Import statements

In [1]:

```
# Operating System
import os

#Pandas and Numpy
import pandas as pd
import numpy as np

#ramdom generator
import random

from sklearn.model_selection import train_test_split

from sklearn.pipeline import Pipeline, FeatureUnion
from sklearn.base import TransformerMixin, BaseEstimator

import category_encoders as ce
from sklearn.preprocessing import KBinsDiscretizer

from sklearn.ensemble import RandomForestClassifier
from sklearn.tree import DecisionTreeClassifier

from sklearn.metrics import precision_score, recall_score, accuracy_score, roc_curve, r
oc_auc_score, classification_report



#Plots
import matplotlib.pyplot as plt
%matplotlib inline

# Statistics
from scipy.stats import binom_test

# Strings
import re
```

Define utility functions

In [2]:

```
def simple_clean(doc, regex_list=[("[\.\?\(\)\|:;_!@/*\-]", " "), (" +", " ")] ):

    # Make sure it is a string!
    doc = str(doc)

    # remove or replace characters
    for regex in regex_list:
        doc = re.sub(regex[0], regex[1], doc)
    # lowercase
    doc = doc.lower()
    # Trim
    doc = doc.strip()
    # tokenize
    #words = tokenizer.tokenize(doc)
    # remove punctuation
    #words = list(filter(lambda x: x not in string.punctuation, words))
    # stem
    #stems = list(map(stemmer.stem, words))
    #new_doc = " ".join(stems)
    new_doc = doc
    return new_doc
```

Load original data

In [3]:

```
#file_path = ".\data\train.csv"
#file_path = os.path.join('data', 'train.csv')
file_path = os.path.join('C:\\Users\\jnpicao\\Documents\\GitHub', 'train.csv')

# Option for reading a sample of the file
# sample 20% of the rows
p = 1

random.seed(178) # this is to get always the same sample. can be removed if we want the
sample to change
try:
    df_original = pd.read_csv(file_path,
                              skiprows = lambda row_num: random.random() > p and row_num
> 0,
                              #nrows = 10000,
                              header=0,
                              warn_bad_lines=True)
except:
    print('Ooops!!! We got an error!')
else:
    # Drop observations correspoding to stops that didn't lead to a search
    df = df_original[df_original.VehicleSearchedIndicator==True].reset_index(drop=True)
.drop(columns='VehicleSearchedIndicator')
```

Train-Test split

In [4]:

```
X_train, X_test, y_train, y_test = train_test_split(df.drop(columns='ContrabandIndicato
r'),
                                                    df['ContrabandIndicator'],
                                                    test_size=0.6,
                                                    random_state=42)
```

Pre-process

Both the train set and the test set will enter this pre-processing to prepare for fits ans transforms:

- Select columns to keep;
- Clean text features;

In [5]:

```
def pre_process_data(df: pd.DataFrame) -> pd.DataFrame:

    """Transforms the original DataFrame to make it suited to enter the workflow.

    Args:
        df (pd.DataFrame):  Original DataFrame, it will be first X_train and then X_tes
t.

    Returns:
        df_new (pd.DataFrame): Transformed DataFrame, ready to enter the workflow.

    TODO:
        * to do list

    """

    columns_to_keep = ['Department Name', 'SubjectAge']
#     columns_to_keep = ['Department Name',
#                        'InterventionReasonCode',
#                        'ResidentIndicator',
#                        'SearchAuthorizationCode',
#                        'StatuteReason',
#                        'SubjectAge',
#                        'SubjectEthnicityCode',
#                        'SubjectRaceCode',
#                        'SubjectSexCode'
#                        ]

    # copy the argument
    df_new = df.copy()

    df_new = df_new[columns_to_keep]

    df_new['Department Name'] = df_new['Department Name'].apply(simple_clean)

    return df_new
```

In [6]:

```
# Initializations

decision_thr = 0.5

ordinalencoder = ce.ordinal.OrdinalEncoder()
binarizer = KBinsDiscretizer(n_bins=10, encode='ordinal', strategy='uniform')
clf = RandomForestClassifier(random_state = 42)


X_train_cln = pre_process_data(X_train)
X_train_cln = ordinalencoder.fit_transform(X_train_cln)
X_train_cln['SubjectAge'] = binarizer.fit_transform(X_train_cln[['SubjectAge']])
clf.fit(X_train_cln, y_train)


X_test_cln = pre_process_data(X_test)
X_test_cln = ordinalencoder.fit_transform(X_test_cln)
X_test_cln['SubjectAge'] = binarizer.fit_transform(X_test_cln[['SubjectAge']])
#y_pred = clf.predict(X_test_cln)
y_prob = clf.predict_proba(X_test_cln)[:,1]
y_pred = y_prob > decision_thr
```

```
C:\Users\jnpicao\AppData\Local\Continuum\anaconda3\lib\site-packages\sklea
rn\ensemble\forest.py:246: FutureWarning: The default value of n_estimator
s will change from 10 in version 0.20 to 100 in 0.22.
  "10 in version 0.20 to 100 in 0.22.", FutureWarning)
```

In [7]:

```
clf.decision_path(X_train_cln)
```

Out[7]:

```
(<30697x11534 sparse matrix of type '<class 'numpy.int64'>'
        with 3583847 stored elements in Compressed Sparse Row format>,
 array([    0,  1131,  2282,  3451,  4618,  5761,  6908,  8081,  9218,
        10381, 11534], dtype=int32))
```

In [8]:

```
X_train_cln.shape
```

Out[8]:

```
(30697, 2)
```

In [9]:

```
y_pred
```

Out[9]:

```
array([False, False, False, ..., False,  True, False])
```

In [10]:

```
precision_score(y_test, y_pred)
```

Out[10]:

```
0.565959952885748
```

In [11]:

```
recall_score(y_test, y_pred)
```

Out[11]:

```
0.3123781042777272
```

In [12]:

```
accuracy_score(y_test, y_pred)
```

Out[12]:

```
0.6902662554836468
```

In [13]:

```
fpr, tpr, thresholds = roc_curve(y_true=y_test, y_score=y_prob)
AUROC = roc_auc_score(y_true=y_test, y_score=y_prob)*100
```

In [14]:

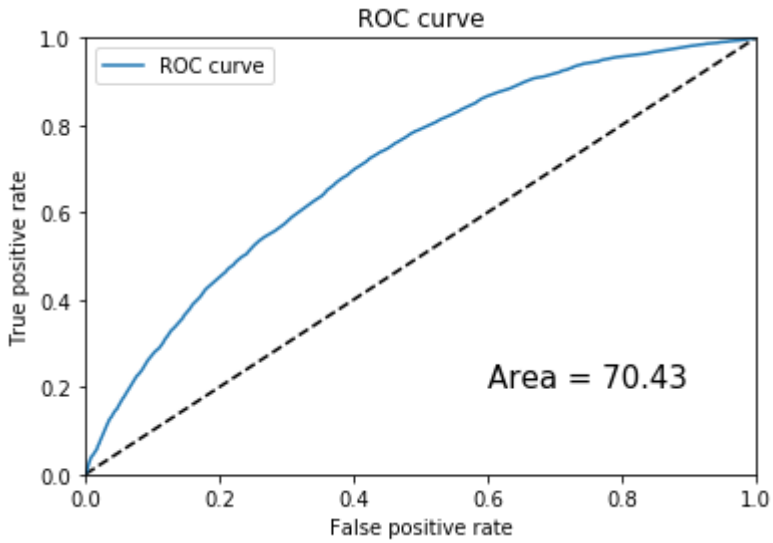
```
roc_auc_score(y_true=y_test, y_score=y_prob)
```

Out[14]:

```
0.7042873232553369
```

In [36]:

```
plt.figure(1)
plt.plot([0, 1], [0, 1], 'k--')
plt.plot(fpr, tpr, label='ROC curve')

plt.xlabel('False positive rate')
plt.ylabel('True positive rate')
plt.title('ROC curve')

plt.xlim(0, 1)
plt.ylim(0, 1)

plt.text(0.6, 0.2, "Area = {}".format(round(AUROC,2)), dict(size=15))

plt.legend(loc='best')
plt.show()
```



In [16]:

```
print(classification_report(y_test, y_pred))
```

```
              precision    recall  f1-score   support

       False       0.72      0.88      0.79     30664
        True       0.57      0.31      0.40     15382

   micro avg       0.69      0.69      0.69     46046
   macro avg       0.64      0.60      0.60     46046
weighted avg       0.67      0.69      0.66     46046
```

In [17]:

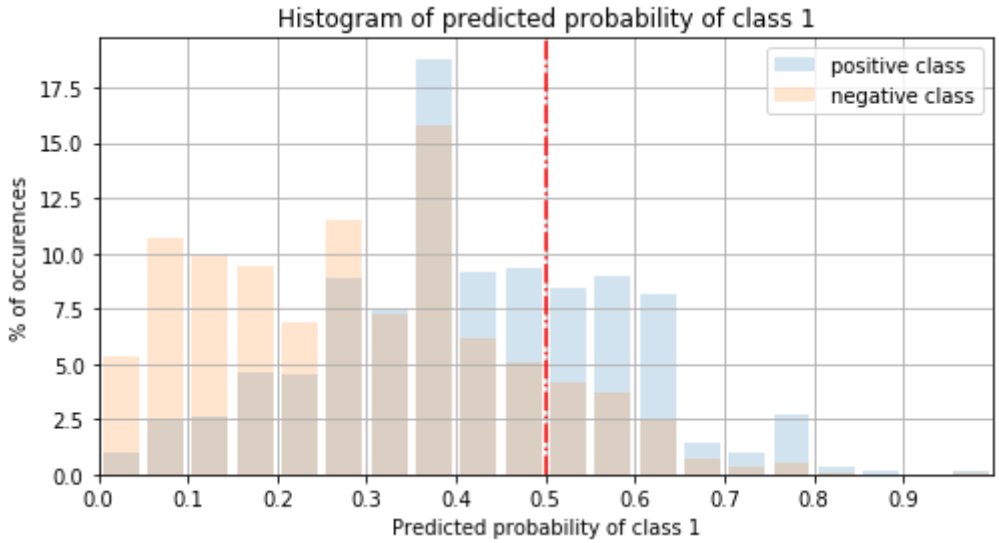
```
df_results = y_test.to_frame(name='y_true')
df_results['y_pred'] = y_pred
df_results['y_prob'] = y_prob
df_results.head()
```

Out[17]:

	y_true	y_pred	y_prob
30717	False	False	0.417500
44889	True	False	0.461068
13938	False	False	0.293258
20220	False	False	0.365724
21837	True	False	0.236796

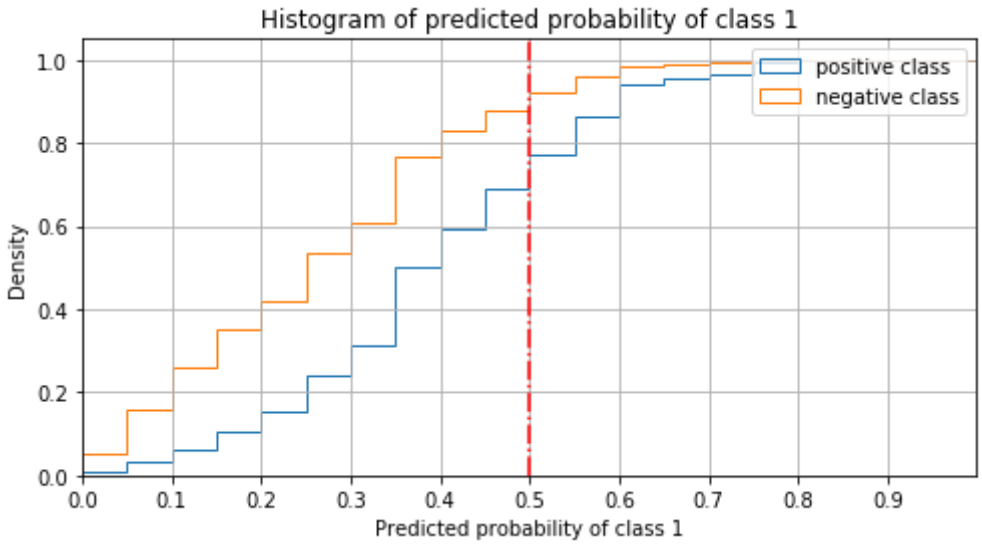
In [18]:

```
n_trues = df_results[df_results.y_true==True].shape[0]
n_falses = df_results[df_results.y_true==False].shape[0]

plt.figure(figsize=(8,4))
df_results[df_results.y_true==True].y_prob.hist(bins=20, weights=np.ones(n_trues)/n_tru
es*100, align='mid', rwidth=0.8, alpha=0.2, label='positive class')
df_results[df_results.y_true==False].y_prob.hist(bins=20, weights=np.ones(n_falses)/n_f
alses*100, align='mid', rwidth=0.8, alpha=0.2, label='negative class')

plt.axvline(x=decision_thr, color='r', linestyle='-.')

plt.title('Histogram of predicted probability of class 1')
plt.xlabel("Predicted probability of class 1")
plt.ylabel("% of occurences")

plt.xlim(0,1)
plt.xticks(np.arange(0, 1, step=0.1))

plt.legend();
```



In [19]:

```
df_results[df_results.y_true==True].y_prob.hist(bins=20, figsize=(8,4), histtype='step'
,label='positive class', density=True, cumulative=True)
df_results[df_results.y_true==False].y_prob.hist(bins=20, figsize=(8,4), histtype='ste
p', label='negative class', density=True, cumulative=True)

plt.axvline(x=decision_thr, color='r', linestyle='-.')

plt.title('Histogram of predicted probability of class 1')
plt.xlabel("Predicted probability of class 1")
plt.ylabel("Density")

plt.xlim(0,1)
plt.xticks(np.arange(0, 1, step=0.1))

plt.legend();
```



In [20]:

```
df_results.set_index('y_prob').y_true
```

Out[20]:

y_prob	
0.417500	False
0.461068	True
0.293258	False
0.365724	False
0.236796	True
0.085835	False
0.000000	False
0.443217	False
0.419935	False
0.631086	True
0.087786	False
0.111245	False
0.494298	True
0.557048	False
0.413515	True
0.000000	False
0.369180	False
0.211717	False
0.508553	False
0.522931	True
0.396144	True
0.271380	False
0.648179	False
0.421760	True
0.541667	False
0.101694	False
0.543150	False
0.148773	False
0.535179	True
0.381724	False
	...
0.570066	True
0.088301	False
0.197346	False
0.138950	False
0.369180	True
0.369180	False
0.117940	True
0.564416	False
0.631086	True
0.278531	False
0.360222	True
0.491664	True
0.570066	True
0.488414	False
0.635456	False
0.334592	True
0.648179	True
0.183335	False
0.278531	False
0.341673	False
0.045911	False
0.394337	False
0.078445	False
0.463421	True
0.535179	True
0.000000	False
0.101694	True

```
0.101694    False
0.564416     True
0.000000     True
Name: y_true, Length: 46046, dtype: bool
```

Predict all `True`

In [21]:

```
y_pred_true = np.ones(y_test.shape).astype(bool)
```

In [22]:

```
precision_score(y_test, y_pred_true)
```

Out[22]:

```
0.3340572471007254
```

In [23]:

```
recall_score(y_test, y_pred_true)
```

Out[23]:

```
1.0
```

In [24]:

```
accuracy_score(y_test, y_pred_true)
```

Out[24]:

```
0.3340572471007254
```

Predict all `False`

In [25]:

```
y_pred_false = np.zeros(y_test.shape).astype(bool)
```

In [26]:

```
precision_score(y_test, y_pred_false)
```

```
C:\Users\jnpicao\AppData\Local\Continuum\anaconda3\lib\site-packages\sklea
rn\metrics\classification.py:1143: UndefinedMetricWarning: Precision is il
l-defined and being set to 0.0 due to no predicted samples.
  'precision', 'predicted', average, warn_for)
```

Out[26]:

```
0.0
```

In [27]:

```
recall_score(y_test, y_pred_false)
```

Out[27]:

```
0.0
```

In [28]:

```
accuracy_score(y_test, y_pred_false)
```

Out[28]:

```
0.6659427528992746
```

Predict randomly with positive\negative ratio `r`

In [29]:

```
np.random.seed(425)
ratio = 0.90
```

In [30]:

```
# y_pred_rand = np.random.randint(2, size=y_test.shape).astype(bool)
y_pred_rand = np.random.binomial(n=1, p=ratio, size=y_test.shape).astype(bool)
```

In [31]:

```
y_pred_rand.sum()/y_pred_rand.shape[0]
```

Out[31]:

```
0.9005342483603354
```

In [32]:

```
y_pred_rand.shape
```

Out[32]:

```
(46046,)
```

In [33]:

```
precision_score(y_test, y_pred_rand)
```

Out[33]:

```
0.3345150243573048
```

In [34]:

```
recall_score(y_test, y_pred_rand)
```

Out[34]:

```
0.9017683006111039
```

In [35]:

```
accuracy_score(y_test, y_pred_rand)
```

Out[35]:

```
0.36789297658862874
```

In [ ]:

In [ ]:

In [ ]:

In [ ]:

In [ ]:

In [ ]:

In [ ]:

In [ ]: