Bamwani@gmail.com_20.5_TFIDF_and _Models

May 12, 2019

1 3. Featurizing text data with tfidf vectorizer

```
In [40]: import os
         import numpy as np
         import pandas as pd
         import seaborn as sns
         from tqdm import tqdm_notebook as tqdm
         import matplotlib.pyplot as plt
         %matplotlib inline

         import warnings
         warnings.filterwarnings('ignore')

         from sklearn.feature_extraction.text import CountVectorizer, TfidfVectorizer
         from sklearn.linear_model import SGDClassifier
         from sklearn.calibration import CalibratedClassifierCV
         from sklearn.metrics import log_loss, confusion_matrix, accuracy_score
```

1.1 3.1. Loading data

1.1.1 3.1.1. Loading raw data

```
In [41]: df = pd.read_csv("train.csv")
         df = df.fillna("")

In [42]: df.columns

Out[42]: Index(['id', 'qid1', 'qid2', 'question1', 'question2', 'is_duplicate'], dtype='object

In [43]: #avoid decoding problem
         df["question1"] = df['question1'].apply(lambda x: str(x))
         df["question2"] = df['question2'].apply(lambda x: str(x))

In [44]: df.head()

Out[44]:    id  qid1  qid2                                                question1  \
         0   0     1     2  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...
```

```
2   2     5     6  How can I increase the speed of my internet co...
3   3     7     8  Why am I mentally very lonely? How can I solve...
4   4     9    10  Which one dissolve in water quikly sugar, salt...

                                              question2  is_duplicate
0  What is the step by step guide to invest in sh...             0
1  What would happen if the Indian government sto...             0
2  How can Internet speed be increased by hacking...             0
3  Find the remainder when [math]23^{24}[/math] i...             0
4             Which fish would survive in salt water?             0
```

1.2 3.1.2 Loading preprocessed data

In [45]:
```
#prepro_features_train.csv (Simple Preprocessing Feartures)
#nlp_features_train.csv (NLP Features)
if os.path.isfile('nlp_features_train.csv'):
    df_nlp = pd.read_csv("nlp_features_train.csv",encoding='latin-1')
else:
    print("run previous notebook")

if os.path.isfile('df_fe_without_preprocessing_train.csv'):
    df_ppro = pd.read_csv("df_fe_without_preprocessing_train.csv",encoding='latin-1')
else:
    print("run previous notebook")
```

In [46]:
```
df_nlp.head(3)
```

Out[46]:
```
   id  qid1  qid2                                          question1  \
0   0     1     2  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...
2   2     5     6  how can i increase the speed of my internet co...

                                          question2  is_duplicate   cwc_min  \
0  what is the step by step guide to invest in sh...             0  0.999980
1  what would happen if the indian government sto...             0  0.799984
2  how can internet speed be increased by hacking...             0  0.399992

    cwc_max   csc_min   csc_max  ...   ctc_max  last_word_eq  first_word_eq  \
0  0.833319  0.999983  0.999983  ...  0.785709           0.0            1.0
1  0.399996  0.749981  0.599988  ...  0.466664           0.0            1.0
2  0.333328  0.399992  0.249997  ...  0.285712           0.0            1.0

   abs_len_diff  mean_len  token_set_ratio  token_sort_ratio  fuzz_ratio  \
0           2.0      13.0              100                93          93
1           5.0      12.5               86                63          66
2           4.0      12.0               66                66          54

   fuzz_partial_ratio  longest_substr_ratio
```

```
0                 100              0.982759
1                  75              0.596154
2                  54              0.166667

[3 rows x 21 columns]
```

```
In [47]: df_ppro.head(3)
```

Out[47]:

	id	qid1	qid2	question1	question2	is_duplicate	freq_qid1	freq_qid2	q1len	q2len	q1_n_words	q2_n_words	diff_of_word_count	word_Common	word_Total	word_share	freq_q1+q2	freq_q1-q2	single_word
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	2	10.0	23.0	0.434783	2	0	False
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	-5	4.0	20.0	0.200000	5	3	False
2	2	5	6	How can I increase the speed of my internet co...	How can Internet speed be increased by hacking...	0	1	1	73	59	14	10	4	4.0	24.0	0.166667	2	0	False

```
In [48]: df1 = df_nlp.drop(['qid1','qid2','question1','question2'],axis=1)
         df2 = df_ppro.drop(['qid1','qid2','question1','question2','is_duplicate'],axis=1)
```

```
In [49]: print("Advanced engineered features : ")
         df1.head(3)
```

```
Advanced engineered features :
```

