3. TFIDF W2V

```
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

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


# a = []
# while(1):
#     a.append(1)


from google.colab import drive
drive.mount('/content/drive')
```

```
Go to this URL in a browser: https://accounts.google.com/o/oauth2/auth?client_id=947318989803-6bn6qk8qdgf4n4g3pfee6491h

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

```
# avoid decoding problems
df = pd.read_csv("/content/drive/My Drive/qqps/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))


df.head()
```

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

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

```
    print( download nlp_features_train.csv from drive or run previous notebook )

if os.path.isfile('/content/drive/My Drive/qqps/df_fe_without_preprocessing_train.csv'):
    dfppro = pd.read_csv("/content/drive/My Drive/qqps/df_fe_without_preprocessing_train.csv",encoding='latin-1')
else:
    print("download df_fe_without_preprocessing_train.csv from drive or run previous notebook")


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','is_duplicate'],axis=1)
#df3_q1 = pd.DataFrame(df3.q1_feats_m.values.tolist(), index= df3.index)
#df3_q2 = pd.DataFrame(df3.q2_feats_m.values.tolist(), index= df3.index)


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

	id	is_duplicate	cwc_min	cwc_max	csc_min	csc_max	ctc_min	ctc_max	last_word_eq	first_word_eq	abs_len_diff
0	0	0	0.999980	0.833319	0.999983	0.999983	0.916659	0.785709	0.0	1.0	2.0
1	1	0	0.799984	0.399996	0.749981	0.599988	0.699993	0.466664	0.0	1.0	5.0
2	2	0	0.399992	0.333328	0.399992	0.249997	0.399996	0.285712	0.0	1.0	4.0
3	3	0	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.0	0.0	2.0
4	4	0	0.399992	0.199998	0.999950	0.666644	0.571420	0.307690	0.0	1.0	6.0

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

	id	freq_qid1	freq_qid2	q1len	q2len	q1_n_words	q2_n_words	word_Common	word_Total	word_share	freq_q1+q2	freq
0	0	1	1	66	57	14	12	10.0	23.0	0.434783	2	
1	1	4	1	51	88	8	13	4.0	20.0	0.200000	5	
2	2	1	1	73	59	14	10	4.0	24.0	0.166667	2	
3	3	1	1	50	65	11	9	0.0	19.0	0.000000	2	
4	4	3	1	76	39	13	7	2.0	20.0	0.100000	4	

```
df3.head()
```

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

```
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 :", df3.shape[1])
# print("Number of features in question2 w2v  dataframe :", df3_q2.shape[1])
print("Number of features in final dataframe  :", df1.shape[1]+df2.shape[1]+df3.shape[1])
```

```
Number of features in nlp dataframe : 17
Number of features in preprocessed dataframe : 12
Number of features in question1 w2v  dataframe : 3
Number of features in final dataframe  : 32
```

```
dff = df1.merge(df2, on='id',how='left')
```

```
dff = df3.merge(dff, on='id',how='left')
```

```
dff.shape
```

```
(404290, 30)
```

```
dff.head(2)
```

	id	question1	question2	is_duplicate	cwc_min	cwc_max	csc_min	csc_max	ctc_min	ctc_max	last_word_eq	firs
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	0.833319	0.999983	0.999983	0.916659	0.785709	0.0	
1	1	What is the story of Kohinoor (Koh-i-Noor) Dia...	What would happen if the Indian government sto...	0	0.799984	0.399996	0.749981	0.599988	0.699993	0.466664	0.0	

3.1 Random train test split(70:30)

```
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.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
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


#dff_sampled = dff.sample(n=100000)
#X = dff_sampled.drop('is_duplicate',axis=1)
```

```
#y_true = df1_sampled['is_duplicate']

X = dff.drop('is_duplicate',axis=1)
y_true = dff['is_duplicate']

print(X.shape)
print(y_true.shape)
```

```
(404290, 29)
(404290,)
```

```
X.head(2)
```

	id	question1	question2	cwc_min	cwc_max	csc_min	csc_max	ctc_min	ctc_max	last_word_eq	first_word_eq	abs
0	0	What is the step by step guide to invest in sh...	What is the step by step guide to invest in sh...	0.999980	0.833319	0.999983	0.999983	0.916659	0.785709	0.0	1.0	
1	1	What is the story of Kohinoor (Koh-i-Noor) Dia...	What would happen if the Indian government sto...	0.799984	0.399996	0.749981	0.599988	0.699993	0.466664	0.0	1.0	

```
from sklearn.model_selection import train_test_split
X_train,X_test, y_train, y_test = train_test_split(X, y_true, stratify=y_true, test_size=0.3)
```

3.2 Featurizing text data with TFIDF W2V

```
from sklearn.feature_extraction.text import TfidfVectorizer
from sklearn.feature_extraction.text import CountVectorizer
# merge texts
```

```
questions = list(X_train['question1']) + list(X_train['question2'])

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

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

- After we find TF-IDF scores, we convert each question to a weighted average of word2vec vectors by these scores.
- here we use a pre-trained GLOVE model which comes free with "Spacy". https://spacy.io/usage/vectors-similarity
- It is trained on Wikipedia and therefore, it is stronger in terms of word semantics.

```
# en_vectors_web_lg, which includes over 1 million unique vectors.
nlp = spacy.load('en_core_web_sm')

vecs1_train = []
# https://github.com/noamraph/tqdm
# tqdm is used to print the progress bar
for qu1 in tqdm(list(X_train['question1'])):
    doc1 = nlp(qu1)
    # 384 is the number of dimensions of vectors
    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_train.append(mean_vec1)
# df['q1_feats_m'] = list(vecs1)
```

```
100%|██████████| 283003/283003 [44:16<00:00, 106.53it/s]
```

```
vecs2_train = []
for qu2 in tqdm(list(X_train['question2'])):
    doc2 = nlp(qu2)
    mean_vec2 = np.zeros([len(doc1), len(doc2[0].vector)])
    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_train.append(mean_vec2)
# df['q2_feats_m'] = list(vecs2)
```

```
100%|██████████| 283003/283003 [45:06<00:00, 104.56it/s]
```

```
# en_vectors_web_lg, which includes over 1 million unique vectors.
nlp = spacy.load('en_core_web_sm')

vecs1_test = []
# https://github.com/noamraph/tqdm
# tqdm is used to print the progress bar
for qu1 in tqdm(list(X_test['question1'])):
    doc1 = nlp(qu1)
    # 384 is the number of dimensions of vectors
    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_test.append(mean_vec1)
# df['q1_feats_m'] = list(vecs1)
```

```
100%|██████████| 121287/121287 [19:00<00:00, 106.32it/s]
```

```
vecs2_test = []
for qu2 in tqdm(list(X_test['question2'])):
    doc2 = nlp(qu2)
    mean_vec2 = np.zeros([len(doc1), len(doc2[0].vector)])
    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_test.append(mean_vec2)
# df['q2_feats_m'] = list(vecs2)
```

```
100%|██████████| 121287/121287 [18:44<00:00, 107.83it/s]
```

```
type(vecs1_train)
```

```
list
```

```
q1_tfidfw2v_train_df = pd.DataFrame(vecs1_train)
q1_tfidfw2v_train_df = q1_tfidfw2v_train_df.fillna(0)
```

