

```
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.cross_validation 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
```



C:\Users\brahm\Anaconda3\lib\site-packages\sklearn\cross\_validation.py:41: DeprecationWarning:

## 4. Machine Learning Models

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

```
#Creating db file from csv
if not os.path.isfile('train.db'):
    disk_engine = create_engine('sqlite:///train.db')
    start = dt.datetime.now()
    chunksize = 180000
    j = 0
    index_start = 1
    for df in pd.read_csv('final_features.csv', names=['Unnamed: 0','id','is_duplicate','cwc_']):
        df.index += index_start
        j+=1
        print('{} rows'.format(j*chunksize))
        df.to_sql('data', disk_engine, if_exists='append')
        index_start = df.index[-1] + 1

#http://www.sqlitetutorial.net/sqlite-python/create-tables/
def create_connection(db_file):
    """ create a database connection to the SQLite database
        specified by db_file
    :param db_file: database file
    :return: Connection object or None
    """
    try:
        conn = sqlite3.connect(db_file)
        return conn
    except Error as e:
        print(e)

    return None

def checkTableExists(dbcon):
    cursr = dbcon.cursor()
    str = "select name from sqlite_master where type='table'"
    table_names = cursr.execute(str)
    print("Tables in the database:")
    tables = table_names.fetchall()
    print(tables[0][0])
    return(len(tables))

read_db = 'train.db'
conn_r = create_connection(read_db)
```

```
checkTableExists(conn_r)
conn_r.close()
```

 Tables in the database:  
data

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

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

# remove the first row
data.drop(data.index[0], inplace=True)
y_true = data['is_duplicate']
data.drop(['Unnamed: 0', 'id','index','is_duplicate'], axis=1, inplace=True)
```

```
data.head()
```

	cwc_min	cwc_max	csc_min	csc_max	
1	0.199996000079998	0.166663888935184	0.0	0.0	0.1428551
2	0.399992000159997	0.399992000159997	0.499987500312492	0.499987500312492	0.44443950
3	0.833319444675922	0.714275510349852	0.999983333611106	0.857130612419823	0.68749570
4	0.0	0.0	0.599988000239995	0.499991666805553	0.24999791
5	0.749981250468738	0.749981250468738	0.499987500312492	0.499987500312492	0.62499218

5 rows × 794 columns

## 4.2 Converting strings to numerics

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

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

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

```
X_train,X_test, y_train, y_test = train_test_split(data, y_true, stratify=y_true, test_size=0
```

```
print("Number of data points in train data :",X_train.shape)
print("Number of data points in test data :",X_test.shape)
```

 Number of data points in train data : (70000, 794)  
Number of data points in test data : (30000, 794)

```
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[0])/test_len, "Class 1: ",int(test_distr[1])/test_len)
```

 ----- Distribution of output variable in train data -----
 Class 0: 0.6324857142857143 Class 1: 0.36751428571428574
 ----- Distribution of output variable in train data -----
 Class 0: 0.3675 Class 1: 0.3675

```
# 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 cl

    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 corresponds to columns and axis=1 corresponds to rows in two dia
    # 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 corresponds to columns and axis=1 corresponds to rows in two dia
# C.sum(axix =0) = [[4, 6]]
# (C/C.sum(axis=0)) = [[1/4, 2/6],
#                      [3/4, 4/6]]
plt.figure(figsize=(20,4))

labels = [1,2]
# representing A in heatmap format
cmap=sns.light_palette("blue")
plt.subplot(1, 3, 1)
sns.heatmap(C, annot=True, cmap=cmap, fmt=".3f", xticklabels=labels, yticklabels=labels)
plt.xlabel('Predicted Class')
plt.ylabel('Original Class')
plt.title("Confusion matrix")

plt.subplot(1, 3, 2)
sns.heatmap(B, annot=True, cmap=cmap, fmt=".3f", xticklabels=labels, yticklabels=labels)
plt.xlabel('Predicted Class')
plt.ylabel('Original Class')
plt.title("Precision matrix")

plt.subplot(1, 3, 3)
# representing B in heatmap format
sns.heatmap(A, annot=True, cmap=cmap, fmt=".3f", xticklabels=labels, yticklabels=labels)
plt.xlabel('Predicted Class')
plt.ylabel('Original Class')
plt.title("Recall matrix")

plt.show()

```

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

```

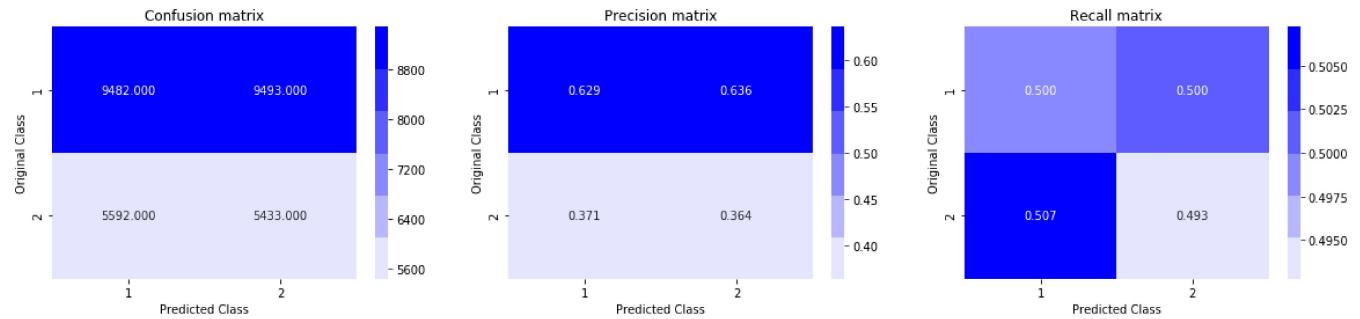
# we need to generate 9 numbers and the sum of numbers should be 1
# one solution is to generate 9 numbers and divide each of the numbers by their sum
# ref: https://stackoverflow.com/a/18662466/4084039
# we create a output array that has exactly same size as the CV data
predicted_y = np.zeros((test_len,2))
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(v test, predicted v)

```



## Log loss on Test Data using Random Model 0.887242646958



## 4.4 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
# -----
# default parameters
# SGDClassifier(loss='hinge', penalty='l2', alpha=0.0001, l1_ratio=0.15, fit_intercept=True,
# shuffle=True, verbose=0, epsilon=0.1, n_jobs=1, random_state=None, learning_rate='optimal',
# 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)
    clf.fit(X_train, y_train)
    sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
    sig_clf.fit(X_train, y_train)
    predict_y = sig_clf.predict_proba(X_test)
    log_error_array.append(log_loss(y_test, predict_y, labels=clf.classes_, eps=1e-15))
    print('For values of alpha = ', i, "The log loss is:",log_loss(y_test, predict_y, labels=clf.classes_))

fig, ax = plt.subplots()

```

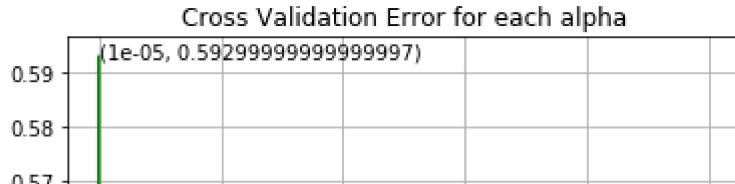
```
ax.plot(alpha, log_error_array,c='g')
for i, txt in enumerate(np.round(log_error_array,3)):
    ax.annotate((alpha[i],np.round(txt,3)), (alpha[i],log_error_array[i]))
plt.grid()
plt.title("Cross Validation Error for each alpha")
plt.xlabel("Alpha i's")
plt.ylabel("Error measure")
plt.show()

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

predict_y = sig_clf.predict_proba(X_train)
print('For values of best alpha = ', alpha[best_alpha], "The train log loss is:",log_loss(y_t
predict_y = sig_clf.predict_proba(X_test)
print('For values of best alpha = ', alpha[best_alpha], "The test log loss is:",log_loss(y_te
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: 0.592800211149
For values of alpha = 0.0001 The log loss is: 0.532351700629
For values of alpha = 0.001 The log loss is: 0.527562275995
For values of alpha = 0.01 The log loss is: 0.534535408885
For values of alpha = 0.1 The log loss is: 0.525117052926
For values of alpha = 1 The log loss is: 0.520035530431
For values of alpha = 10 The log loss is: 0.521097925307
```



## 4.5 Linear SVM with hyperparameter tuning

Back | | | | | | | |

```
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
# -----
# default parameters
# SGDClassifier(loss='hinge', penalty='l2', alpha=0.0001, l1_ratio=0.15, fit_intercept=True,
# shuffle=True, verbose=0, epsilon=0.1, n_jobs=1, random_state=None, learning_rate='optimal',
# 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, y_train)
    sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
    sig_clf.fit(X_train, y_train)
    predict_y = sig_clf.predict_proba(X_test)
    log_error_array.append(log_loss(y_test, predict_y, labels=clf.classes_, eps=1e-15))
    print('For values of alpha = ', i, "The log loss is:",log_loss(y_test, predict_y, labels=
```

```
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("Cross Validation error")
```

```
plt.yticks(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, y_train)
sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
sig_clf.fit(X_train, y_train)

predict_y = sig_clf.predict_proba(X_train)
print('For values of best alpha = ', alpha[best_alpha], "The train log loss is:",log_loss(y_t
predict_y = sig_clf.predict_proba(X_test)
print('For values of best alpha = ', alpha[best_alpha], "The test log loss is:",log_loss(y_te
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: 0.657611721261
For values of alpha = 0.0001 The log loss is: 0.489669093534
For values of alpha = 0.001 The log loss is: 0.521829068562
For values of alpha = 0.01 The log loss is: 0.566295616914
For values of alpha = 0.1 The log loss is: 0.599957866217
For values of alpha = 1 The log loss is: 0.635059427016
```

## 4.6 XGBoost

```
import xgboost as xgb
params = {}
params['objective'] = 'binary:logistic'
params['eval_metric'] = 'logloss'
params['eta'] = 0.02
params['max_depth'] = 4

d_train = xgb.DMatrix(X_train, label=y_train)
d_test = xgb.DMatrix(X_test, label=y_test)

watchlist = [(d_train, 'train'), (d_test, 'valid')]

bst = xgb.train(params, d_train, 400, watchlist, early_stopping_rounds=20, verbose_eval=10)

xgdmat = xgb.DMatrix(X_train,y_train)
predict_y = bst.predict(d_test)
print("The test log loss is:",log_loss(y_test, predict_y, labels=clf.classes_, eps=1e-15))
```



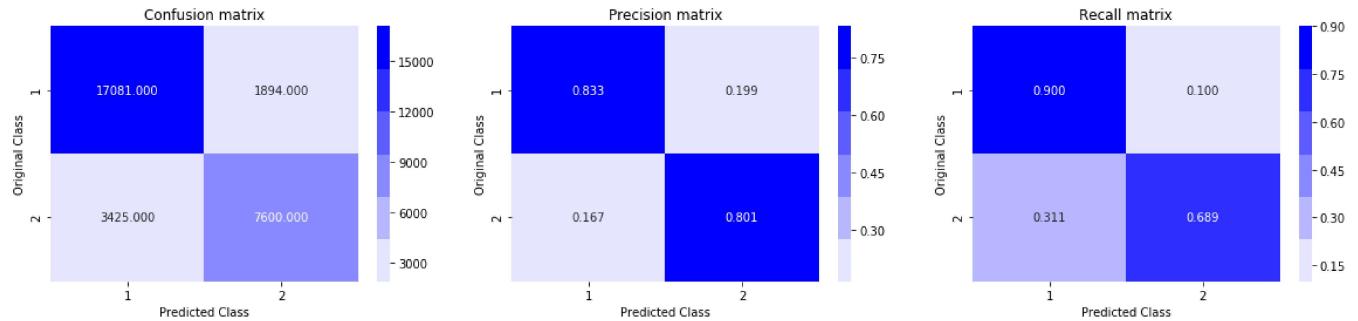
```
[0]      train-logloss:0.684819  valid-logloss:0.684845
Multiple eval metrics have been passed: 'valid-logloss' will be used for early stopping

Will train until valid-logloss hasn't improved in 20 rounds.
[10]     train-logloss:0.61583   valid-logloss:0.616104
[20]     train-logloss:0.564616  valid-logloss:0.565273
[30]     train-logloss:0.525758  valid-logloss:0.52679
[40]     train-logloss:0.496661  valid-logloss:0.498021
[50]     train-logloss:0.473563  valid-logloss:0.475182
[60]     train-logloss:0.455315  valid-logloss:0.457186
[70]     train-logloss:0.440442  valid-logloss:0.442482
[80]     train-logloss:0.428424  valid-logloss:0.430795
[90]     train-logloss:0.418803  valid-logloss:0.421447
[100]    train-logloss:0.41069   valid-logloss:0.413583
[110]    train-logloss:0.403831  valid-logloss:0.40693
[120]    train-logloss:0.398076  valid-logloss:0.401402
[130]    train-logloss:0.393305  valid-logloss:0.396851
[140]    train-logloss:0.38913   valid-logloss:0.392952
[150]    train-logloss:0.385469  valid-logloss:0.389521
[160]    train-logloss:0.385469  valid-logloss:0.389521
```

```
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 : 30000



```
[390]      train-logloss:0.345568  valid-logloss:0.35674
```

## 5. Assignments

1. Try out models (Logistic regression, Linear-SVM) with simple TF-IDF vectors instead of TD\_IDF weighted word2Vec.
2. Perform hyperparameter tuning of XgBoost models using RandomsearchCV with vectorizer as TF-IDF W2V to reduce the log-loss.