In [1]:

```
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
```

4. Machine Learning Models

In [3]:

```
# remove the first row
data_xgboost = pd.read_csv(r"D:\AppliedAI\Homework-n-Assignments\# 20
Quora\final_features_old.csv")
data_xgboost = data_xgboost.head(80000)
data_xgboost.drop(data_xgboost.index[0], inplace=True)
y_true_xgboost = data_xgboost['is_duplicate']
data_xgboost.drop(['Unnamed: 0', 'id','is_duplicate'], axis=1, inplace=True)
```

In [4]:

```
print (data_xgboost.shape)
data_xgboost.head()
```

```
(79999, 794)
```

Out[4]:

	cwc_min	cwc_max	csc_min	csc_max	ctc_min	ctc_max	last_word_eq	first_word_eq	abs_len_diff	mean_len	...	
1	0.799984	0.399996	0.749981	0.599988	0.699993	0.466664	0.0	1.0	5.0	12.5	...	-4.9
2	0.399992	0.333328	0.399992	0.249997	0.399996	0.285712	0.0	1.0	4.0	12.0	...	8.3
3	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.0	0.0	2.0	12.0	...	3.3
4	0.399992	0.199998	0.999950	0.666644	0.571420	0.307690	0.0	1.0	6.0	10.0	...	-2.4
5	0.666656	0.571420	0.888879	0.799992	0.705878	0.705878	1.0	0.0	0.0	17.0	...	10.

5 rows × 794 columns

4.2 Converting strings to numerics

In [ ]:

```
# after we read from sql table each entry was read it as a string
# we convert all the features into numaric before we apply any model
cols = list(data.columns)
for i in cols:
    data[i] = data[i].apply(pd.to_numeric)
    print(i)
```

In [5]:

```
# https://stackoverflow.com/questions/7368789/convert-all-strings-in-a-list-to-int
y_true_xgboost = list(map(int, y_true_xgboost))
print (len(y_true_xgboost))
```

```
79999
```

4.3 Random train test split(70:30)

In [6]:

```
X_train_xgboost,X_test_xgboost, y_train_xgboost, y_test_xgboost = train_test_split(data_xgboost, y_
true_xgboost, stratify=y_true_xgboost, test_size=0.3)
```

In [6]:

```
print("Number of data points in train data for XGBoost setup :",X_train_xgboost.shape)
print("Number of data points in test data for XGBoost setup:",X_test_xgboost.shape)
```

```
Number of data points in train data for XGBoost setup : (55999, 794)
Number of data points in test data for XGBoost setup: (24000, 794)
```

In [7]:

```
print("-"*10, "Distribution of output variable in train data for xgboost setup", "-"*10)
train_distr_xgboost = Counter(y_train_xgboost)
train_len_xgboost = len(y_train_xgboost)
print("Class 0: ",int(train_distr_xgboost[0])/train_len_xgboost,"Class 1: ", int(train_distr_xgboos
t[1])/train_len_xgboost)
print("-"*10, "Distribution of output variable in train data for xgboost setup", "-"*10)
test_distr_xgboost = Counter(y_test_xgboost)
test_len_xgboost = len(y_test_xgboost)
print("Class 0: ",int(test_distr_xgboost[1])/test_len_xgboost, "Class 1: ",int(test_distr_xgboost[1
])/test_len_xgboost)
```

```
---------- Distribution of output variable in train data for xgboost setup ----------
```

```
Class 0:  0.6274754906337613 Class 1:  0.3725245093662387
---------- Distribution of output variable in train data for xgboost setup ----------
Class 0:  0.37254166666666666 Class 1:  0.37254166666666666
```

In [8]:

```
# 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 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)
    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()
```

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

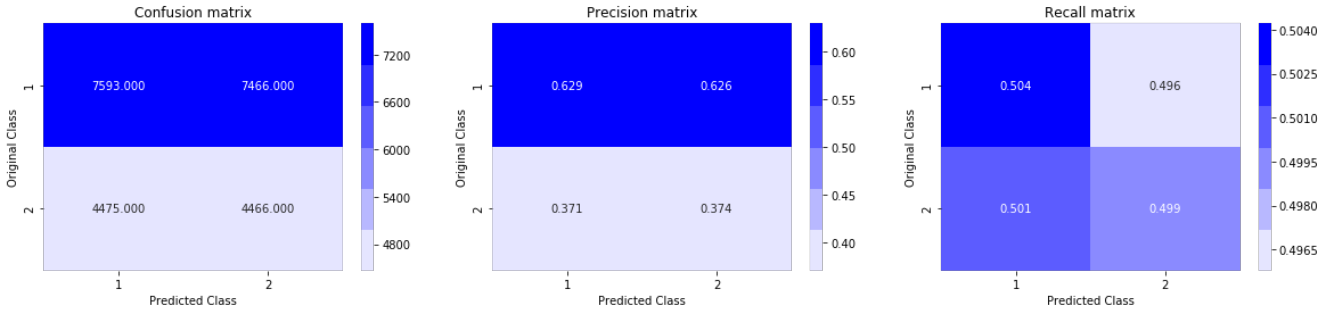
In [9]:

```
# 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_xgboost = np.zeros((test_len_xgboost,2))
for i in range(test_len_xgboost):
```

```
    rand_probs_xgboost = np.random.rand(1,2)
    predicted_y_xgboost[i] = ((rand_probs_xgboost/sum(sum(rand_probs_xgboost)))[0])
print("Log loss on Test Data using Random Model",log_loss(y_test_xgboost, predicted_y_xgboost, eps
=1e-15))

predicted_y_xgboost =np.argmax(predicted_y_xgboost, axis=1)
plot_confusion_matrix(y_test_xgboost, predicted_y_xgboost)
```

```
Log loss on Test Data using Random Model 0.8909061016014086
```



4.6 XGBoost

In [12]:

```
from xgboost import XGBClassifier

from scipy.stats import uniform, randint
from sklearn.model_selection import cross_val_score, GridSearchCV, KFold, RandomizedSearchCV,
train_test_split
import warnings
warnings.filterwarnings("ignore")


XGB = XGBClassifier(booster='gbtree',objective = 'binary:logistic',eval_metric= 'logloss')

param_grid = {'max_depth':[1,3,5,7,9],'n_estimators':[50,100,200,300,500]}
xgboost_GBDT = RandomizedSearchCV(XGB,param_grid,cv=3, verbose=2)
xgboost_GBDT.fit(X_train_xgboost,y_train_xgboost)
xgboost_GBDT.best_params_
```

```
Fitting 3 folds for each of 10 candidates, totalling 30 fits
[CV] n_estimators=500, max_depth=7 ...................................

[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.

[CV] ..................... n_estimators=500, max_depth=7, total=43.1min
[CV] n_estimators=500, max_depth=7 ...................................

[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed: 43.1min remaining:    0.0s

[CV] ..................... n_estimators=500, max_depth=7, total=44.6min
[CV] n_estimators=500, max_depth=7 ...................................
[CV] ..................... n_estimators=500, max_depth=7, total=43.9min
[CV] n_estimators=100, max_depth=5 ...................................
[CV] ..................... n_estimators=100, max_depth=5, total= 6.3min
[CV] n_estimators=100, max_depth=5 ...................................
[CV] ..................... n_estimators=100, max_depth=5, total= 6.3min
[CV] n_estimators=100, max_depth=5 ...................................
[CV] ..................... n_estimators=100, max_depth=5, total= 6.3min
[CV] n_estimators=200, max_depth=7 ...................................
[CV] ..................... n_estimators=200, max_depth=7, total=17.4min
[CV] n_estimators=200, max_depth=7 ...................................
[CV] ..................... n_estimators=200, max_depth=7, total=17.7min
[CV] n_estimators=200, max_depth=7 ...................................
[CV] ..................... n_estimators=200, max_depth=7, total=18.6min
[CV] n_estimators=500, max_depth=3 ...................................
[CV] ..................... n_estimators=500, max_depth=3, total=19.0min
[CV] n_estimators=500, max_depth=3 ...................................
[CV] ..................... n_estimators=500, max_depth=3, total=19.4min
```

```
[CV] n_estimators=500, max_depth=3 ....................................
[CV] ..................... n_estimators=500, max_depth=3, total=19.4min
[CV] n_estimators=200, max_depth=9 ....................................
[CV] ..................... n_estimators=200, max_depth=9, total=22.9min
[CV] n_estimators=200, max_depth=9 ....................................
[CV] ..................... n_estimators=200, max_depth=9, total=22.7min
[CV] n_estimators=200, max_depth=9 ....................................
[CV] ..................... n_estimators=200, max_depth=9, total=22.6min
[CV] n_estimators=300, max_depth=9 ....................................
[CV] ..................... n_estimators=300, max_depth=9, total=33.0min
[CV] n_estimators=300, max_depth=9 ....................................
[CV] ..................... n_estimators=300, max_depth=9, total=33.3min
[CV] n_estimators=300, max_depth=9 ....................................
[CV] ..................... n_estimators=300, max_depth=9, total=33.4min
[CV] n_estimators=300, max_depth=1 ....................................
[CV] ..................... n_estimators=300, max_depth=1, total= 4.7min
[CV] n_estimators=300, max_depth=1 ....................................
[CV] ..................... n_estimators=300, max_depth=1, total= 4.7min
[CV] n_estimators=300, max_depth=1 ....................................
[CV] ..................... n_estimators=300, max_depth=1, total= 4.7min
[CV] n_estimators=50, max_depth=1 .....................................
[CV] ...................... n_estimators=50, max_depth=1, total=  51.6s
[CV] n_estimators=50, max_depth=1 .....................................
[CV] ...................... n_estimators=50, max_depth=1, total=  51.5s
[CV] n_estimators=50, max_depth=1 .....................................
[CV] ...................... n_estimators=50, max_depth=1, total=  51.8s
[CV] n_estimators=300, max_depth=7 ....................................
[CV] ..................... n_estimators=300, max_depth=7, total=26.4min
[CV] n_estimators=300, max_depth=7 ....................................
[CV] ..................... n_estimators=300, max_depth=7, total=26.8min
[CV] n_estimators=300, max_depth=7 ....................................
[CV] ..................... n_estimators=300, max_depth=7, total=26.8min
[CV] n_estimators=300, max_depth=3 ....................................
[CV] ..................... n_estimators=300, max_depth=3, total=11.6min
[CV] n_estimators=300, max_depth=3 ....................................
[CV] ..................... n_estimators=300, max_depth=3, total=11.6min
[CV] n_estimators=300, max_depth=3 ....................................
[CV] ..................... n_estimators=300, max_depth=3, total=11.7min

[Parallel(n_jobs=1)]: Done  30 out of  30 | elapsed: 561.6min finished
```