```
q2_tfidfw2v_train_df = pd.DataFrame(vecs2_train)
q2_tfidfw2v_train_df = q2_tfidfw2v_train_df.fillna(0)

q1_tfidfw2v_test_df = pd.DataFrame(vecs1_test)
q1_tfidfw2v_test_df = q1_tfidfw2v_test_df.fillna(0)

q2_tfidfw2v_test_df = pd.DataFrame(vecs2_test)
q2_tfidfw2v_test_df = q2_tfidfw2v_test_df.fillna(0)


q1_tfidfw2v_train_df['id']=X_train['id']
q2_tfidfw2v_train_df['id']=X_train['id']
q1_tfidfw2v_test_df['id']=X_test['id']
q2_tfidfw2v_test_df['id']=X_test['id']


X_train_tfidfw2v = X_train.merge(q1_tfidfw2v_train_df, on='id',how='left')
X_train_tfidfw2v = X_train_tfidfw2v.merge(q2_tfidfw2v_train_df, on='id',how='left')

X_test_tfidfw2v = X_test.merge(q1_tfidfw2v_test_df, on='id',how='left')
X_test_tfidfw2v = X_test_tfidfw2v.merge(q2_tfidfw2v_test_df, on='id',how='left')


X_train_tfidfw2v = X_train_tfidfw2v.fillna(0)
X_test_tfidfw2v = X_test_tfidfw2v.fillna(0)


X_train_tfidfw2v = X_train_tfidfw2v.drop(['question1','question2'],axis=1)
X_test_tfidfw2v = X_test_tfidfw2v.drop(['question1','question2'],axis=1)


print(X_train_tfidfw2v.shape)
print(X_test_tfidfw2v.shape)
```

```
(283003, 219)
(121287, 219)
```

```
X_train_tfidfw2v.head(2)
```

	id	cwc_min	cwc_max	csc_min	csc_max	ctc_min	ctc_max	last_word_eq	first_word_eq	abs_len_diff	mean_len
0	402501	0.714276	0.624992	0.749981	0.599988	0.727266	0.571424	0.0	1.0	3.0	12.5
1	212709	0.599988	0.499992	0.999980	0.714276	0.799992	0.615380	1.0	1.0	3.0	11.5

2 rows × 219 columns

```
X_test_tfidfw2v.head(2)
```

	id	cwc_min	cwc_max	csc_min	csc_max	ctc_min	ctc_max	last_word_eq	first_word_eq	abs_len_diff	mean_len
0	113755	0.874989	0.874989	0.999983	0.999983	0.928565	0.928565	0.0	1.0	0.0	14.0
1	365279	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.0	0.0	6.0	11.0

2 rows × 219 columns

```
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 variable in train data ----------
Class 0:  0.6308025003268517 Class 1:  0.36919749967314835
---------- Distribution of output variable in train data ----------
Class 0:  0.3691986775169639 Class 1:  0.3691986775169639
```

```
# 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)
```

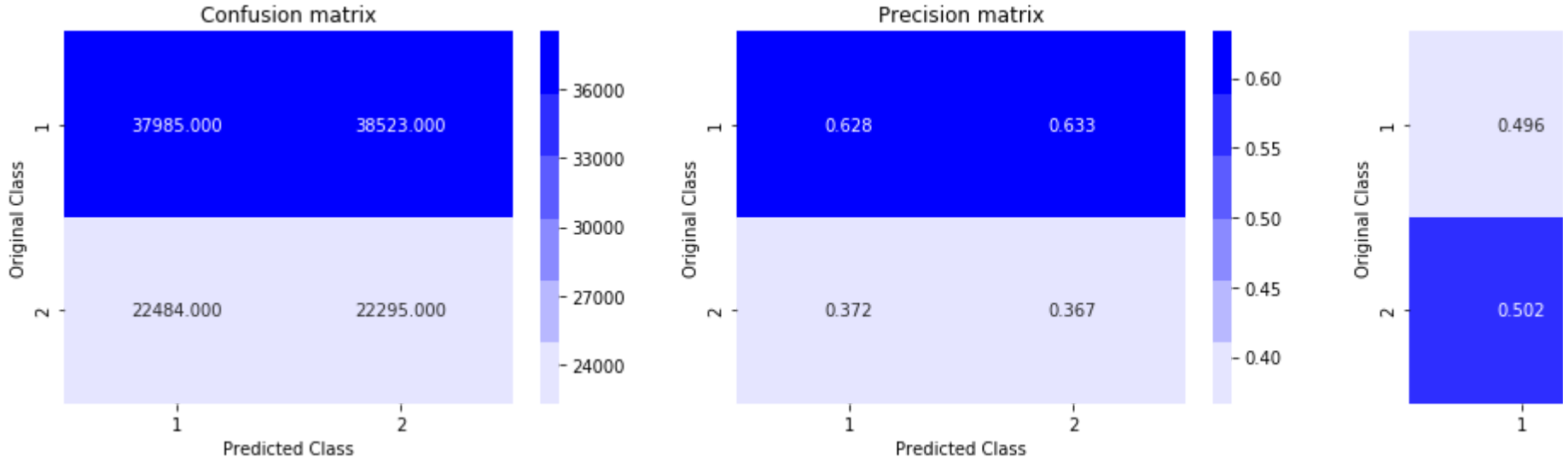
```
C = confusion_matrix(test_y, predict_y)
# C = 9,9 matrix, each cell (i,j) represents number of points of class i are predicted class j

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 columns and axis=1 corresponds to rows in two diamensional 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 columns and axis=1 corresponds to rows in two diamensional 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)
```

```
    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()
```

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

