CS

September 12, 2023

[1]:
```python
import sys
## import all the packages needed
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import sklearn
import seaborn as sns
```

[2]:
```python
## read NHANES dataset
df = pd.read_csv('/Users/zhiyi/Desktop/for Yupei/CS.csv')
```

[3]:
```python
## find all the distinct values of os
df.os.value_counts()
```

[3]:
```
0    15392
1     4256
Name: os, dtype: int64
```

[4]:
```python
## data preparation
# exclude null values and NA
df = df[df.os.notnull()]
# check os
df.os.describe()
```

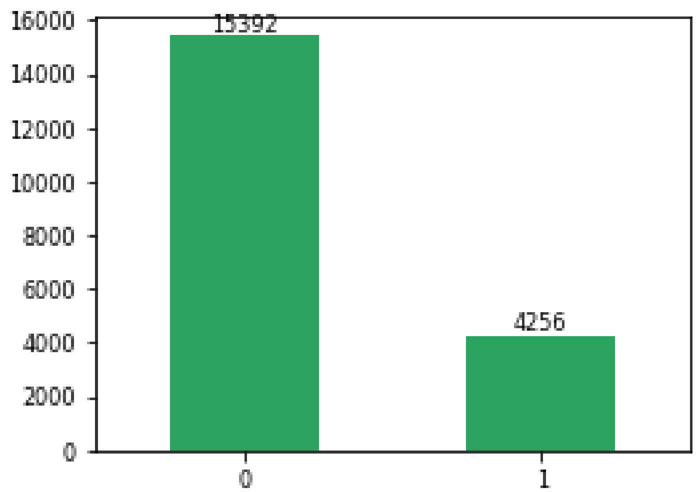
[4]:
```
count    19648.000000
mean         0.216612
std          0.411947
min          0.000000
25%          0.000000
50%          0.000000
75%          0.000000
max          1.000000
Name: os, dtype: float64
```

[5]:
```python
# exclude non-numeric values
d = df.select_dtypes(['number'])
```

```
# exclude columns that have over 50% NaN
d = d.dropna(thresh = 0.5*len(d), axis =1)

print(len(d.columns), 'columns are left')
```

```
21 columns are left
```

[6]:
```
## plot the distribution of values of response variable
vals = d.os.value_counts()

plt.figure(figsize=(4,3))
plt.rc('font', size=8)

ax = vals.plot.bar(rot=0, color='#2ca25f')
for i in range(len(vals)):
    ax.annotate(vals[i], xy=[vals.index[i], vals[i]], ha='center', va='bottom')
```



[7]:
```
# replace NA with most frequent values
from sklearn.impute import SimpleImputer
imp_mode = SimpleImputer(strategy='most_frequent')

## show the complete dataset
d = pd.DataFrame(imp_mode.fit_transform(d), columns=d.columns)
d
```

[7]:

	os	gender	race	age	size	marry	income	site	grade	kind	…	N	\
0	1	2	2	3	3	1	3	1	5	1	…	3	
1	0	1	1	3	1	3	3	2	2	1	…	2	
2	0	2	1	3	3	2	3	2	2	1	…	1	
3	0	1	3	3	1	3	3	1	5	1	…	1	

```
4        0        1      2     3      3       2        3      1       2      1  …  1
…     ..       …      …   …     …      …       …     …      …     …   …  ..
19643    0        2      1     2      3       2        2      1       5      1  …  3
19644    1        2      2     3      3       2        2      1       5      1  …  1
19645    0        1      1     2      1       2        1      1       5      1  …  3
19646    0        2      1     2      3       3        2      1       5      1  …  3
19647    1        2      1     3      3       3        2      1       5      1  …  1

       surgery_pri  RX_Summ  radiate  chem  CEA  bone  brain  lung  group
0                0        0        0     0    1     0      0     1      3
1                1        0        0     0    0     0      0     0      1
2                0        0        0     1    1     0      0     0      3
3                0        0        0     0    1     0      0     1      3
4                0        0        0     1    2     0      0     1      3
…             …      …      …    …  …    …    …   …    …
19643            0        0        0     0    1     0      0     1      3
19644            0        0        0     0    2     0      0     0      3
19645            0        0        1     1    1     0      0     0      3
19646            1        0        0     0    2     0      0     0      3
19647            0        0        0     0    2     0      0     0      3

[19648 rows x 21 columns]
```

[8]:
```python
## separate predictors and responses
X = d.loc[:, d.columns != 'os']
y = d.os
print('X shape:', X.shape)
print('y shape:', y.shape)
```

```
X shape: (19648, 20)
y shape: (19648,)
```