Out[12]:

```
{'n_estimators': 500, 'max_depth': 7}
```

In [9]:

```
from xgboost import XGBClassifier

from scipy.stats import uniform, randint
from sklearn.model_selection import cross_val_score, GridSearchCV, KFold, RandomizedSearchCV,
train_test_split
import warnings

besthyperpara_xgboost = XGBClassifier(booster='gbtree',objective = 'binary:logistic',eval_metric= '
logloss',max_depth=9,n_estimators=500)
besthyperpara_xgboost.fit(X_train_xgboost,y_train_xgboost)
sig_clf = CalibratedClassifierCV(besthyperpara_xgboost, method="sigmoid")
sig_clf.fit(X_train_xgboost, y_train_xgboost)
predict_y_xgboo = sig_clf.predict_proba(X_test_xgboost)
```

In [11]:

```
print (log_loss(y_test_xgboost, predict_y_xgboo, labels=besthyperpara_xgboost.classes_, eps=1e-15))
```

```
0.3644462554369013
```

In [13]:

```
print (type(predict_y_xgboo))
print (predict_y_xgboo.shape)
```

```
<class 'numpy.ndarray'>
```

```
<class 'numpy.ndarray'>
(24000, 2)
```

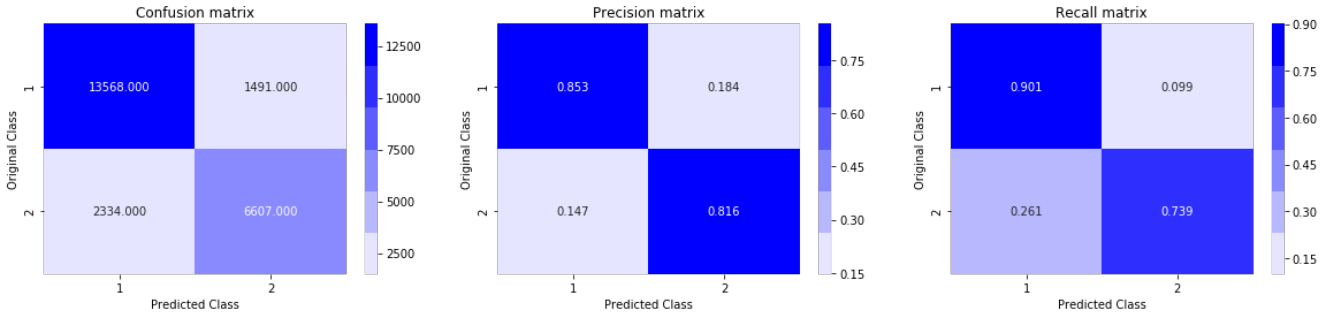
In [16]:

```
predicted_y_xgboo =np.argmax(predict_y_xgboo,axis=1)
print (type(predicted_y_xgboo))
print (predicted_y_xgboo.shape)
```

```
<class 'numpy.ndarray'>
(24000,)
```

In [17]:

```
plot_confusion_matrix(y_test_xgboost, predicted_y_xgboo)
```



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.