Try out models (Logistic regression, Linear-SVM) with simple TF-IDF vectors instead of TD_IDF weighted word2Vec.

In [1]:

```python
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
```

In [163]:

```
rows = 400000
```

In [164]:

```
if os.path.isfile('nlp_features_train.csv'):
    dfnlp = pd.read_csv("nlp_features_train.csv",encoding='latin-1', nrows = rows)
else:
    print("download nlp_features_train.csv from drive or run previous notebook")

if os.path.isfile('df_fe_without_preprocessing_train.csv'):
    dfppro = pd.read_csv("df_fe_without_preprocessing_train.csv",encoding='latin-1', nrows = rows)
else:
    print("download df_fe_without_preprocessing_train.csv from drive or run previous notebook")
```

In [165]:

```
dfnlp.head(2)
```

Out[165]:

	id	qid1	qid2	question1	question2	is_duplicate	cwc_min	cwc_max	csc_min	csc_max	...	ctc_max	last_word_eq	first_word_eq	abs_len_di
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	0.999980	0.833319	0.999983	0.999983	...	0.785709	0.0	1.0	2.
1	1	3	4	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	...	0.466664	0.0	1.0	5.

2 rows × 21 columns

In [166]:

```
print(dfnlp.shape)
print(dfppro.shape)
```

```
(400000, 21)
(400000, 17)
```

In [167]:

```
dfppro.head(2)
```

Out[167]:

	id	qid1	qid2	question1	question2	is_duplicate	freq_qid1	freq_qid2	q1len	q2len	q1_n_words	q2_n_words	word_Common	word_Total	wor
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	66	57	14	12	10.0	23.0	0
1	1	3	4	What is the story of Kohinoor (Koh-i-Noor) Dia...	What would happen if the Indian government sto...	0	4	1	51	88	8	13	4.0	20.0	0

Have to combine these 2 dfs first So that later we can add just one tfidf vector for questions via hstack

As question1 and ques2 are preprocessed in dfnlp then we must vectorize with dfnlp questions

In [168]:
```
dfppro = dfppro.drop(['qid1', 'qid2', 'question1', 'question2','is_duplicate'], axis=1)
dfppro.head()
```

Out[168]:

	id	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	0	1	1	66	57	14	12	10.0	23.0	0.434783	2	0
1	1	4	1	51	88	8	13	4.0	20.0	0.200000	5	3
2	2	1	1	73	59	14	10	4.0	24.0	0.166667	2	0
3	3	1	1	50	65	11	9	0.0	19.0	0.000000	2	0
4	4	3	1	76	39	13	7	2.0	20.0	0.100000	4	2

In [169]:
```
df = dfnlp.merge(dfppro, on=['id'],how='left')
```

In [ ]:
```

```

In [170]:
```
print(df.shape)
```

```
(400000, 32)
```

Now we have everything preprocessed, So lets first split our data before doing vectorizing as it might cause data leakage which we dont want at any cost

In [171]:
```
df.columns
```

Out[171]:
```
Index(['id', 'qid1', 'qid2', 'question1', 'question2', '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'],
      dtype='object')
```

In [ ]:
```

```

In [172]:

```
df["question1"].head()
```

Out[172]:

```
0    what is the step by step guide to invest in sh...
1    what is the story of kohinoor  koh i noor  dia...
2    how can i increase the speed of my internet co...
3    why am i mentally very lonely  how can i solve...
4    which one dissolve in water quikly sugar  salt...
Name: question1, dtype: object
```

In [173]:

```
y_true = df["is_duplicate"]
```

In [174]:

```
df.drop(['is_duplicate', 'qid1', 'qid2'], axis=1, inplace=True)
```

In [175]:

```
print(df.shape)
```

```
(400000, 29)
```

In [176]:

```
df = df.fillna(' ')
```

In [ ]:

```

```

In [177]:

```
X_train,X_test, y_train, y_test = train_test_split(df, y_true, stratify=y_true, test_size=0.3)
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 : (280000, 29)
Number of data points in test data : (120000, 29)
```