```
# we need to generate 9 numbers and the sum of numbers should be 1
# one solution is to genarate 9 numbers and divide each of the numbers by their sum
# ref: https://stackoverflow.com/a/18662466/4084039
# we create a output array that has exactly same 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 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 0.8887162780872625
```

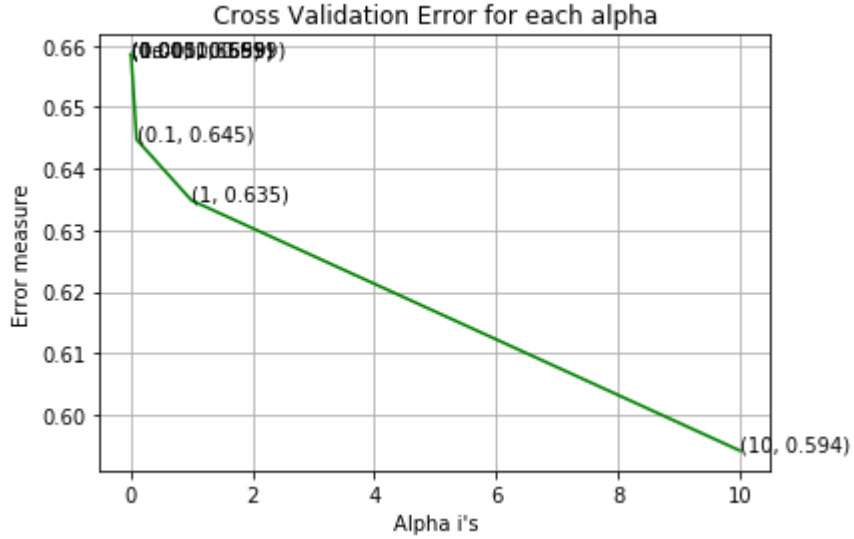


3.4 Logistic Regression with hyperparameter tuning

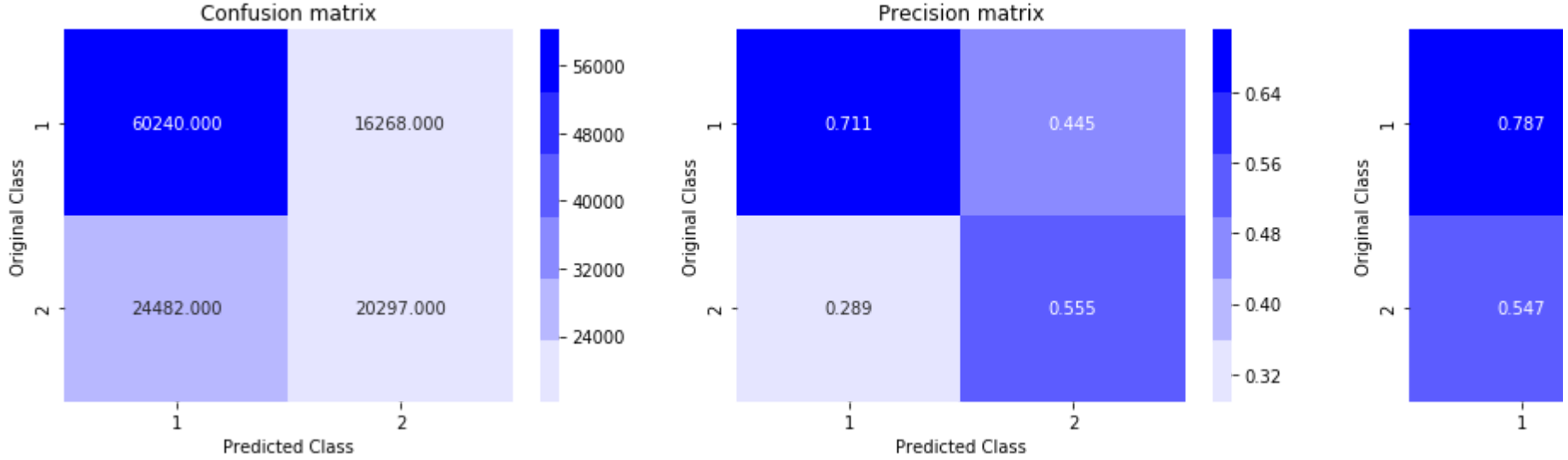
```
alpha = [10 ** x for x in range(-5, 2)] # hyperparam for SGD classifier.

# read more about SGDClassifier() at http://scikit-learn.org/stable/modules/generated/sklearn.linear_model.SGDClassifier.htı
# ------------------------------
# default parameters
# SGDClassifier(loss='hinge', penalty='l2', alpha=0.0001, l1_ratio=0.15, fit_intercept=True, max_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 Descent.
# predict(X)  Predict class labels for samples in X.

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

```
log_error_array=[]
for i in alpha:
    clf = SGDClassifier(alpha=i, penalty='l2', loss='log', random_state=42,n_jobs=-1)
    clf.fit(X_train_tfidfw2v, y_train)
    sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
    sig_clf.fit(X_train_tfidfw2v, y_train)
    predict_y = sig_clf.predict_proba(X_test_tfidfw2v)
    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_tfidfw2v, y_train)
sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
sig_clf.fit(X_train_tfidfw2v, y_train)

predict_y = sig_clf.predict_proba(X_train_tfidfw2v)
print('For values of best alpha = ', alpha[best_alpha], "The train log loss is:",log_loss(y_train, predict_y, labels=clf.cla
predict_y = sig_clf.predict_proba(X_test_tfidfw2v)
print('For values of best alpha = ', alpha[best_alpha], "The test log loss is:",log_loss(y_test, predict_y, labels=clf.class
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: 0.6585278256347589
For values of alpha =  0.0001 The log loss is: 0.6585278256347589
For values of alpha =  0.001 The log loss is: 0.6585278256347589
For values of alpha =  0.01 The log loss is: 0.6585278256347589
For values of alpha =  0.1 The log loss is: 0.6447398098588599
For values of alpha =  1 The log loss is: 0.6348496347523985
For values of alpha =  10 The log loss is: 0.5941716050926925
```




```
For values of best alpha =  10 The train log loss is: 0.5922424445697081
For values of best alpha =  10 The test log loss is: 0.5941716050926925
Total number of data points : 121287
```