Out[49]:

	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
0	0	0	0.999980	0.833319	0.999983	0.999983	0.916659	0.785709	0.0	1.0	2.0	13.0	100	93	93	100
1	1	0	0.799984	0.399996	0.749981	0.599988	0.699993	0.466664	0.0	1.0	5.0	12.5				
2	2	0	0.399992	0.333328	0.399992	0.249997	0.399996	0.285712	0.0	1.0	4.0	12.0				

```
1               86                 63          66                   75
2               66                 66          54                   54

   longest_substr_ratio
0              0.982759
1              0.596154
2              0.166667
```

```
In [50]: print("Basic engineered features : ")
         df2.head(3)
```

```
Basic engineered features :
```

```
Out[50]:    id  freq_qid1  freq_qid2  q1len  q2len  q1_n_words  q2_n_words  \
         0   0          1          1     66     57          14          12
         1   1          4          1     51     88           8          13
         2   2          1          1     73     59          14          10

            diff_of_word_count  word_Common  word_Total  word_share  freq_q1+q2  \
         0                   2         10.0        23.0    0.434783           2
         1                  -5          4.0        20.0    0.200000           5
         2                   4          4.0        24.0    0.166667           2

            freq_q1-q2  single_word
         0           0        False
         1           3        False
         2           0        False
```

```
In [51]: #merging both basic & advanced engineered features in a one df.
         df_features = df1.merge(df2, how='left', on='id')
```

```
In [52]: df_features.head(3)
```

```
Out[52]:    id  is_duplicate   cwc_min   cwc_max   csc_min   csc_max   ctc_min  \
         0   0             0  0.999980  0.833319  0.999983  0.999983  0.916659
         1   1             0  0.799984  0.399996  0.749981  0.599988  0.699993
         2   2             0  0.399992  0.333328  0.399992  0.249997  0.399996

             ctc_max  last_word_eq  first_word_eq  ...  q2len  q1_n_words  q2_n_words  \
         0  0.785709           0.0            1.0  ...     57          14          12
         1  0.466664           0.0            1.0  ...     88           8          13
         2  0.285712           0.0            1.0  ...     59          14          10

            diff_of_word_count  word_Common  word_Total  word_share  freq_q1+q2  \
         0                   2         10.0        23.0    0.434783           2
         1                  -5          4.0        20.0    0.200000           5
         2                   4          4.0        24.0    0.166667           2
```

```
   freq_q1-q2  single_word
0           0        False
1           3        False
2           0        False

[3 rows x 30 columns]
```

```
In [53]: df_features.shape
```

```
Out[53]: (404290, 30)
```

```
In [54]: df_features_main = df_features
```

```
In [55]: df_features["question1"] = df["question1"]
         df_features["question2"] = df["question2"]
```

```
In [56]: df_features.shape
```

```
Out[56]: (404290, 32)
```

```
In [57]: #saving "is_duplicate" column separately.
         result_class = df_features["is_duplicate"]

         #dropping columns 'id' & 'is_duplicate'
         df_features.drop(['id', 'is_duplicate'], axis=1, inplace=True)
```

```
In [58]: df_features.shape
```

```
Out[58]: (404290, 30)
```

```
In [59]: result_class.shape
```

```
Out[59]: (404290,)
```

1.3 3.2. Splitting data into train & test

```
In [60]: #splitting the dataset into train and test set
         #train: 70%
         #test : 30%
         from sklearn.model_selection import train_test_split
         X_train, X_test, Y_train, Y_test = train_test_split(df_features, result_class, random
```

```
In [61]: print("shape of X train set :", X_train.shape)
         print("shape of X test set :", X_test.shape)
         print("shape of Y train set :", Y_train.shape)
         print("shape of Y test set :", Y_test.shape)
```

```
shape of X train set : (283003, 30)
shape of X test set : (121287, 30)
shape of Y train set : (283003,)
shape of Y test set : (121287,)
```

