|---|

| 0 | id | qid1 | qid2 | question1 | question2 | is_dupli |
|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | What is the step by step guide to invest in sh... | What is the step by step guide to invest in sh... | |
| 1 | 1 | 3 | 4 | What is the story of Kohinoor (Koh-i-Noor) Dia... | What would happen if the Indian government sto... | |
| 2 | 2 | 5 | 6 | How can I increase the speed of my internet co... | How can Internet speed be increased by hacking... | |
| 3 | 3 | 7 | 8 | Why am I mentally very lonely? How can I solve... | Find the remainder when [math]23^{24} [/math] i... | |
| 4 | 4 | 9 | 10 | Which one dissolve in water quikly sugar, salt... | Which fish would survive in salt water? | |

In [0]:

```
dfnlp = pd.read_csv("Quora/nlp_features_train.csv",encoding='latin-1')
dfppro = pd.read_csv("Quora/df_fe_without_preprocessing_train.csv",encoding='latin-1')
df1 = dfnlp.drop(['qid1','qid2','question1','question2','is_duplicate'],axis=1)
df2 = dfppro.drop(['qid1','qid2','question1','question2','is_duplicate'],axis=1)
```

```
df3 = dfnlp[['id','question1','question2']]
duplicate = dfnlp.is_duplicate
```

In [7]:
```
df1.shape
```

Out[7]:
```
(404290, 16)
```

In [8]:
```
df2.shape
```

Out[8]:
```
(404290, 12)
```

In [9]:
```
df3.shape
```

Out[9]:
```
(404290, 3)
```

In [0]:
```
df3 = df3.fillna(' ')
#assigning new dataframe with columns question (q1+q2) and id same as df3
new_df = pd.DataFrame()
new_df['questions'] = df3.question1 + ' ' + df3.question2
new_df['id'] = df3.id
df2['id']=df1['id']
new_df['id']=df1['id']
final_df = df1.merge(df2, on='id',how='left') #merging df1 and df2
X  = final_df.merge(new_df, on='id',how='left') #merging final_df and new_df
```

In [0]:
```
X=X[:100000]
```

In [12]:
```
X=X.drop('id',axis=1)
X.columns
```

Out[12]:
```
Index(['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_rat
io', 'fuzz_ratio',
       'fuzz_partial_ratio', 'longest_sub
str_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', 'questions'],
      dtype='object')
```

In [0]:
```
duplicate=duplicate[:100000]
```

In [0]:
```
Y=np.array(duplicate)
```

In [15]:
```
Y.shape
```

Out[15]:
```
(100000,)
```

In [0]:
```
from sklearn.model_selection import train_test_
split
X_train, X_test, y_train, y_test = train_test_s
plit(X, Y, test_size=0.3, random_state=0,strati
fy=Y)
```

In [17]:
```
print(X_train.shape)
print(y_train.shape)
print(X_test.shape)
print(y_test.shape)
```

```
(70000, 27)
(70000,)
```

```
(30000, 27)
(30000,)
```

In [0]:

```
from sklearn.feature_extraction.text import Tfi
dfVectorizer
from sklearn.feature_extraction.text import Cou
ntVectorizer
# merge texts
questions = list(X_train['questions'])

tfidf = TfidfVectorizer(lowercase=False, )
tfidf.fit_transform(questions)

# dict key:word and value:tf-idf score
word2tfidf = dict(zip(tfidf.get_feature_names
(), tfidf.idf_))
```

In [0]:

```
nlp = spacy.load('en_core_web_sm')
```

In [20]:

```
vecs1 = []
# https://github.com/noamraph/tqdm
# tqdm is used to print the progress bar
for qu1 in tqdm(list(X_train['questions'])):
    doc1 = nlp(qu1)
    # 384 is the number of dimensions of vector
s
    mean_vec1 = np.zeros([len(doc1),len(doc1[0]
.vector)])
    for word1 in doc1:
        # word2vec
        vec1 = word1.vector
        # fetch df score
        try:
            idf = word2tfidf[str(word1)]
        except:
```

```
            idf = 0
        # compute final vec
        mean_vec1 += vec1 * idf
    mean_vec1 = mean_vec1.mean(axis=0)
    vecs1.append(mean_vec1)
#df['q1_feats_m'] = list(vecs1)
```

```
100%|██████████| 70000/70000 [12:51<00:0
0, 90.73it/s]
```

In [21]:

```
vecs2 = []
for qu2 in tqdm(list(X_test['questions'])):
    doc2 = nlp(qu2)
    mean_vec2 = np.zeros([len(doc2), 96])
    for word2 in doc2:
        # word2vec
        vec2 = word2.vector
        # fetch df score
        try:
            idf = word2tfidf[str(word2)]
        except:
            #print word
            idf = 0
        # compute final vec
        mean_vec2 += vec2 * idf
    mean_vec2 = mean_vec2.mean(axis=0)
    vecs2.append(mean_vec2)
#df['q2_feats_m'] = list(vecs2)ora/final_featur
es.csv",nrows=100001)
```

```
100%|██████████| 30000/30000 [05:28<00:0
0, 91.21it/s]
```

In [0]:

```
first_df=pd.DataFrame(vecs1)
second_df=pd.DataFrame(vecs2)
```

In [0]:
```
X_train=X_train.drop('questions',axis=1)
X_test=X_test.drop('questions',axis=1)
```

In [24]:
```
X_train.head()
```

Out[24]:

| | cwc_min | cwc_max | csc_min | csc_max | ctc |
|---|---|---|---|---|---|
| **20946** | 0.333328 | 0.333328 | 0.000000 | 0.000000 | 0.1 |
| **279** | 0.999950 | 0.499988 | 0.499975 | 0.333322 | 0.5 |
| **74424** | 0.749981 | 0.499992 | 0.999983 | 0.857131 | 0.8 |
| **87566** | 0.499992 | 0.499992 | 0.714276 | 0.624992 | 0.6 |
| **89750** | 0.999967 | 0.749981 | 0.999967 | 0.599988 | 0.9 |

In [25]:
```
import xgboost as xgb
from xgboost.sklearn import XGBClassifier,DMatrix
from sklearn.model_selection import RandomizedSearchCV
max_depth =  [1,3,5,7,9]
base_learners =  [250, 300, 350, 400, 450, 500]
learning_rate = [0.1, 0.2, 0.3, 0.4]
gamma = [1,2,3,4]
parameters = { 'max_depth' : max_depth, 'n_estimators' : base_learners, 'learning_rate' : learning_rate, 'gamma' : gamma}

clf = XGBClassifier(random_state=0, subsample=0.7, n_jobs=-1)
randomCV = RandomizedSearchCV(clf, parameters, cv = 5, scoring='neg_log_loss', n_jobs=-1)
randomCV.fit(X_train, y_train)
```

```
print("Best Estimator: ", randomCV.best_estimat
or_)
print("Best param: ", randomCV.best_params_)
print("Best Score: ", randomCV.best_score_)

best_depth = randomCV.best_params_['max_depth']
best_base_learner = randomCV.best_params_['n_es
timators']
best_learning_rate = randomCV.best_params_['lea
rning_rate']
best_gamma = randomCV.best_params_['gamma']
```

```
Best Estimator:  XGBClassifier(base_score
=0.5, booster='gbtree', colsample_bylevel
=1,
              colsample_bynode=1, colsamp
le_bytree=1, gamma=4,
              learning_rate=0.2, max_delt
a_step=0, max_depth=3,
              min_child_weight=1, missing
=None, n_estimators=300, n_jobs=-1,
              nthread=None, objective='bi
nary:logistic', random_state=0,

              reg_alpha=0, reg_lambda=1,
scale_pos_weight=1, seed=None,
              silent=None, subsample=0.7,
verbosity=1)
Best param:  {'n_estimators': 300, 'max_d
epth': 3, 'learning_rate': 0.2, 'gamma':
4}
Best Score:  -0.34377790891600224
```

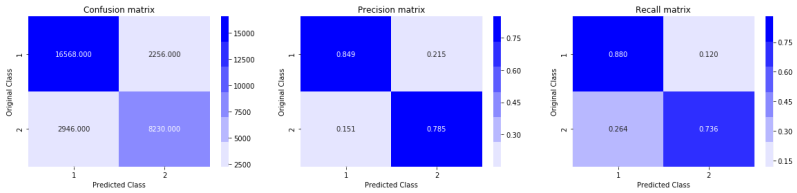
In [33]:

```
clf = XGBClassifier(n_estimators = best_base_le
arner, max_depth=best_depth,
                    learning_rate = best_learni
```

```
ng_rate, gamma = best_gamma,
                    random_state=0, n_jobs=-1)
clf.fit(X_train, y_train)

predict_y = clf.predict_proba(X_test)
print("The test log loss is:",log_loss(y_test,
predict_y, eps=1e-15))
predicted_y = clf.predict(X_test)
plot_confusion_matrix(y_test, predicted_y)
```

```
The test log loss is: 0.34394112083662987
```




# Conclusion:

In [40]:

```
from prettytable import PrettyTable
x = PrettyTable()
x.field_names = ["Model", " log loss"]
x.add_row(["Logistic Regression with TF-IDF",
0.5200])
x.add_row(["Linear SVM with TF-IDF", 0.4896])
x.add_row(["XGBoost with TF-IDF", 0.3358])
x.add_row(["XGBoost(TF-IDF w2v) ", 0.3439])
print(x)
```

```
+----------------------------------+------
-----+
|               Model              |  log
loss |
+----------------------------------+------
-----+
```