In [178]:

```
from sklearn.feature_extraction.text import TfidfVectorizer
questions_train = list(X_train['question1']) + list(X_train['question2'])

tfidf = TfidfVectorizer(lowercase=False)
tfidf.fit(questions_train)

tfidf_train_q1 = tfidf.transform(X_train['question1'])
tfidf_train_q2 = tfidf.transform(X_train['question2'])
tfidf_test_q1 = tfidf.transform(X_test['question1'])
tfidf_test_q2 = tfidf.transform(X_test['question2'])

print(tfidf_train_q1.shape)
print(tfidf_train_q2.shape)
print(tfidf_test_q1.shape)
print(tfidf_test_q2.shape)


```

```
(280000, 73371)
(280000, 73371)
(120000, 73371)
(120000, 73371)
```

In [179]:

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

In [180]:

```
print(X_train.shape)
```

```
(280000, 27)
```

In [181]:

```
from scipy.sparse import hstack
X_train_final = hstack([tfidf_train_q1, tfidf_train_q2, X_train.values]).tocsr()
X_test_final = hstack([tfidf_test_q1, tfidf_test_q2, X_test.values]).tocsr()
print(X_train_final.shape, X_test_final.shape)
```

```
(280000, 146769) (120000, 146769)
```

In [182]:

```
# This function plots the confusion matrices given y_i, y_i_hat.
def plot_confusion_matrix(test_y, predict_y):
    C = confusion_matrix(test_y, predict_y)
    # C = 9,9 matrix, each cell (i,j) represents number of points of class i are 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 arra
    # 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 arra
    # 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 = [0,1]
    # 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()
```

Random Model

In [183]:

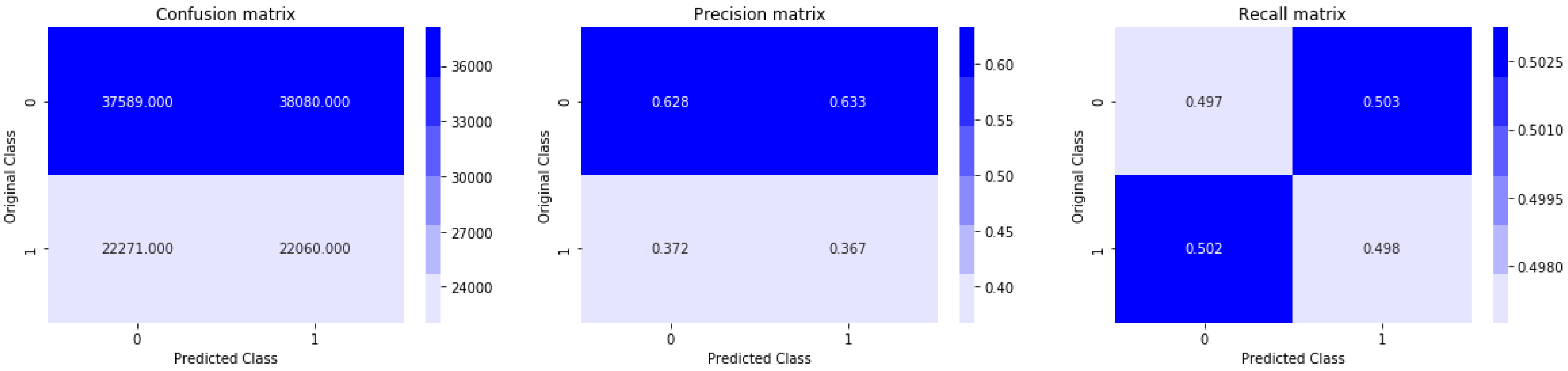
```
print("-"*10, "Distribution of output variable in train data", "-"*10)
train_distr = Counter(y_train)
train_len = len(y_train)
print("Class 0: ",int(train_distr[0])/train_len,"Class 1: ", int(train_distr[1])/train_len)
print("-"*10, "Distribution of output variable in train data", "-"*10)
test_distr = 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:  0.6305785714285714 Class 1:  0.36942142857142857
---------- Distribution of output variable in train data ----------
Class 0:  0.369425 Class 1:  0.369425
```