1.4 3.3. Featurizing the data using tfidf vectorizer

In [62]:
```
#collecting all the question available in train set for creating tfidf dictionary
questions_in_train = list(X_train['question1'] + X_train['question2'])

#initializing tfidf vectorizer
tfidf = TfidfVectorizer(ngram_range=(1,3), min_df=10)
tfidf.fit(questions_in_train)
```

Out[62]:
```
TfidfVectorizer(analyzer='word', binary=False, decode_error='strict',
        dtype=<class 'numpy.float64'>, encoding='utf-8', input='content',
        lowercase=True, max_df=1.0, max_features=None, min_df=10,
        ngram_range=(1, 3), norm='l2', preprocessor=None, smooth_idf=True,
        stop_words=None, strip_accents=None, sublinear_tf=False,
        token_pattern='(?u)\\b\\w\\w+\\b', tokenizer=None, use_idf=True,
        vocabulary=None)
```

In [63]:
```
#create a tfidf vector for questions in train and test

train_q1 = tfidf.transform(X_train["question1"])
train_q2 = tfidf.transform(X_train["question2"])

testq1 = tfidf.transform(X_test["question1"])
testq2 = tfidf.transform(X_test["question2"])
```

In [64]:
```
train_q1.shape
```

Out[64]:
```
(283003, 121863)
```

In [65]:
```
testq1.shape
```

Out[65]:
```
(121287, 121863)
```

In [66]:
```
# stacking the sparse matrices
from scipy.sparse import hstack
train_stacked_q12 = hstack((train_q1, train_q2))
test_stacked_q12 = hstack((testq1, testq2))
```

In [67]:
```
train_stacked_q12.shape
```

Out[67]:
```
(283003, 243726)
```

In [68]:
```
test_stacked_q12.shape
```

Out[68]:
```
(121287, 243726)
```

In [69]:
```
for features in X_train.columns.values:
    print(features)
```

```
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
diff_of_word_count
word_Common
word_Total
word_share
freq_q1+q2
freq_q1-q2
single_word
question1
question2
```

```
In [70]: X_train.drop(['question1', 'question2'], axis=1, inplace=True)
         X_test.drop(['question1', 'question2'], axis=1, inplace=True)
```

```
In [71]: # stacking the engineered features dataframe with tfidf sparse matrix for both train
         X_train = hstack((X_train.astype(float), train_stacked_q12))
         X_test = hstack((X_test.astype(float), test_stacked_q12))
```

```
In [72]: #converting to compressed row format.
         X_train = X_train.tocsr()
         X_test = X_test.tocsr()
```

```
In [73]: X_train.shape
```

```
Out[73]: (283003, 243754)
```

```
In [74]: X_test.shape
```

```
Out[74]: (121287, 243754)
```

1.5 3.4. Machine Learning Models

In [75]:
```
# This function plots the confusion matrices given y_i, y_i_hat.
def plot_confusion_matrix(Y_test, Y_predict):
    C = confusion_matrix(Y_test, Y_predict)
    # C = 9,9 matrix, each cell (i,j) represents number of points of class i are pred

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

    # 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
    # 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
    # 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=
    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=
    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=l
            plt.xlabel('Predicted Class')
            plt.ylabel('Original Class')
            plt.title("Recall matrix")

            plt.show()
```