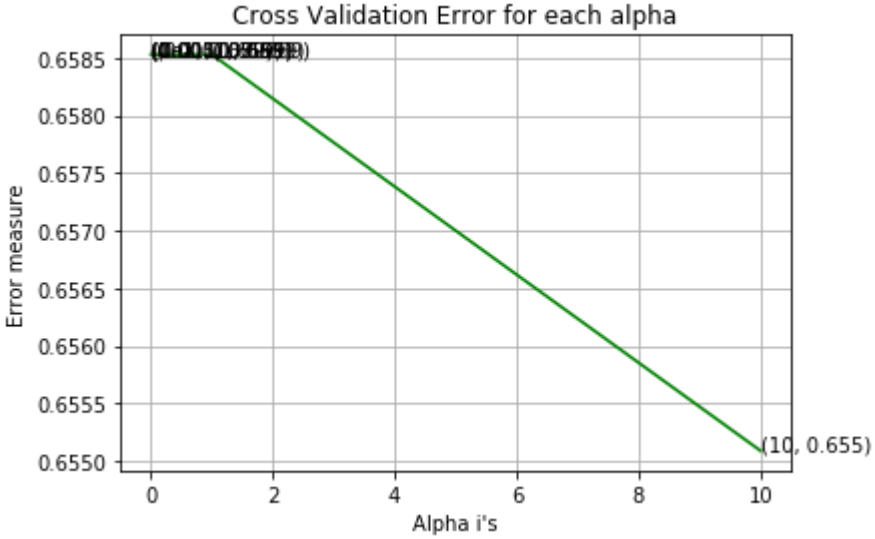


3.5 Linear SVM with hyperparameter tuning

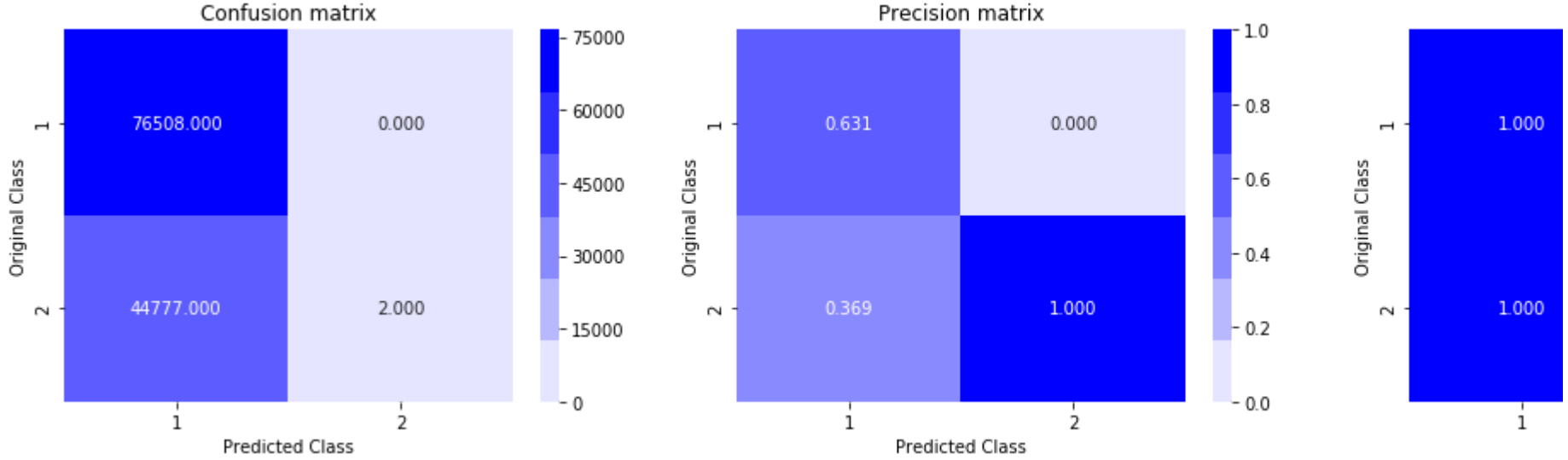
```
alpha = [10 ** x for x in range(-5, 2)] # hyperparam for SGD classifier.

# read more about SGDClassifier() at http://scikit-learn.org/stable/modules/generated/sklearn.linear_model.SGDClassifier.ht
# ------------------------------
# default parameters
# SGDClassifier(loss='hinge', penalty='l2', alpha=0.0001, l1_ratio=0.15, fit_intercept=True, max_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 Descent.
# predict(X)  Predict class labels for samples in X.

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


log_error_array=[]
for i in alpha:
    clf = SGDClassifier(alpha=i, penalty='l1', loss='hinge', random_state=42,n_jobs=-1)
    clf.fit(X_train_tfidfw2v, y_train)
    sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
    sig_clf.fit(X_train_tfidfw2v, y_train)
    predict_y = sig_clf.predict_proba(X_test_tfidfw2v)
    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.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_tfidfw2v, y_train)
sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
sig_clf.fit(X_train_tfidfw2v, y_train)

predict_y = sig_clf.predict_proba(X_train_tfidfw2v)
print('For values of best alpha = ', alpha[best_alpha], "The train log loss is:",log_loss(y_train, predict_y, labels=clf.cla
predict_y = sig_clf.predict_proba(X_test_tfidfw2v)
print('For values of best alpha = ', alpha[best_alpha], "The test log loss is:",log_loss(y_test, predict_y, labels=clf.class
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: 0.6585278256347589
For values of alpha =  0.0001 The log loss is: 0.6585278256347589
For values of alpha =  0.001 The log loss is: 0.6585278256347589
For values of alpha =  0.01 The log loss is: 0.6585278256347589
For values of alpha =  0.1 The log loss is: 0.6585278256347589
For values of alpha =  1 The log loss is: 0.6585278256347589
For values of alpha =  10 The log loss is: 0.655087920478348
```




```
For values of best alpha =  10 The train log loss is: 0.6557461044790134
For values of best alpha =  10 The test log loss is: 0.655087920478348
Total number of data points : 121287
```



3.6 XGBoost

```
from sklearn.model_selection import RandomizedSearchCV
from xgboost import XGBClassifier
import matplotlib.pyplot as plt
```

```
tuned_parameters = {'max_depth':[2,5,7,10],'n_estimators':[10,50,100,500]}

clf_gb = XGBClassifier(objective='binary:logistic', eval_metric='logloss',n_jobs=-1)
```

```
#Using RandomSearchCV
model_tfidfw2v = RandomizedSearchCV(clf_gb, tuned_parameters,verbose=5,n_jobs=10)
model_tfidfw2v.fit(X_train_tfidfw2v, y_train)
```

```
print(model_tfidfw2v.best_estimator_)
print(model_tfidfw2v.score(X_train_tfidfw2v, y_train))
```

```
Fitting 3 folds for each of 10 candidates, totalling 30 fits
[Parallel(n_jobs=10)]: Using backend LokyBackend with 10 concurrent workers.
[Parallel(n_jobs=10)]: Done  18 out of  30 | elapsed: 58.4min remaining: 39.0min
[Parallel(n_jobs=10)]: Done  25 out of  30 | elapsed: 90.5min remaining: 18.1min
[Parallel(n_jobs=10)]: Done  30 out of  30 | elapsed: 100.4min finished
XGBClassifier(base_score=0.5, booster='gbtree', colsample_bylevel=1,
              colsample_bynode=1, colsample_bytree=1, eval_metric='logloss',
              gamma=0, learning_rate=0.1, max_delta_step=0, max_depth=10,
              min_child_weight=1, missing=None, n_estimators=100, n_jobs=-1,
              nthread=None, objective='binary:logistic', random_state=0,
              reg_alpha=0, reg_lambda=1, scale_pos_weight=1, seed=None,
              silent=None, subsample=1, verbosity=1)
0.8724395147754618
```

```
print(model_tfidfw2v.best_estimator_)
print(model_tfidfw2v.score(X_test_tfidfw2v, y_test))
```

```
XGBClassifier(base_score=0.5, booster='gbtree', colsample_bylevel=1,
              colsample_bynode=1, colsample_bytree=1, eval_metric='logloss',
              gamma=0, learning_rate=0.1, max_delta_step=0, max_depth=10,
              min_child_weight=1, missing=None, n_estimators=100, n_jobs=-1,
              nthread=None, objective='binary:logistic', random_state=0,
              reg_alpha=0, reg_lambda=1, scale_pos_weight=1, seed=None,
              silent=None, subsample=1, verbosity=1)
0.8328757410109905
```

```
print('optimal max_depth:10')
print('optimal n_estimators:100')
```

```
optimal max_depth:10
optimal n_estimators:100
```

```
import xgboost as xgb
params = {}
params['objective'] = 'binary:logistic'
params['eval_metric'] = 'logloss'
params['eta'] = 0.02
params['max_depth'] = 10
```

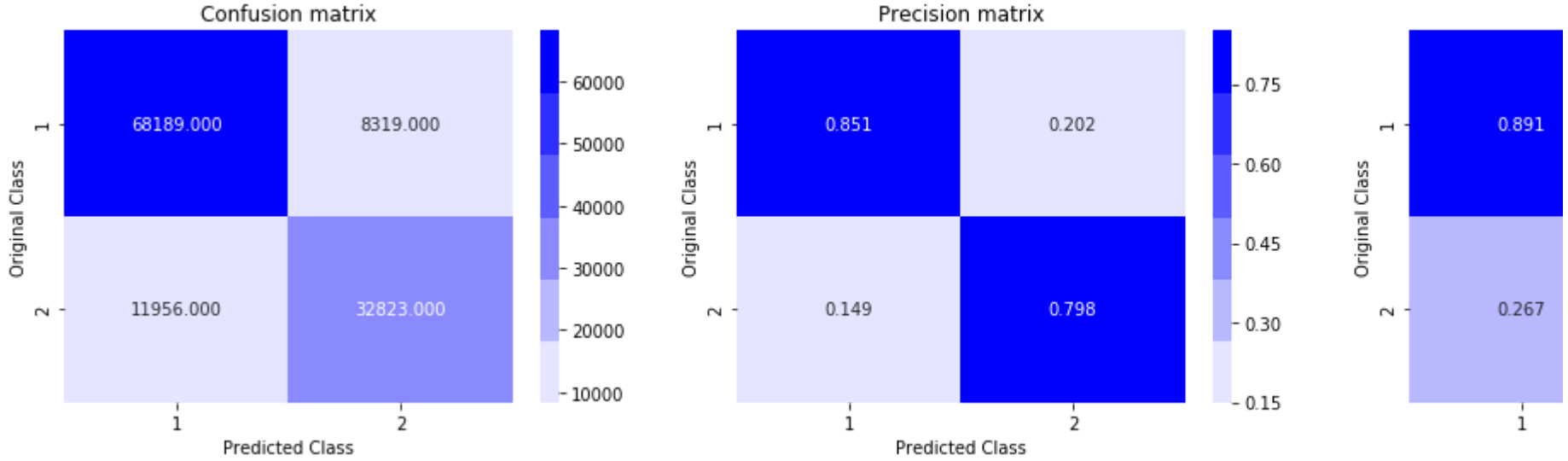
```
params['n_estimators'] = 100

d_train = xgb.DMatrix(X_train_tfidfw2v, label=y_train)
d_test = xgb.DMatrix(X_test_tfidfw2v, 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_tfidfw2v,y_train)
predict_y = bst.predict(d_test)
print("The test log loss is:",log_loss(y_test, predict_y, eps=1e-15))
```

```
[0]	train-logloss:0.682592	valid-logloss:0.682864
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:0.596266	valid-logloss:0.599114
[20]	train-logloss:0.534559	valid-logloss:0.539765
[30]	train-logloss:0.488898	valid-logloss:0.496228
[40]	train-logloss:0.453819	valid-logloss:0.463194
[50]	train-logloss:0.426552	valid-logloss:0.437859
[60]	train-logloss:0.405104	valid-logloss:0.418226
[70]	train-logloss:0.3881	valid-logloss:0.4028
[80]	train-logloss:0.37424	valid-logloss:0.390549
[90]	train-logloss:0.362689	valid-logloss:0.380593
[100]	train-logloss:0.35305	valid-logloss:0.372372
[110]	train-logloss:0.345021	valid-logloss:0.365723
[120]	train-logloss:0.338514	valid-logloss:0.360496
[130]	train-logloss:0.333071	valid-logloss:0.35633
[140]	train-logloss:0.328545	valid-logloss:0.352976
[150]	train-logloss:0.324543	valid-logloss:0.35014
[160]	train-logloss:0.321081	valid-logloss:0.34781
[170]	train-logloss:0.318243	valid-logloss:0.345872
[180]	train-logloss:0.315795	valid-logloss:0.344264
[190]	train-logloss:0.313554	valid-logloss:0.342972
[200]	train-logloss:0.311673	valid-logloss:0.341885
[210]	train-logloss:0.309864	valid-logloss:0.340942
[220]	train-logloss:0.308276	valid-logloss:0.340151
[230]	train-logloss:0.306766	valid-logloss:0.339416
[240]	train-logloss:0.305399	valid-logloss:0.338819
[250]	train-logloss:0.304115	valid-logloss:0.33833
[260]	train-logloss:0.302696	valid-logloss:0.337856
[270]	train-logloss:0.301516	valid-logloss:0.337436
[280]	train-logloss:0.300413	valid-logloss:0.337084
[290]	train-logloss:0.29934	valid-logloss:0.336695
[300]	train-logloss:0.298283	valid-logloss:0.336387
[310]	train-logloss:0.297315	valid-logloss:0.336094
[320]	train-logloss:0.296395	valid-logloss:0.335849
[330]	train-logloss:0.295288	valid-logloss:0.335614
[340]	train-logloss:0.294256	valid-logloss:0.3354
[350]	train-logloss:0.293254	valid-logloss:0.335237
[360]	train-logloss:0.29233	valid-logloss:0.335131
[370]	train-logloss:0.291219	valid-logloss:0.334926
[380]	train-logloss:0.290511	valid-logloss:0.334869
[390]	train-logloss:0.289584	valid-logloss:0.334745
```

```
[399]   train-logloss:0.288712  valid-logloss:0.334651
The test log loss is: 0.3346510975373082
```

```
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 : 121287
```



4. TFIDF

```
from sklearn.feature_extraction.text import TfidfVectorizer

# merge texts
questions = list(X_train['question1']) + list(X_train['question2'])


tfidf = TfidfVectorizer(min_df=5)
tfidf.fit(questions)
```

```
q1_train_tfidf = tfidf.transform(X_train['question1'].values)
q2_train_tfidf = tfidf.transform(X_train['question2'].values)

q1_test_tfidf = tfidf.transform(X_test['question1'].values)
q2_test_tfidf = tfidf.transform(X_test['question2'].values)


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

print("After vectorizations")
print(q1_train_tfidf.shape)
print(q2_train_tfidf.shape)
print(q1_test_tfidf.shape)
print(q2_test_tfidf.shape)

print(tfidf.get_feature_names())
```

```
After vectorizations
(283003, 25458)
(283003, 25458)
(121287, 25458)
(121287, 25458)
['00', '000', '00am', '01', '02', '03', '04', '05', '06', '07', '08', '09', '0s', '10', '100', '1000', '10000', '100000
```

```
X_train_df = X_train.drop(['question1','question2'],axis=1)
X_test_df = X_test.drop(['question1','question2'],axis=1)


import scipy
X_train_sparse = scipy.sparse.csr_matrix(X_train_df)
print(X_train_df.shape)
print(X_train_sparse.shape)
```

```
(283003, 27)
(283003, 27)
```

```
from scipy.sparse import hstack
```

```
X_train_tfidf = hstack((X_train_sparse,q1_train_tfidf,q2_train_tfidf))
X_train_tfidf.shape
```

```
(283003, 50943)
```

```
import scipy
X_test_sparse = scipy.sparse.csr_matrix(X_test_df)
print(X_test_df.shape)
print(X_test_sparse.shape)
```

```
(121287, 27)
(121287, 27)
```

```
from scipy.sparse import hstack

X_test_tfidf = hstack((X_test_sparse,q1_test_tfidf,q2_test_tfidf))
X_test_tfidf.shape
```

```
(121287, 50943)
```

```
# q1_tfidf_train_df = pd.DataFrame(q1_train_tfidf)
# q1_tfidf_train_df = q1_tfidf_train_df.fillna(0)

# q2_tfidf_train_df = pd.DataFrame(q2_train_tfidf)
# q2_tfidf_train_df = q2_tfidf_train_df.fillna(0)

# q1_tfidf_test_df = pd.DataFrame(q1_test_tfidf)
# q1_tfidf_test_df = q1_tfidf_test_df.fillna(0)

# q2_tfidf_test_df = pd.DataFrame(q2_test_tfidf)
# q2_tfidf_test_df = q2_tfidf_test_df.fillna(0)


# q1_tfidf_train_df['id']=X_train['id']
# q2_tfidf_train_df['id']=X_train['id']
# q1_tfidf_test_df['id']=X_test['id']
```

```
# q2_tfidf_test_df['id']=X_test['id']


# X_train_tfidf = X_train.merge(q1_tfidf_train_df, on='id',how='left')
# X_train_tfidf = X_train_tfidf.merge(q2_tfidf_train_df, on='id',how='left')

# X_test_tfidf = X_test.merge(q1_tfidf_test_df, on='id',how='left')
# X_test_tfidf = X_test_tfidf.merge(q2_tfidf_test_df, on='id',how='left')


# X_train_tfidf = X_train_tfidf.fillna(0)
# X_test_tfidf = X_test_tfidf.fillna(0)


# X_train_tfidf = X_train_tfidf.drop(['question1','question2'],axis=1)
# X_test_tfidf = X_test_tfidf.drop(['question1','question2'],axis=1)


# print(X_train_tfidf.shape)
# print(X_test_tfidf.shape)
```

```
(283003, 29)
(121287, 29)
```

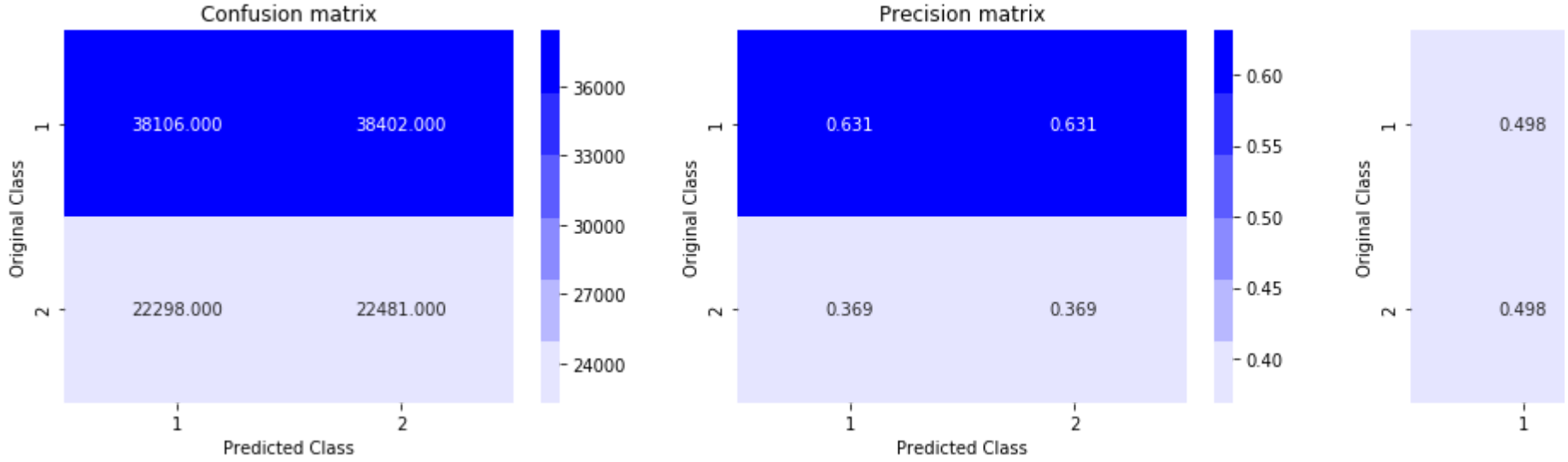
```
# X_train_tfidf.head(2)


# X_test_tfidf.head(2)
```

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

```
# we need to generate 9 numbers and the sum of numbers should be 1
# one solution is to genarate 9 numbers and divide each of the numbers by their sum
# ref: https://stackoverflow.com/a/18662466/4084039
# we create a output array that has exactly same 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 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 0.8868944695427189
```



4.2 Logistic Regression with hyperparameter tuning

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

# read more about SGDClassifier() at http://scikit-learn.org/stable/modules/generated/sklearn.linear_model.SGDClassifier.ht
# ------------------------------
# default parameters
# SGDClassifier(loss='hinge', penalty='l2', alpha=0.0001, l1_ratio=0.15, fit_intercept=True, max_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 Descent.
# predict(X)  Predict class labels for samples in X.

#-------------------------------
```

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


log_error_array=[]
for i in alpha:
    clf = SGDClassifier(alpha=i, penalty='l2', loss='log', random_state=42,n_jobs=-1)
    clf.fit(X_train_tfidf, y_train)
    sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
    sig_clf.fit(X_train_tfidf, y_train)
    predict_y = sig_clf.predict_proba(X_test_tfidf)
    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_tfidf, y_train)
sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
sig_clf.fit(X_train_tfidf, y_train)

predict_y = sig_clf.predict_proba(X_train_tfidf)
print('For values of best alpha = ', alpha[best_alpha], "The train log loss is:",log_loss(y_train, predict_y, labels=clf.cl
predict_y = sig_clf.predict_proba(X_test_tfidf)
print('For values of best alpha = ', alpha[best_alpha], "The test log loss is:",log_loss(y_test, predict_y, labels=clf.class
predicted_y =np.argmax(predict_y,axis=1)
print("Total number of data points :", len(predicted_y))
plot_confusion_matrix(y_test, predicted_y)
```

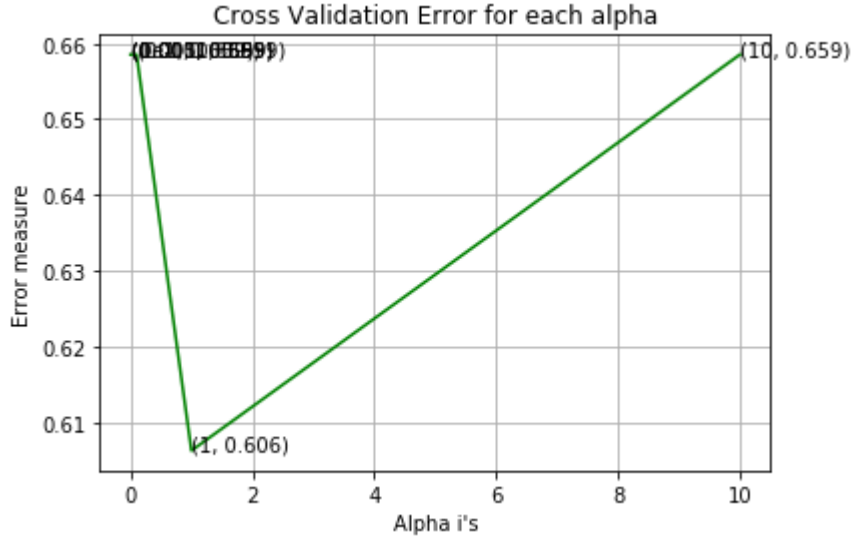
```
For values of alpha =  1e-05 The log loss is: 0.6585278256347588
For values of alpha =  0.0001 The log loss is: 0.6585278256347588
```