In [184]:

```
# 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 0.8937041392914908
```

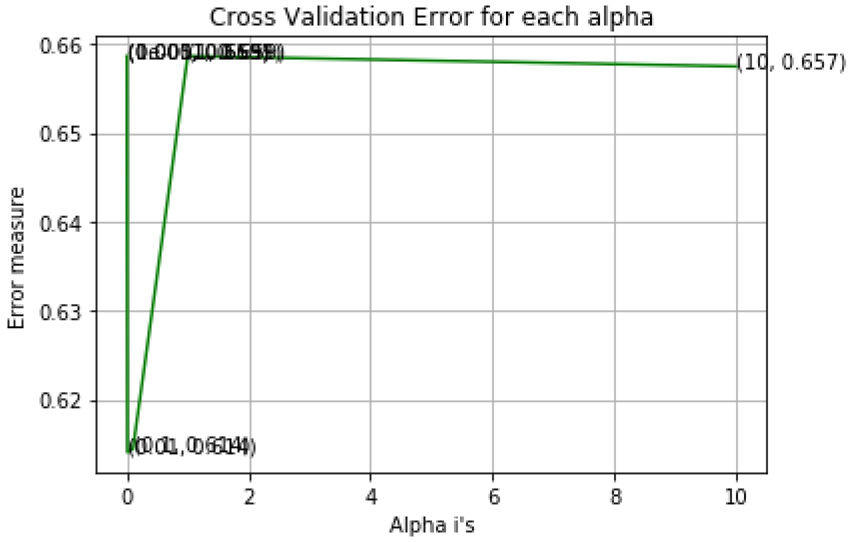


LOGISTIC REGRESSION

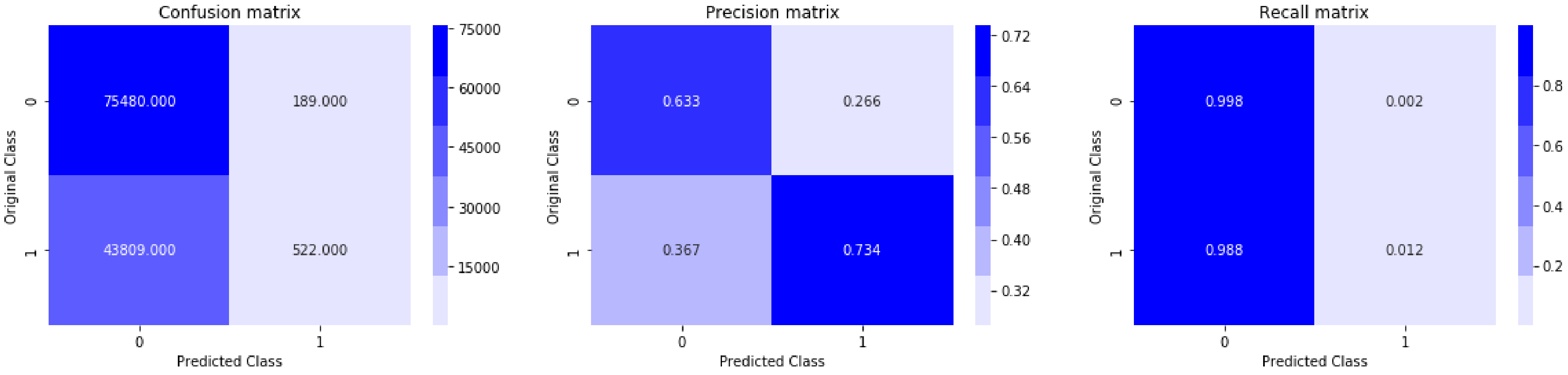
In [192]:

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

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

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_final, y_train)
sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
sig_clf.fit(X_train_final, y_train)

predict_y = sig_clf.predict_proba(X_train_final)
print('For values of best alpha = ', alpha[best_alpha], "The train log loss is:",log_loss(y_train, predict_y, la
predict_y = sig_clf.predict_proba(X_test_final)
print('For values of best alpha = ', alpha[best_alpha], "The test log loss is:",log_loss(y_test, predict_y, labe
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: 0.6586489466732767
For values of alpha =  0.0001 The log loss is: 0.6586489466732767
For values of alpha =  0.001 The log loss is: 0.6586489466732767
For values of alpha =  0.01 The log loss is: 0.614065123886705
For values of alpha =  0.1 The log loss is: 0.6144293652923921
For values of alpha =  1 The log loss is: 0.6586489466732767
For values of alpha =  10 The log loss is: 0.6574867280589907
```



```
For values of best alpha =  0.01 The train log loss is: 0.6143797442084187
For values of best alpha =  0.01 The test log loss is: 0.614065123886705
Total number of data points : 120000
```



In [193]:

```
LogisticRegression_alpha = alpha[best_alpha]
LogisticRegression_logloss = log_loss(y_test, predict_y, labels=clf.classes_, eps=1e-15)
```

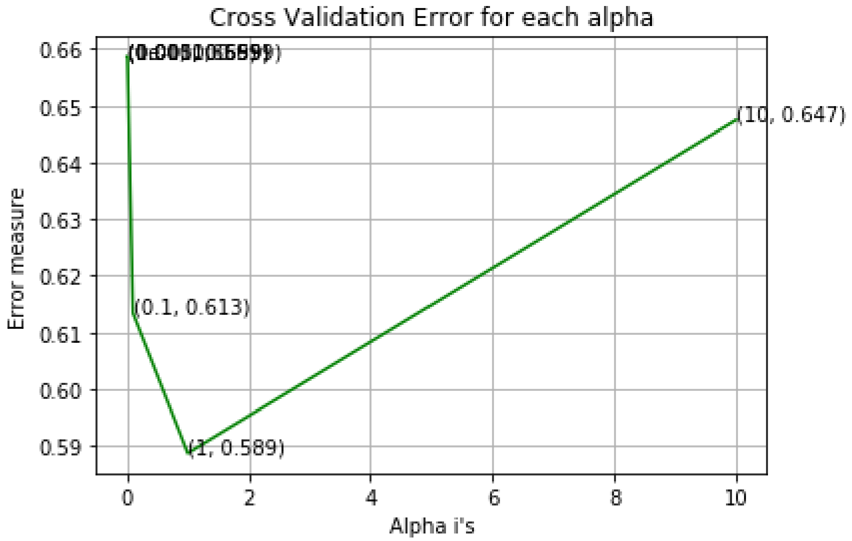
LINEAR SVM

In [194]:

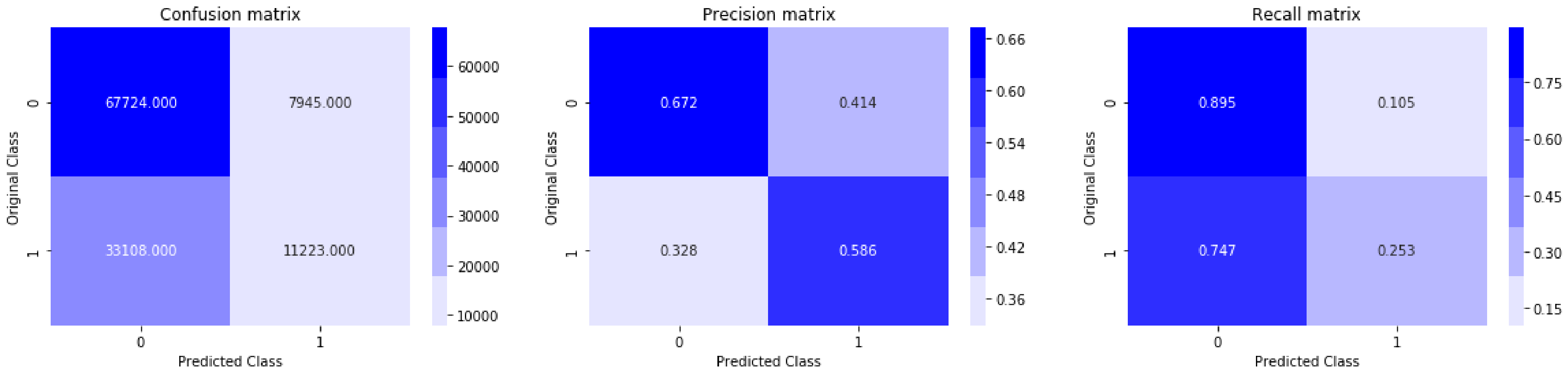
```
alpha = [10 ** x for x in range(-5, 2)] # hyperparam for SGD classifier.

# read more about SGDClassifier() at http://scikit-learn.org/stable/modules/generated/sklearn.linear_model.
# ------------------------------
# default parameters
# SGDClassifier(loss=’hinge’, penalty=’l2’, alpha=0.0001, l1_ratio=0.15, fit_intercept=True, max_iter=None,
# shuffle=True, verbose=0, epsilon=0.1, n_jobs=1, random_state=None, learning_rate=’optimal’, eta0=0.0, pow
# 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)
    clf.fit(X_train_final, y_train)
    sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
    sig_clf.fit(X_train_final, y_train)
    predict_y = sig_clf.predict_proba(X_test_final)
    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_,

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


best_alpha = np.argmin(log_error_array)
clf = SGDClassifier(alpha=alpha[best_alpha], penalty='l1', loss='hinge', random_state=42)
```

```
clf.fit(X_train_final, y_train)
sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
sig_clf.fit(X_train_final, y_train)

predict_y = sig_clf.predict_proba(X_train_final)
print('For values of best alpha = ', alpha[best_alpha], "The train log loss is:",log_loss(y_train, predict_
predict_y = sig_clf.predict_proba(X_test_final)
print('For values of best alpha = ', alpha[best_alpha], "The test log loss is:",log_loss(y_test, predict_y,
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: 0.6586489466732767
For values of alpha =  0.0001 The log loss is: 0.6586489466732767
For values of alpha =  0.001 The log loss is: 0.6586489466732767
For values of alpha =  0.01 The log loss is: 0.6586489466732767
For values of alpha =  0.1 The log loss is: 0.61342744507318
For values of alpha =  1 The log loss is: 0.5886888763223536
For values of alpha =  10 The log loss is: 0.6474710342982285
```



```
For values of best alpha =  1 The train log loss is: 0.5891724271157317
For values of best alpha =  1 The test log loss is: 0.5886888763223536
Total number of data points : 120000
```



In [195]:

```python
SVM_alpha = alpha[best_alpha]
SVM_logloss = log_loss(y_test, predict_y, labels=clf.classes_, eps=1e-15)
```

SUMMARY

In [196]:

```python
from prettytable import PrettyTable

x = PrettyTable()
x.field_names = ["Vectorizer", "Model", "Hyperparameter (ALPHA)", "LOG LOSS", "Data Points"]
x.add_row(["Tfidf", "Logistic Regression", LogisticRegression_alpha, LogisticRegression_logloss, rows])
x.add_row(["Tfidf", "Linear SVM", SVM_alpha, SVM_logloss, rows])
print(x)
```

```
+------------+---------------------+------------------------+---------------------+-------------+
| Vectorizer |        Model        | Hyperparameter (ALPHA) |       LOG LOSS      | Data Points |
+------------+---------------------+------------------------+---------------------+-------------+
|   Tfidf    | Logistic Regression |          0.01          |  0.614065123886705  |    400000   |
|   Tfidf    |      Linear SVM     |           1            |  0.5886888763223536 |    400000   |
+------------+---------------------+------------------------+---------------------+-------------+
```

TFIDF weighted W2V (100k datapoints) gave better performance than TFIDF Vectorizer (400k datapoints).