In [76]:
```
result = []
```

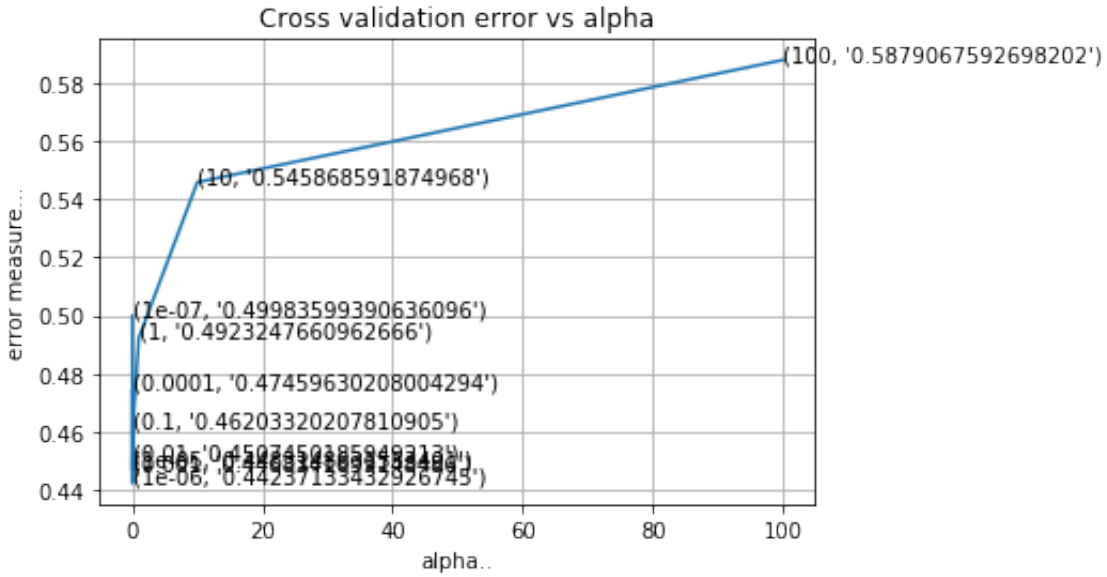
1.5.1 3.4.1 Logistic Regression

3.4.1.1 Hyperparameter tuning

In [77]:
```
alpha = [10**x for x in range(-7,3)] #hyperparameter for SGDClassifier
cv_log_error = []

for i in alpha:
    clf = SGDClassifier(loss='log', alpha=i, n_jobs=-1)
    clf.fit(X_train, Y_train)

    sig_clf = CalibratedClassifierCV(clf)
    sig_clf.fit(X_train, Y_train)
    sig_clf_probs = sig_clf.predict_proba(X_test)

    cv_log_error.append(log_loss(Y_test, sig_clf_probs, eps=1e-15, labels=clf.classes_
    print("for alpha values = {}, Log-loss is {}".format(i, log_loss(Y_test, sig_clf_p

#plotting the error vs alpha.
fig, ax = plt.subplots()
ax.plot(alpha, cv_log_error)
for i, txt in enumerate(cv_log_error):
    ax.annotate((alpha[i], str(txt)),(alpha[i], cv_log_error[i]))

plt.title("Cross validation error vs alpha")
plt.xlabel("alpha..")
plt.ylabel("error measure...")
plt.grid()
plt.show()
```

```
for alpha values = 1e-07, Log-loss is 0.49983599390636096
for alpha values = 1e-06, Log-loss is 0.44237133432926745
for alpha values = 1e-05, Log-loss is 0.4483148631553401
for alpha values = 0.0001, Log-loss is 0.47459630208004294
for alpha values = 0.001, Log-loss is 0.4468341699148486
for alpha values = 0.01, Log-loss is 0.4507450185949213
for alpha values = 0.1, Log-loss is 0.46203320207810905
for alpha values = 1, Log-loss is 0.4923247660962666
```

```
for alpha values = 10, Log-loss is 0.545868591874968
for alpha values = 100, Log-loss is 0.5879067592698202
```

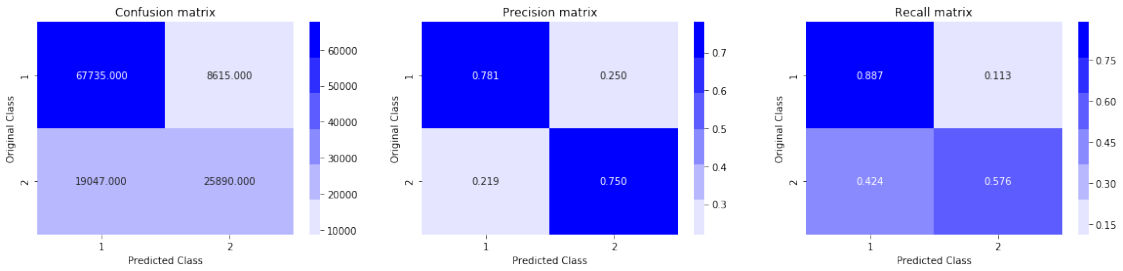


3.4.1.2 Logistic Regression model using tuned parameters

```
In [79]: best_alpha = alpha[np.argmin(cv_log_error)]
         clf = SGDClassifier(alpha=best_alpha, loss='log', n_jobs=-1)
         clf.fit(X_train, Y_train)

         sig_clf = CalibratedClassifierCV(clf)
         sig_clf.fit(X_train, Y_train)

         Y_predict = sig_clf.predict_proba(X_train)
         print("for optimal alpha values = {}, Train log-loss is {}".format(best_alpha, log_los

         Y_predict = sig_clf.predict_proba(X_test)
         print("for optimal alpha values = {}, Test log-loss is {}".format(best_alpha, log_loss

         log_loss_LR = log_loss(Y_test,Y_predict)

         result.append(('Logistic Regression', log_loss(Y_test, Y_predict, eps=1e-15, labels=cl

         Y_predicted =np.argmax(Y_predict,axis=1)
         print("Total number of data points :", len(Y_predicted))
         plot_confusion_matrix(Y_test, Y_predicted)
```

```
for optimal alpha values = 1e-06, Train log-loss is 0.4460278866870911
for optimal alpha values = 1e-06, Test log-loss is 0.44645368306547223
```

```
Total number of data points : 121287
```



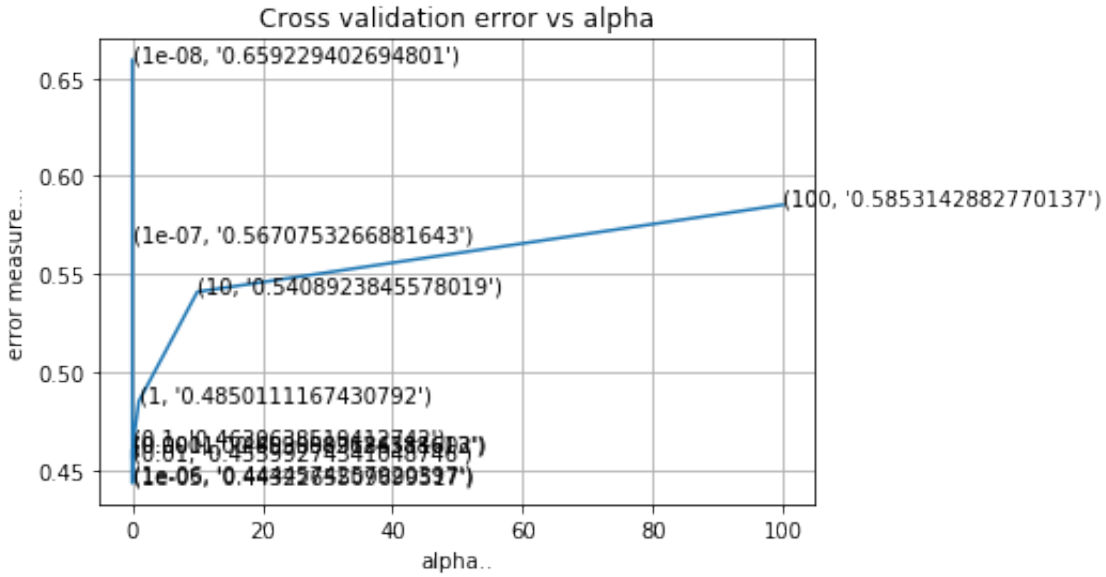
1.5.2 3.4.2 Linear SVM

3.4.2.1 Hyperparameter tuning

```
In [80]: alpha = [10**x for x in range(-8,3)] #hyperparameter for SGDClassifier
         cv_log_error = []

         for i in alpha:
             clf = SGDClassifier(loss='hinge', alpha=i, n_jobs=-1)
             clf.fit(X_train, Y_train)

             sig_clf = CalibratedClassifierCV(clf)
             sig_clf.fit(X_train, Y_train)
             sig_clf_probs = sig_clf.predict_proba(X_test)

             cv_log_error.append(log_loss(Y_test, sig_clf_probs, eps=1e-15, labels=clf.classes
             print("for alpha values = {}, Log-loss is {}".format(i, log_loss(Y_test, sig_clf_

         #plotting the error vs alpha.
         fig, ax = plt.subplots()
         ax.plot(alpha, cv_log_error)
         for i, txt in enumerate(cv_log_error):
             ax.annotate((alpha[i], str(txt)),(alpha[i], cv_log_error[i]))

         plt.title("Cross validation error vs alpha")
         plt.xlabel("alpha..")
         plt.ylabel("error measure...")
         plt.grid()
         plt.show()
```

```
for alpha values = 1e-08, Log-loss is 0.659229402694801
for alpha values = 1e-07, Log-loss is 0.5670753266881643
for alpha values = 1e-06, Log-loss is 0.4444574257920397
for alpha values = 1e-05, Log-loss is 0.4432265509699517
```

```
for alpha values = 0.0001, Log-loss is 0.4595509186511602
for alpha values = 0.001, Log-loss is 0.46030082624388613
for alpha values = 0.01, Log-loss is 0.45599274341048746
for alpha values = 0.1, Log-loss is 0.4630638519412742
for alpha values = 1, Log-loss is 0.4850111167430792
for alpha values = 10, Log-loss is 0.5408923845578019
for alpha values = 100, Log-loss is 0.5853142882770137
```

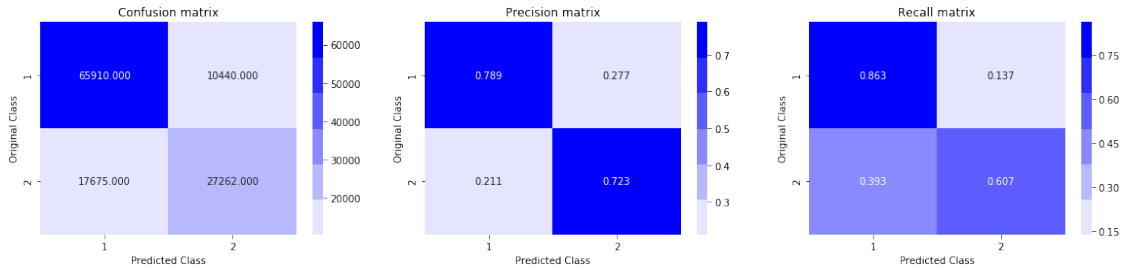


3.4.2.2 Linear SVM model using tuned parameters

```
In [81]: best_alpha = alpha[np.argmin(cv_log_error)]
         clf = SGDClassifier(alpha=best_alpha, loss='log', n_jobs=-1)
         clf.fit(X_train, Y_train)

         sig_clf = CalibratedClassifierCV(clf)
         sig_clf.fit(X_train, Y_train)

         Y_predict = sig_clf.predict_proba(X_train)
         print("for optimal alpha values = {}, Train log-loss is {}".format(best_alpha, log_los

         Y_predict = sig_clf.predict_proba(X_test)
         print("for optimal alpha values = {}, Test log-loss is {}".format(best_alpha, log_loss

         log_loss_SVM = log_loss(Y_test,Y_predict)

         result.append(('SVM', log_loss(Y_test, Y_predict, eps=1e-15, labels=clf.classes_)))
```

```
        Y_predicted =np.argmax(Y_predict,axis=1)
        print("Total number of data points :", len(Y_predicted))
        plot_confusion_matrix(Y_test, Y_predicted)
```

```
for optimal alpha values = 1e-05, Train log-loss is 0.4432615357644263
for optimal alpha values = 1e-05, Test log-loss is 0.4448263277723572
Total number of data points : 121287
```



1.6 Conclusion

```
In [83]: from prettytable import PrettyTable
         conclusion_table = PrettyTable()
         conclusion_table.field_names = ["Model", "Log-loss"]
         conclusion_table.add_row(["Logistic Regression", np.round(log_loss_LR,4)])
         conclusion_table.add_row(["Linear SVM", np.round(log_loss_SVM,4)])

         print(conclusion_table)
```

```
+---------------------+----------+
|        Model        | Log-loss |
+---------------------+----------+
| Logistic Regression |  0.4465  |
|      Linear SVM     |  0.4448  |
+---------------------+----------+
```

Conclusion: 1. TFIDF W2V gives slightly bettter results than simple TFIDF featurization.