4.3 Linear SVM with hyperparameter tuning

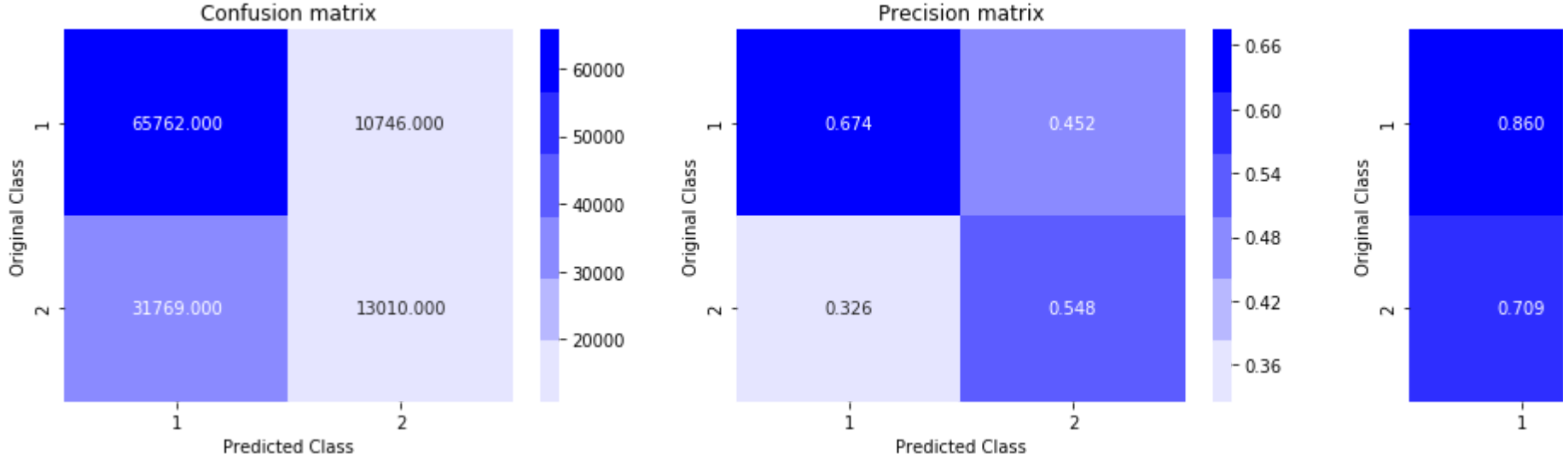
```
alpha = [10 ** x for x in range(-5, 2)] # hyperparam for SGD classifier.

# read more about SGDClassifier() at http://scikit-learn.org/stable/modules/generated/sklearn.linear_model.SGDClassifier.ht
# ------------------------------
# default parameters
# SGDClassifier(loss='hinge', penalty='l2', alpha=0.0001, l1_ratio=0.15, fit_intercept=True, max_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 Descent.
# predict(X)  Predict class labels for samples in X.

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


log_error_array=[]
for i in alpha:
    clf = SGDClassifier(alpha=i, penalty='l1', loss='hinge', random_state=42,n_jobs=-1)
    clf.fit(X_train_tfidf, y_train)
    sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
    sig_clf.fit(X_train_tfidf, y_train)
    predict_y = sig_clf.predict_proba(X_test_tfidf)
    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.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_tfidf, y_train)
sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
sig_clf.fit(X_train_tfidf, y_train)

predict_y = sig_clf.predict_proba(X_train_tfidf)
print('For values of best alpha = ', alpha[best_alpha], "The train log loss is:",log_loss(y_train, predict_y, labels=clf.cl
predict_y = sig_clf.predict_proba(X_test_tfidf)
print('For values of best alpha = ', alpha[best_alpha], "The test log loss is:",log_loss(y_test, predict_y, labels=clf.class
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: 0.6585278256347588
For values of alpha =  0.0001 The log loss is: 0.6585278256347588
For values of alpha =  0.001 The log loss is: 0.6585278256347588
For values of alpha =  0.01 The log loss is: 0.6585278256347588
For values of alpha =  0.1 The log loss is: 0.6585278256347588
For values of alpha =  1 The log loss is: 0.6062366069508072
For values of alpha =  10 The log loss is: 0.6585278256302662
```




```
For values of best alpha =  1 The train log loss is: 0.6067287950035007
For values of best alpha =  1 The test log loss is: 0.6062366069508072
Total number of data points : 121287
```



4.4 XGBoost

```
from sklearn.model_selection import RandomizedSearchCV
from xgboost import XGBClassifier
import matplotlib.pyplot as plt



tuned_parameters = {'max_depth':[2,5,7,10],'n_estimators':[10,50,100,500]}

clf_gb = XGBClassifier(objective='binary:logistic', eval_metric='logloss',n_jobs=-1)



#Using RandomSearchCV
model_tfidf = RandomizedSearchCV(clf_gb, tuned_parameters,verbose=5,n_jobs=10)
model_tfidf.fit(X_train_tfidf, y_train)



print(model_tfidf.best_estimator_)
print(model_tfidf.score(X_train_tfidf, y_train))
```

```
Fitting 3 folds for each of 10 candidates, totalling 30 fits
[Parallel(n_jobs=10)]: Using backend LokyBackend with 10 concurrent workers.
[Parallel(n_jobs=10)]: Done  18 out of  30 | elapsed: 15.7min remaining: 10.5min
[Parallel(n_jobs=10)]: Done  25 out of  30 | elapsed: 55.8min remaining: 11.2min
[Parallel(n_jobs=10)]: Done  30 out of  30 | elapsed: 64.2min finished
XGBClassifier(base_score=0.5, booster='gbtree', colsample_bylevel=1,
              colsample_bynode=1, colsample_bytree=1, eval_metric='logloss',
              gamma=0, learning_rate=0.1, max_delta_step=0, max_depth=10,
              min_child_weight=1, missing=None, n_estimators=500, n_jobs=-1,
              nthread=None, objective='binary:logistic', random_state=0,
              reg_alpha=0, reg_lambda=1, scale_pos_weight=1, seed=None,
              silent=None, subsample=1, verbosity=1)
0.9055840397451617
```

```
print(model_tfidf.best_estimator_)
print(model_tfidf.score(X_test_tfidf, y_test))
```

```
XGBClassifier(base_score=0.5, booster='gbtree', colsample_bylevel=1,
              colsample_bynode=1, colsample_bytree=1, eval_metric='logloss',
              gamma=0, learning_rate=0.1, max_delta_step=0, max_depth=10,
              min_child_weight=1, missing=None, n_estimators=500, n_jobs=-1,
              nthread=None, objective='binary:logistic', random_state=0,
              reg_alpha=0, reg_lambda=1, scale_pos_weight=1, seed=None,
              silent=None, subsample=1, verbosity=1)
0.8573218894028214
```

```
print('optimal max_depth:10')
print('optimal n_estimators:100')
```

```
optimal max_depth:10
optimal n_estimators:100
```

```
import xgboost as xgb
params = {}
params['objective'] = 'binary:logistic'
params['eval_metric'] = 'logloss'
params['eta'] = 0.02
params['max_depth'] = 10
```

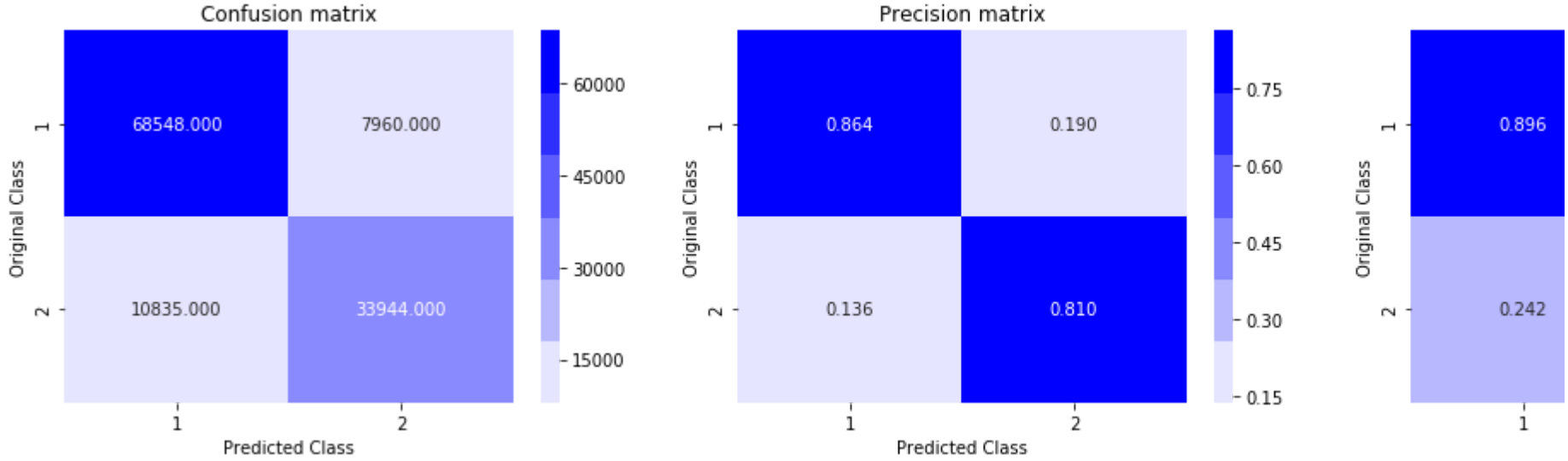
```
params['n_estimators'] = 100

d_train = xgb.DMatrix(X_train_tfidf, label=y_train)
d_test = xgb.DMatrix(X_test_tfidf, 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_tfidf,y_train)
predict_y = bst.predict(d_test)
print("The test log loss is:",log_loss(y_test, predict_y, eps=1e-15))
```

```
[0]	train-logloss:0.68258	valid-logloss:0.682776
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:0.596218	valid-logloss:0.598214
[20]	train-logloss:0.534654	valid-logloss:0.53833
[30]	train-logloss:0.488967	valid-logloss:0.494187
[40]	train-logloss:0.453788	valid-logloss:0.460552
[50]	train-logloss:0.42645	valid-logloss:0.434648
[60]	train-logloss:0.404879	valid-logloss:0.414432
[70]	train-logloss:0.387611	valid-logloss:0.398371
[80]	train-logloss:0.373569	valid-logloss:0.385428
[90]	train-logloss:0.361984	valid-logloss:0.374927
[100]	train-logloss:0.352304	valid-logloss:0.366176
[110]	train-logloss:0.344578	valid-logloss:0.359211
[120]	train-logloss:0.338082	valid-logloss:0.353496
[130]	train-logloss:0.332451	valid-logloss:0.348649
[140]	train-logloss:0.327651	valid-logloss:0.344653
[150]	train-logloss:0.323642	valid-logloss:0.34136
[160]	train-logloss:0.320292	valid-logloss:0.338676
[170]	train-logloss:0.317441	valid-logloss:0.336347
[180]	train-logloss:0.315036	valid-logloss:0.334366
[190]	train-logloss:0.313124	valid-logloss:0.332845
[200]	train-logloss:0.311474	valid-logloss:0.331547
[210]	train-logloss:0.309715	valid-logloss:0.330285
[220]	train-logloss:0.308234	valid-logloss:0.329224
[230]	train-logloss:0.307049	valid-logloss:0.328305
[240]	train-logloss:0.305759	valid-logloss:0.327386
[250]	train-logloss:0.304288	valid-logloss:0.326413
[260]	train-logloss:0.303374	valid-logloss:0.325763
[270]	train-logloss:0.302509	valid-logloss:0.325156
[280]	train-logloss:0.301676	valid-logloss:0.324647
[290]	train-logloss:0.30094	valid-logloss:0.324176
[300]	train-logloss:0.300212	valid-logloss:0.323708
[310]	train-logloss:0.29938	valid-logloss:0.323226
[320]	train-logloss:0.298216	valid-logloss:0.322596
[330]	train-logloss:0.297355	valid-logloss:0.322121
[340]	train-logloss:0.296451	valid-logloss:0.32156
[350]	train-logloss:0.295561	valid-logloss:0.321043
[360]	train-logloss:0.294873	valid-logloss:0.32064
[370]	train-logloss:0.294175	valid-logloss:0.320269
[380]	train-logloss:0.293496	valid-logloss:0.319898
[390]	train-logloss:0.292712	valid-logloss:0.319478
```

```
[399]   train-logloss:0.292119  valid-logloss:0.31918
The test log loss is: 0.319180192509611
```

```
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 : 121287
```



5. Conclusion

```
# Please compare all your models using Prettytable library
# http://zetcode.com/python/prettytable/

from prettytable import PrettyTable

x = PrettyTable()
x.field_names= ("Vectorizer","Model", "Log Loss")

x.add_row(["tfidf w2v" ,"Random",  0.88871])
```

```
x.add_row(["tfidf w2v" ,"Logistic Regression", 0.59417])
x.add_row(["tfidf w2v" ,"Liner SVM", 0.65508])
x.add_row(["tfidf w2v" ,"GBDT", 0.33465])

x.add_row([" " ," ", " "])

x.add_row(["tfidf"  ,"Random", 0.88689])
x.add_row(["tfidf" ,"Logistic Regression", 0.60338 ])
x.add_row(["tfidf" ,"Liner SVM", 0.60623])
x.add_row(["tfidf" ,"GBDT", 0.31918])



print(x)
```

```
+------------+---------------------+----------+
| Vectorizer |        Model        | Log Loss |
+------------+---------------------+----------+
| tfidf w2v  |        Random       | 0.88871  |
| tfidf w2v  | Logistic Regression | 0.59417  |
| tfidf w2v  |      Liner SVM      | 0.65508  |
| tfidf w2v  |         GBDT        | 0.33465  |
|            |                     |          |
|   tfidf    |        Random       | 0.88689  |
|   tfidf    | Logistic Regression | 0.60338  |
|   tfidf    |      Liner SVM      | 0.60623  |
|   tfidf    |         GBDT        | 0.31918  |
+------------+---------------------+----------+
```