[9]:
```python
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2,␣
↪random_state=12)
```

[10]:
```python
from xgboost import XGBClassifier
from sklearn.metrics import classification_report, accuracy_score,␣
↪confusion_matrix

model = XGBClassifier()
model.fit(X_train, y_train)
y_pred = model.predict(X_test)

accuracy = accuracy_score(y_test, y_pred)
print("Accuracy: %.2f%%" % (accuracy * 100.0))
```

```
def confusion(y_test, y_pred):
    conf = pd.DataFrame(confusion_matrix(y_test, y_pred), index=['True[0]',␣
 ↪'True[1]'], columns=['Predict[0]', 'Predict[1]'])
    print('Confusion Matrix:')
    print(conf)
    return conf

confusion(y_test, y_pred)
```

```
Accuracy: 80.33%
Confusion Matrix:
         Predict[0]  Predict[1]
True[0]        2792         264
True[1]         509         365
```

[10]:

	Predict[0]	Predict[1]
True[0]	2792	264
True[1]	509	365

[11]:
```
from imblearn.over_sampling import SMOTE

smote = SMOTE(random_state=12)
X_train_sm, y_train_sm = smote.fit_resample(X_train, y_train)
X_test_sm, y_test_sm = smote.fit_resample(X_test, y_test)

X_train_sm = pd.DataFrame(X_train_sm, columns=X.columns)
X_test_sm = pd.DataFrame(X_test_sm, columns=X.columns)

print(y_train_sm.value_counts())
print(y_test_sm.value_counts())
```

```
1    12336
0    12336
Name: os, dtype: int64
0    3056
1    3056
Name: os, dtype: int64
```

[12]:
```
# After oversampling, the classification result is more reasonable.
model = XGBClassifier()
model.fit(X_train_sm, y_train_sm)
y_pred_sm = model.predict(X_test_sm)

accuracy = accuracy_score(y_test_sm, y_pred_sm)
print("Accuracy: %.2f%%" % (accuracy * 100.0))
conf = pd.DataFrame(confusion_matrix(y_test_sm, y_pred_sm), index=['True[0]',␣
 ↪'True[1]'], columns=['Predict[0]', 'Predict[1]'])
```

```
conf
```

Accuracy: 76.62%

[12]:

	Predict[0]	Predict[1]
True[0]	2422	634
True[1]	795	2261

[13]:

```
X_scale = d.loc[:, d.columns != 'os']
y = d.os
```

[14]:

```
## min-max scaling
from sklearn.preprocessing import MinMaxScaler
minmax = MinMaxScaler()
X = pd.DataFrame(minmax.fit_transform(X_scale), columns=X_scale.columns)
X
```

[14]:

	gender	race	age	size	marry	income	site	grade	kind	T	N	\
0	1.0	0.5	1.0	1.0	0.0	1.0	0.0	1.00	0.0	1.0	1.0	
1	0.0	0.0	1.0	0.0	1.0	1.0	1.0	0.25	0.0	0.5	0.5	
2	1.0	0.0	1.0	1.0	0.5	1.0	1.0	0.25	0.0	0.5	0.0	
3	0.0	1.0	1.0	0.0	1.0	1.0	0.0	1.00	0.0	0.5	0.0	
4	0.0	0.5	1.0	1.0	0.5	1.0	0.0	0.25	0.0	0.0	0.0	
…	…	…	…	…	…	…	…	…	…	…	…	
19643	1.0	0.0	0.5	1.0	0.5	0.5	0.0	1.00	0.0	0.0	1.0	
19644	1.0	0.5	1.0	1.0	0.5	0.5	0.0	1.00	0.0	0.0	0.0	
19645	0.0	0.0	0.5	0.0	0.5	0.0	0.0	1.00	0.0	1.0	1.0	
19646	1.0	0.0	0.5	1.0	1.0	0.5	0.0	1.00	0.0	1.0	1.0	
19647	1.0	0.0	1.0	1.0	1.0	0.5	0.0	1.00	0.0	1.0	0.0	

	surgery_pri	RX_Summ	radiate	chem	CEA	bone	brain	lung	group
0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.5	1.0
1	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	1.0	0.5	0.0	0.0	0.0	1.0
3	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.5	1.0
4	0.0	0.0	0.0	1.0	1.0	0.0	0.0	0.5	1.0
…	…	…	…	…	…	…	…	…	…
19643	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.5	1.0
19644	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	1.0
19645	0.0	0.0	1.0	1.0	0.5	0.0	0.0	0.0	1.0
19646	1.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	1.0
19647	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	1.0

[19648 rows x 20 columns]

[15]:

```
from sklearn.model_selection import train_test_split
```

```
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2,␣
 ↪random_state=12)
```

[16]:
```
from imblearn.over_sampling import SMOTE

smote = SMOTE(random_state=12)
X_train_sm, y_train_sm = smote.fit_resample(X_train, y_train)
#X_test_sm, y_test_sm = smote.fit_sample(X_test, y_test)

X_train_sm = pd.DataFrame(X_train_sm, columns=X.columns)
#X_test_sm = pd.DataFrame(X_test_sm, columns=X.columns)
```

[17]:
```
print('X train shape: ',X_train_sm.shape)
print('y train values: \n', y_train_sm.value_counts())
print()
print('X test shape: ',X_test_sm.shape)
print('y test values: \n', y_test_sm.value_counts())
```

```
X train shape:  (24672, 20)
y train values:
 1    12336
0    12336
Name: os, dtype: int64

X test shape:  (6112, 20)
y test values:
 0    3056
1    3056
Name: os, dtype: int64
```

[18]:
```
mscore=[]
```

[19]:
```
from sklearn.linear_model import LogisticRegression
from time import process_time

clf = LogisticRegression(max_iter=100, solver='lbfgs', class_weight='balanced',␣
 ↪random_state=12)

start = process_time()
clf.fit(X_train_sm, y_train_sm)
end = process_time()
print(end - start)

clf_prediction_proba = clf.predict_proba(X_test)[:, 1]

y_pred = clf.predict(X_test)
```

```
print('Accuracy Score:', clf.score(X_test, y_test))
print('Prediction:', y_pred)

mscore.append(['Logistic Regression', clf.score(X_test, y_test)])

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

```
0.18044000000000082
Accuracy Score: 0.7592875318066158
Prediction: [0 1 0 … 0 0 0]
              precision    recall  f1-score   support

           0       0.90      0.77      0.83      3056
           1       0.47      0.70      0.57       874

    accuracy                           0.76      3930
   macro avg       0.69      0.74      0.70      3930
weighted avg       0.81      0.76      0.77      3930

Confusion Matrix:
         Predict[0]  Predict[1]
True[0]        2368         688
True[1]         258         616
```

[19]:

	Predict[0]	Predict[1]
True[0]	2368	688
True[1]	258	616

[20]:

```
from sklearn.ensemble import RandomForestClassifier
from time import process_time

rnd_clf = RandomForestClassifier(n_estimators=100, criterion='gini',␣
 ↪random_state=12)

start = process_time()
model = rnd_clf.fit(X_train_sm, y_train_sm)
end = process_time()
print(end - start)

rf_prediction_proba = rnd_clf.predict_proba(X_test)[:, 1]

y_pred = rnd_clf.predict(X_test)

print('Accuracy Score:', rnd_clf.score(X_test, y_test))
print('Prediction:', y_pred)
```

```
mscore.append(['Random Forest', rnd_clf.score(X_test, y_test)])

print(classification_report(y_test, y_pred))
confusion(y_test, y_pred)
print(pd.DataFrame({'Variable':X.columns,
              'Importance':model.feature_importances_}).
 ↪sort_values('Importance', ascending=False))
```

```
2.7347050000000017
Accuracy Score: 0.789058524173028
Prediction: [0 0 0 … 0 0 0]
              precision    recall  f1-score   support

           0       0.85      0.89      0.87      3056
           1       0.53      0.43      0.47       874

    accuracy                           0.79      3930
   macro avg       0.69      0.66      0.67      3930
weighted avg       0.78      0.79      0.78      3930

Confusion Matrix:
         Predict[0]  Predict[1]
True[0]        2727         329
True[1]         500         374
       Variable  Importance
14         chem    0.205154
7         grade    0.091922
2           age    0.080710
4         marry    0.070751
5        income    0.064811
3          size    0.060049
18         lung    0.056253
15          CEA    0.054175
9             T    0.053338
1          race    0.041704
10            N    0.035928
19        group    0.032703
0        gender    0.031439
6          site    0.029272
16         bone    0.021990
11  surgery_pri    0.017856
8          kind    0.015665
12      RX_Summ    0.013605
13      radiate    0.013441
17        brain    0.009235
```

[21]:
```python
from sklearn.ensemble import BaggingClassifier
from sklearn.tree import DecisionTreeClassifier
from time import process_time

bagging = BaggingClassifier(base_estimator=␣
↪DecisionTreeClassifier(random_state=12), max_samples = 1.0, max_features = 1.
↪0,
                            bootstrap = True, bootstrap_features = False,␣
↪random_state=12)

start = process_time()
bagging.fit(X_train_sm, y_train_sm)
end = process_time()
print(end - start)

bg_prediction_proba = bagging.predict_proba(X_test)[:, 1]

y_pred = bagging.predict(X_test)

print('Accuracy Score:', bagging.score(X_test, y_test))
print('Prediction:', y_pred)

mscore.append(['Bagging DecisionTree', bagging.score(X_test, y_test)])

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

```
0.6984320000000004
Accuracy Score: 0.7699745547073792
Prediction: [0 0 0 … 0 0 0]
              precision    recall  f1-score   support

           0       0.83      0.88      0.86      3056
           1       0.48      0.39      0.43       874

    accuracy                           0.77      3930
   macro avg       0.66      0.64      0.64      3930
weighted avg       0.76      0.77      0.76      3930

Confusion Matrix:
         Predict[0]  Predict[1]
True[0]        2682         374
True[1]         530         344
```

[21]:

	Predict[0]	Predict[1]
True[0]	2682	374
True[1]	530	344

[22]:
```python
from sklearn.neighbors import KNeighborsClassifier
from time import process_time

knn = KNeighborsClassifier()

start = process_time()
knn.fit(X_train_sm, y_train_sm)
end = process_time()
print(end - start)

knn_prediction_proba = knn.predict_proba(X_test)[:, 1]

y_pred = knn.predict(X_test)

print('Accuracy Score:', knn.score(X_test, y_test))
print('Prediction:', y_pred)

mscore.append(['KNN', knn.score(X_test, y_test)])

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

```
0.007623999999999853
Accuracy Score: 0.6961832061068702
Prediction: [0 0 0 … 0 0 0]
              precision    recall  f1-score   support

           0       0.88      0.71      0.78      3056
           1       0.39      0.66      0.49       874

    accuracy                           0.70      3930
   macro avg       0.64      0.68      0.64      3930
weighted avg       0.77      0.70      0.72      3930

Confusion Matrix:
         Predict[0]  Predict[1]
True[0]        2155         901
True[1]         293         581
```

[22]:

	Predict[0]	Predict[1]
True[0]	2155	901
True[1]	293	581

[23]:
```python
from sklearn.naive_bayes import GaussianNB
from time import process_time

gnb = GaussianNB()
```

```
start = process_time()
gnb.fit(X_train_sm, y_train_sm)
end = process_time()
print(end - start)

gnb_prediction_proba = gnb.predict_proba(X_test)[:, 1]

y_pred = gnb.predict(X_test)

print('Accuracy Score:', gnb.score(X_test, y_test))
print('Prediction:', y_pred)

mscore.append(['Gaussian Naive Bayes', gnb.score(X_test, y_test)])

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

```
0.018133999999999632
Accuracy Score: 0.6826972010178117
Prediction: [0 1 0 … 0 1 0]
              precision    recall  f1-score   support

           0       0.89      0.67      0.77      3056
           1       0.39      0.72      0.50       874

    accuracy                           0.68      3930
   macro avg       0.64      0.70      0.63      3930
weighted avg       0.78      0.68      0.71      3930

Confusion Matrix:
         Predict[0]  Predict[1]
True[0]        2053        1003
True[1]         244         630
```

[23]:

	Predict[0]	Predict[1]
True[0]	2053	1003
True[1]	244	630

[24]:

```
from sklearn.ensemble import GradientBoostingClassifier
from time import process_time

gbc = GradientBoostingClassifier(learning_rate=0.1, n_estimators=100,␣
 ↪random_state=12)

start = process_time()
model = gbc.fit(X_train_sm, y_train_sm)
```

```python
end = process_time()
print(end - start)

gbc_prediction_proba = gbc.predict_proba(X_test)[:, 1]

y_pred = gbc.predict(X_test)

print('Accuracy Score:', gbc.score(X_test, y_test))
print('Prediction:', y_pred)

mscore.append(['Gradient Boosting', gbc.score(X_test, y_test)])

print(classification_report(y_test, y_pred))
confusion(y_test, y_pred)
print(pd.DataFrame({'Variable':X.columns,
              'Importance':model.feature_importances_}).
 ↪sort_values('Importance', ascending=False))
```

```
2.5942499999999953
Accuracy Score: 0.8129770992366412
Prediction: [0 0 0 … 0 0 0]
              precision    recall  f1-score   support

           0       0.87      0.89      0.88      3056
           1       0.58      0.55      0.57       874

    accuracy                           0.81      3930
   macro avg       0.73      0.72      0.72      3930
weighted avg       0.81      0.81      0.81      3930

Confusion Matrix:
        Predict[0]  Predict[1]
True[0]       2715         341
True[1]        394         480
      Variable  Importance
14        chem    0.433358
7        grade    0.102839
2          age    0.087997
18        lung    0.059656
4        marry    0.047998
9            T    0.044653
5       income    0.044059
15         CEA    0.042455
3         size    0.038965
11 surgery_pri    0.031851
19       group    0.025899
16        bone    0.010312
```

```
1          race    0.007346
10            N    0.006314
12       RX_Summ    0.005013
6          site    0.004589
17         brain    0.002841
13       radiate    0.002317
8          kind    0.001537
0        gender    0.000000
```

[25]:
```python
from sklearn.ensemble import AdaBoostClassifier
from time import process_time

ada = AdaBoostClassifier(learning_rate=1.0, n_estimators=50, random_state=12)

start = process_time()
model = ada.fit(X_train_sm, y_train_sm)
end = process_time()
print(end - start)

ada_prediction_proba = ada.predict_proba(X_test)[:, 1]

y_pred = ada.predict(X_test)

print('Accuracy Score:', ada.score(X_test, y_test))
print('Prediction:', y_pred)

mscore.append(['Adaptive Boosting', ada.score(X_test, y_test)])

# from sklearn.metrics import classification_report
print(classification_report(y_test, y_pred))
confusion(y_test, y_pred)
print(pd.DataFrame({'Variable':X.columns,
              'Importance':model.feature_importances_}).
 ↪sort_values('Importance', ascending=False))
```

```
0.8218000000000032
Accuracy Score: 0.8048346055979644
Prediction: [0 0 0 … 0 0 0]
              precision    recall  f1-score   support

           0       0.88      0.87      0.87      3056
           1       0.56      0.58      0.57       874

    accuracy                           0.80      3930
   macro avg       0.72      0.73      0.72      3930
weighted avg       0.81      0.80      0.81      3930

Confusion Matrix:
```

```
         Predict[0]  Predict[1]
True[0]        2653         403
True[1]         364         510
       Variable  Importance
5        income        0.22
4         marry        0.20
18         lung        0.12
15          CEA        0.12
2           age        0.08
3          size        0.06
16         bone        0.06
7         grade        0.04
10            N        0.02
14         chem        0.02
6          site        0.02
11  surgery_pri        0.02
12      RX_Summ        0.02
17        brain        0.00
0        gender        0.00
13      radiate        0.00
1          race        0.00
9             T        0.00
8          kind        0.00
19        group        0.00
```

[26]:

```
from sklearn.svm import SVC
from time import process_time

svm_clf = SVC(kernel='rbf', gamma='scale', probability=True, random_state=12)

start = process_time()
svm_clf.fit(X_train_sm, y_train_sm)
end = process_time()
print(end - start)

svm_prediction_proba = svm_clf.predict_proba(X_test)[:, 1]

y_pred = svm_clf.predict(X_test)

print('Accuracy Score:', svm_clf.score(X_test, y_test))
print('Prediction:', y_pred)

mscore.append(['SVM', svm_clf.score(X_test, y_test)])

# from sklearn.metrics import classification_report
print(classification_report(y_test, y_pred))
confusion(y_test, y_pred)
```

```
234.605689
Accuracy Score: 0.7580152671755725
Prediction: [0 1 0 … 0 0 0]
              precision    recall  f1-score   support

           0       0.90      0.78      0.83      3056
           1       0.47      0.70      0.56       874

    accuracy                           0.76      3930
   macro avg       0.68      0.74      0.70      3930
weighted avg       0.80      0.76      0.77      3930

Confusion Matrix:
         Predict[0]  Predict[1]
True[0]        2371         685
True[1]         266         608
```

[26]:

	Predict[0]	Predict[1]
True[0]	2371	685
True[1]	266	608

[27]:

```
from xgboost import XGBClassifier
from time import process_time

xgbc = XGBClassifier(eta=0.3, max_depth=6, random_state=12)

start = process_time()
model = xgbc.fit(X_train_sm, y_train_sm)
end = process_time()
print(end - start)

xgbc_prediction_proba = xgbc.predict_proba(X_test)[:, 1]

y_pred = xgbc.predict(X_test)

print('Accuracy Score:', xgbc.score(X_test, y_test))
print('Prediction:', y_pred)

mscore.append(['XGBoost', xgbc.score(X_test, y_test)])

from sklearn.metrics import classification_report
print(classification_report(y_test, y_pred))
confusion(y_test, y_pred)
print(pd.DataFrame({'Variable':X.columns,
              'Importance':model.feature_importances_}).
 ↪sort_values('Importance', ascending=False))
```

```
8.497627000000023
```

```
Accuracy Score: 0.8048346055979644
Prediction: [0 0 0 … 0 0 0]
              precision    recall  f1-score   support

           0       0.85      0.91      0.88      3056
           1       0.58      0.44      0.50       874

    accuracy                           0.80      3930
   macro avg       0.72      0.67      0.69      3930
weighted avg       0.79      0.80      0.79      3930

Confusion Matrix:
         Predict[0]  Predict[1]
True[0]        2778         278
True[1]         489         385
       Variable  Importance
14         chem    0.344881
11  surgery_pri    0.098779
2           age    0.075192
18         lung    0.059739
7         grade    0.049362
15          CEA    0.046022
5        income    0.044570
4         marry    0.041657
9             T    0.040148
16         bone    0.031390
3          size    0.028152
19        group    0.025421
1          race    0.020828
10            N    0.020576
12      RX_Summ    0.020220
13      radiate    0.012359
17        brain    0.012105
6          site    0.011551
8          kind    0.009906
0        gender    0.007143
```

[28]:

```python
from sklearn.neural_network import MLPClassifier
from time import process_time

mlp = MLPClassifier(hidden_layer_sizes=(100,), solver='adam', shuffle=True, tol␣
↪= 0.0001, random_state=12)

start = process_time()
mlp.fit(X_train_sm, y_train_sm)
end = process_time()
print(end - start)
```

```python
mlp_prediction_proba = mlp.predict_proba(X_test)[:, 1]

mlp_pred_diabetes = mlp.predict(X_test)

print('Accuracy Score:', mlp.score(X_test, y_test))
print('Prediction:', mlp_pred_diabetes)
print("parameter: ", mlp.get_params())

mscore.append(['MLP', mlp.score(X_test, y_test)])
```

```
46.838952000000006
Accuracy Score: 0.761323155216285
Prediction: [0 0 0 … 0 0 0]
parameter:  {'activation': 'relu', 'alpha': 0.0001, 'batch_size': 'auto',
'beta_1': 0.9, 'beta_2': 0.999, 'early_stopping': False, 'epsilon': 1e-08,
'hidden_layer_sizes': (100,), 'learning_rate': 'constant', 'learning_rate_init':
0.001, 'max_fun': 15000, 'max_iter': 200, 'momentum': 0.9, 'n_iter_no_change':
10, 'nesterovs_momentum': True, 'power_t': 0.5, 'random_state': 12, 'shuffle':
True, 'solver': 'adam', 'tol': 0.0001, 'validation_fraction': 0.1, 'verbose':
False, 'warm_start': False}
```

```
/Users/zhiyi/opt/anaconda3/lib/python3.9/site-
packages/sklearn/neural_network/_multilayer_perceptron.py:692:
ConvergenceWarning: Stochastic Optimizer: Maximum iterations (200) reached and
the optimization hasn't converged yet.
  warnings.warn(
```

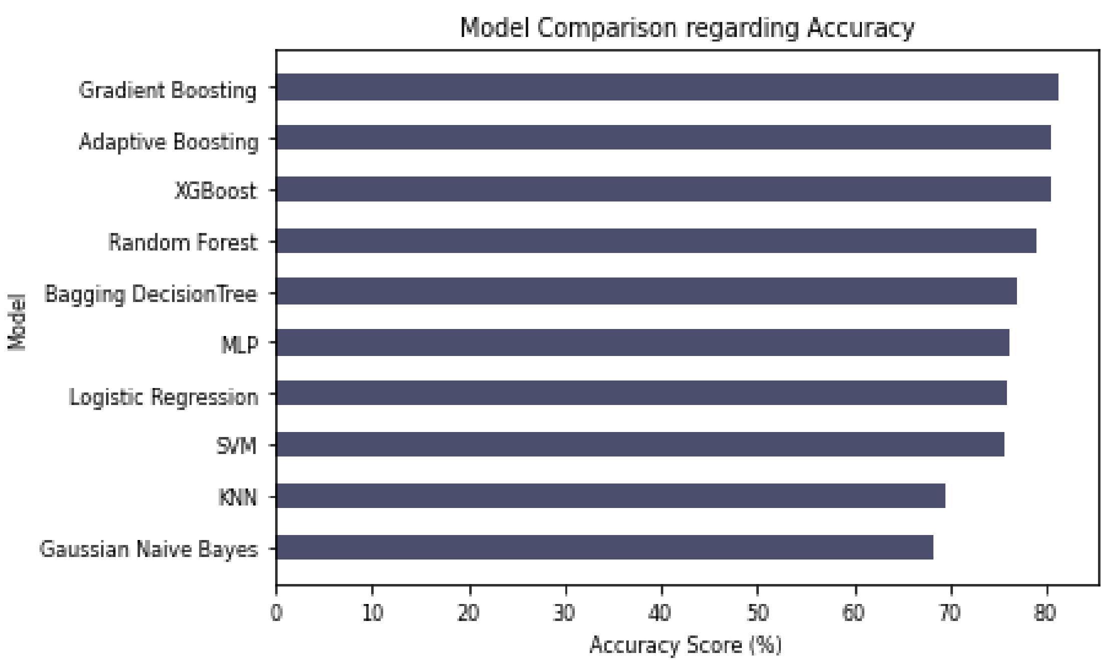
[29]:
```python
mscore.sort(key=lambda x: x[1], reverse=True)
mscore
```

[29]:
```
[['Gradient Boosting', 0.8129770992366412],
 ['Adaptive Boosting', 0.8048346055979644],
 ['XGBoost', 0.8048346055979644],
 ['Random Forest', 0.789058524173028],
 ['Bagging DecisionTree', 0.7699745547073792],
 ['MLP', 0.761323155216285],
 ['Logistic Regression', 0.7592875318066158],
 ['SVM', 0.7580152671755725],
 ['KNN', 0.6961832061068702],
 ['Gaussian Naive Bayes', 0.6826972010178117]]
```

[30]:
```python
model = list(i[0] for i in mscore)
score = list(round(i[1]*100,2) for i in mscore)

print('Accuracy Score: \n')
for m,s in zip(model, score):
    print(f'{m}: {s}%')
```

```python
# creating horizontal bar
plt.barh(model, score, height = 0.5, color='#4B4E6D')

plt.xlabel("Accuracy Score (%)")
plt.ylabel("Model")
plt.title("Model Comparison regarding Accuracy")
plt.gca().invert_yaxis()
plt.rc('font', size=9)
plt.show()
```

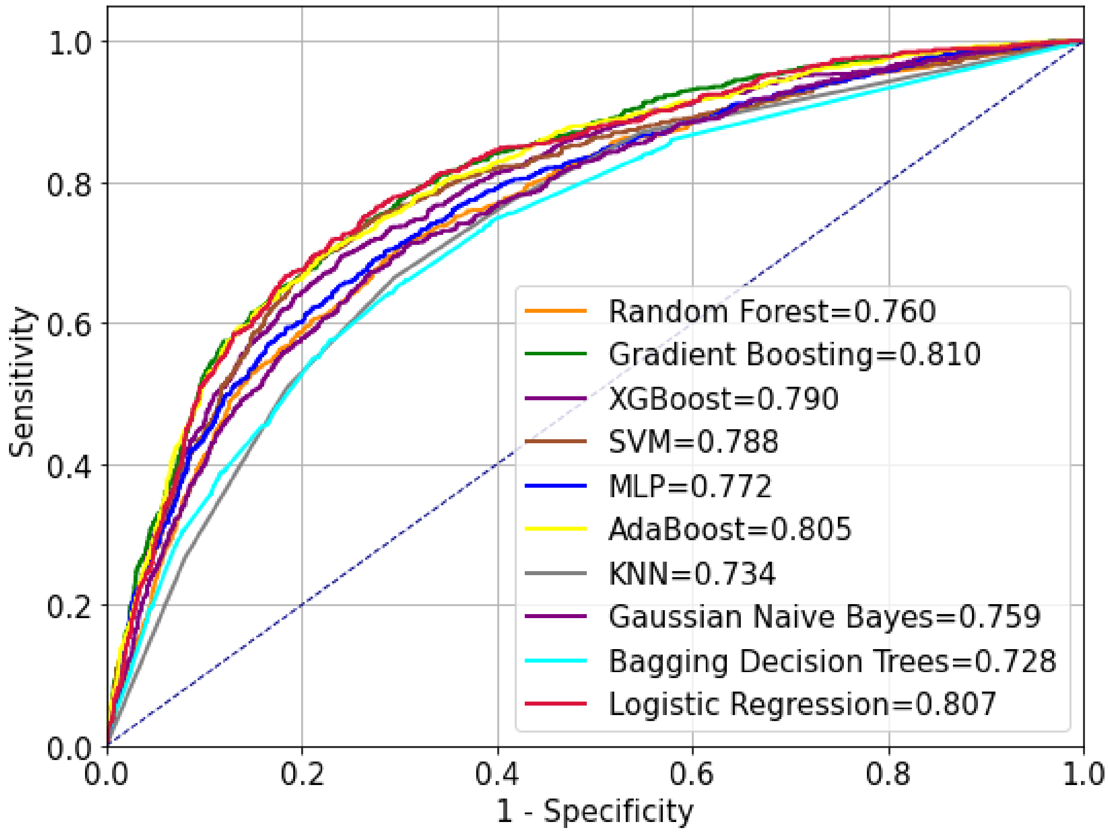
```
Accuracy Score:

Gradient Boosting: 81.3%
Adaptive Boosting: 80.48%
XGBoost: 80.48%
Random Forest: 78.91%
Bagging DecisionTree: 77.0%
MLP: 76.13%
Logistic Regression: 75.93%
SVM: 75.8%
KNN: 69.62%
Gaussian Naive Bayes: 68.27%
```



[31]:

```python
rf_prediction_proba = rnd_clf.predict_proba(X_test)[:, 1]
def roc_curve_and_score(y_test, pred_proba):
    fpr, tpr, _ = roc_curve(y_test.ravel(), pred_proba.ravel())
    roc_auc = roc_auc_score(y_test.ravel(), pred_proba.ravel())
    return fpr, tpr, roc_auc

from sklearn.metrics import roc_auc_score, roc_curve
import matplotlib
import matplotlib.pyplot as plt
plt.figure(figsize=(9, 7))
matplotlib.rcParams.update({'font.size': 15})
plt.grid()
fpr, tpr, roc_auc = roc_curve_and_score(y_test, rf_prediction_proba)
plt.plot(fpr, tpr, color='darkorange', lw=2,
         label='Random Forest={0:.3f}'.format(roc_auc))
fpr, tpr, roc_auc = roc_curve_and_score(y_test, gbc_prediction_proba)
plt.plot(fpr, tpr, color='green', lw=2,
         label='Gradient Boosting={0:.3f}'.format(roc_auc))
fpr, tpr, roc_auc = roc_curve_and_score(y_test, xgbc_prediction_proba)
plt.plot(fpr, tpr, color='purple', lw=2,
         label='XGBoost={0:.3f}'.format(roc_auc))
fpr, tpr, roc_auc = roc_curve_and_score(y_test, svm_prediction_proba)
plt.plot(fpr, tpr, color='sienna', lw=2,
         label='SVM={0:.3f}'.format(roc_auc))
fpr, tpr, roc_auc = roc_curve_and_score(y_test, mlp_prediction_proba)
plt.plot(fpr, tpr, color='blue', lw=2,
         label='MLP={0:.3f}'.format(roc_auc))
fpr, tpr, roc_auc = roc_curve_and_score(y_test, ada_prediction_proba)
plt.plot(fpr, tpr, color='yellow', lw=2,
         label='AdaBoost={0:.3f}'.format(roc_auc))
fpr, tpr, roc_auc = roc_curve_and_score(y_test, knn_prediction_proba)
plt.plot(fpr, tpr, color='grey', lw=2,
         label='KNN={0:.3f}'.format(roc_auc))
fpr, tpr, roc_auc = roc_curve_and_score(y_test, gnb_prediction_proba)
plt.plot(fpr, tpr, color='purple', lw=2,
         label='Gaussian Naive Bayes={0:.3f}'.format(roc_auc))
fpr, tpr, roc_auc = roc_curve_and_score(y_test, bg_prediction_proba)
plt.plot(fpr, tpr, color='cyan', lw=2,
         label='Bagging Decision Trees={0:.3f}'.format(roc_auc))
fpr, tpr, roc_auc = roc_curve_and_score(y_test, clf_prediction_proba)
plt.plot(fpr, tpr, color='crimson', lw=2,
         label='Logistic Regression={0:.3f}'.format(roc_auc))

plt.plot([0, 1], [0, 1], color='navy', lw=1, linestyle='--')
plt.legend(loc="lower right")
plt.xlim([0.0, 1.0])
plt.ylim([0.0, 1.05])
```

```python
plt.xlabel('1 - Specificity')
plt.ylabel('Sensitivity')
plt.show()
```



[ ]: