ps8

March 11, 2019

1. Decision trees

```
In [2]: import pandas as pd
        biden = pd.read_csv("biden.txt")
        biden.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1807 entries, 0 to 1806
Data columns (total 6 columns):
biden     1807 non-null int64
female    1807 non-null int64
age       1807 non-null int64
educ      1807 non-null int64
dem       1807 non-null int64
rep       1807 non-null int64
dtypes: int64(6)
memory usage: 84.8 KB
```

(a)

```
In [4]: from sklearn.model_selection import train_test_split
        from sklearn.tree import DecisionTreeRegressor, DecisionTreeClassifier
        import numpy as np
        X = biden[["female","age","educ","dem","rep"]].values
        y = biden["biden"].values
        X_train, X_test, y_train, y_test = train_test_split(X, y, test_size = 0.3, random_state
        biden_tree = DecisionTreeRegressor(max_depth=3, min_samples_leaf=5)
        biden_tree.fit(X_train, y_train)

Out[4]: DecisionTreeRegressor(criterion='mse', max_depth=3, max_features=None,
                   max_leaf_nodes=None, min_impurity_decrease=0.0,
                   min_impurity_split=None, min_samples_leaf=5,
                   min_samples_split=2, min_weight_fraction_leaf=0.0,
                   presort=False, random_state=None, splitter='best')
```

```
In [57]: from sklearn.tree import export_graphviz
         import graphviz
```

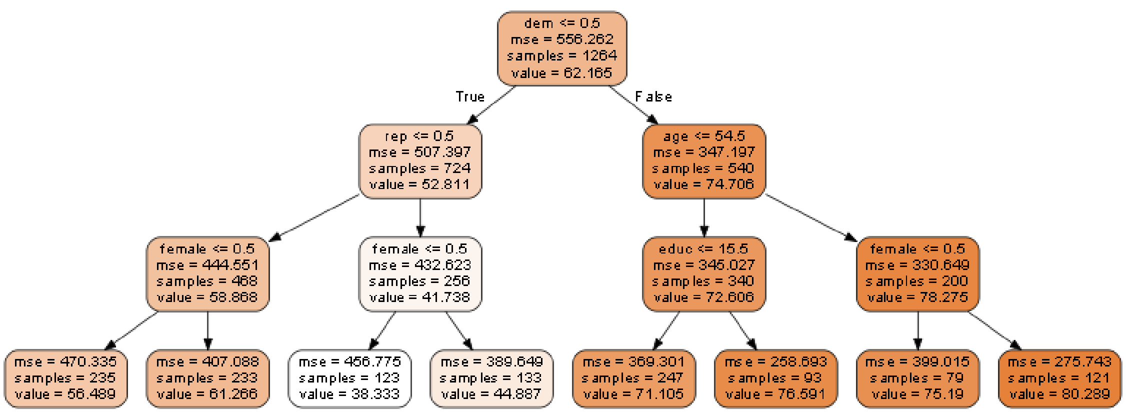
```
import pydotplus
biden_tree_viz = export_graphviz(
    biden_tree,
    out_file=None,
    feature_names=["female","age","educ","dem","rep"],
    class_names=biden.biden,
    rounded=True,
    filled=True,
)

pydot_graph = pydotplus.graph_from_dot_data(biden_tree_viz)
pydot_graph.set_size('"8,8!"')
pydot_graph.write_png('resized_tree.png')
```

Out[57]: True

```
In [58]: from IPython.display import Image
         Image(filename='resized_tree.png')
```

Out[58]:




```
In [12]: from sklearn.metrics import mean_squared_error
         y_pred = biden_tree.predict(X_test)
         MSE1 = mean_squared_error(y_test, y_pred)
         print('test MSE=', MSE1)
```

```
test MSE= 396.1937146321307
```

The binary decision tree splits the predictors into eight leaves. The mse on test set is around 396.19. The first predictor is dem, which indicates affiliation with Democraticans. The left branch of the first node contains people who are not affiliated with Democratic Party and the right who are affiliated with Democratic Party. The second predictor of the left branch is rep, which indicates whether the respondent is affliated with Republicans.The following predictors have the similar mode.The mses in the final eight leaves are mainly between 35 and 85.

(b)

```
In [15]: from sklearn.model_selection import RandomizedSearchCV
         from scipy.stats import randint as sp_randint
         param_dist1 = {'max_depth': [3, 10],
                        'min_samples_split': sp_randint(2, 20),
                        'min_samples_leaf': sp_randint(2, 20)}
         random_search = RandomizedSearchCV(DecisionTreeRegressor(), param_distributions=param_
                                            n_iter=100, n_jobs=-1, cv=5, random_state=25, scor
         rs_fit1 = random_search.fit(X_train, y_train)
         print(rs_fit1.best_params_)
         print('MSE = ', abs(rs_fit1.best_score_))#best_score_ can be negative
```

```
{'max_depth': 3, 'min_samples_leaf': 2, 'min_samples_split': 9}
MSE =  404.7488359884144
```

(c)

```
In [17]: from sklearn.ensemble import RandomForestRegressor, RandomForestClassifier
         param_dist2 = {"n_estimators": [10, 200],
                        "max_depth": [3, 10],
                        "min_samples_split": sp_randint(2, 20),
                        "min_samples_leaf": sp_randint(2, 20),
                        "max_features": sp_randint(1, 5)}
         random_search2 = RandomizedSearchCV(RandomForestRegressor(), param_distributions=param
                                            n_iter=100, n_jobs=-1, cv=5, random_state=25, scor
         rs_fit2 = random_search2.fit(X_train, y_train)
         print(rs_fit2.best_params_)
         print('MSE = ', abs(rs_fit2.best_score_))#best_score_ can be negative
```

```
{'max_depth': 3, 'max_features': 3, 'min_samples_leaf': 17, 'min_samples_split': 12, 'n_estima
MSE =  397.89422745189773
```

```
C:\ProgramData\Anaconda3\lib\site-packages\sklearn\model_selection\_search.py:841: Deprecation
  DeprecationWarning)
```

2. Classier "horse" race

```
In [21]: auto=pd.read_csv("Auto.csv", na_values='?')
         auto.head()
```

```
Out[21]:     mpg  cylinders  displacement  horsepower  weight  acceleration  year  \
         0  18.0          8         307.0       130.0    3504          12.0    70
         1  15.0          8         350.0       165.0    3693          11.5    70
         2  18.0          8         318.0       150.0    3436          11.0    70
         3  16.0          8         304.0       150.0    3433          12.0    70
         4  17.0          8         302.0       140.0    3449          10.5    70
```

```
   origin                       name
0       1  chevrolet chevelle malibu
1       1          buick skylark 320
2       1         plymouth satellite
3       1              amc rebel sst
4       1                ford torino
```

```
In [25]: auto['mpg_high'] = (auto['mpg']>=auto['mpg'].median()).astype('int')
         auto.dropna(inplace=True)
         auto["orgn1"]=np.where(auto["origin"]==1,1,0)
         auto["orgn2"]=np.where(auto["origin"]==2,1,0)
         auto["constant"]=1
         auto.head()
```

```
Out[25]:     mpg  cylinders  displacement  horsepower  weight  acceleration  year  \
         0  18.0          8         307.0       130.0    3504          12.0    70
         1  15.0          8         350.0       165.0    3693          11.5    70
         2  18.0          8         318.0       150.0    3436          11.0    70
         3  16.0          8         304.0       150.0    3433          12.0    70
         4  17.0          8         302.0       140.0    3449          10.5    70

            origin                       name  mpg_high  orgn1  orgn2  constant
         0       1  chevrolet chevelle malibu         0      1      0         1
         1       1          buick skylark 320         0      1      0         1
         2       1         plymouth satellite         0      1      0         1
         3       1              amc rebel sst         0      1      0         1
         4       1                ford torino         0      1      0         1
```

(a)

```
In [29]: from sklearn.linear_model import LogisticRegression
         yvals = auto["mpg_high"].values
         Xvars=auto[["constant","cylinders","displacement","horsepower",
               "weight","acceleration","year","orgn1","orgn2"]].values
         logit = LogisticRegression().fit(Xvars,yvals)
         logit.coef_
```

```
C:\ProgramData\Anaconda3\lib\site-packages\sklearn\linear_model\logistic.py:433: FutureWarning
  FutureWarning)
```

```
Out[29]: array([[-0.07294486, -0.09530101, -0.00121801, -0.07133085, -0.00331596,
                 -0.19412659,  0.26596842, -0.34333934,  0.27100873]])
```

```
In [31]: from sklearn.model_selection import KFold
         from sklearn.metrics import classification_report
         kf_log = KFold(n_splits=4, shuffle=True, random_state=25)
         kf_log.get_n_splits(Xvars)
         MSE_vec_kf = np.zeros(4)
```

```python
ytest_vec = np.zeros(auto.shape[0])
ypred_vec = np.zeros(auto.shape[0])
k_ind = int(0)

for train_index, test_index in kf_log.split(Xvars):
    X_train, X_test = Xvars[train_index], Xvars[test_index]
    y_train, y_test = yvals[train_index], yvals[test_index]
    Logit = LogisticRegression()
    Logit.fit(X_train, y_train)
    y_pred = Logit.predict(X_test)
    ytest_vec[test_index] = y_test
    ypred_vec[test_index] = y_pred
    MSE_vec_kf[k_ind] = (y_test != y_pred).mean()
    print('MSE for test set', k_ind, ' is', MSE_vec_kf[k_ind])
    k_ind += 1

MSE_kf = MSE_vec_kf.mean()
print('Test estimate MSE k-fold = {}.'.format(MSE_kf))
print(classification_report(ytest_vec, ypred_vec))
```

```
MSE for test set 0  is 0.14285714285714285
MSE for test set 1  is 0.09183673469387756
MSE for test set 2  is 0.07142857142857142
MSE for test set 3  is 0.08163265306122448
Test estimate MSE k-fold = 0.09693877551020408.
              precision    recall  f1-score   support

         0.0       0.92      0.89      0.90       196
         1.0       0.89      0.92      0.90       196

   micro avg       0.90      0.90      0.90       392
   macro avg       0.90      0.90      0.90       392
weighted avg       0.90      0.90      0.90       392



C:\ProgramData\Anaconda3\lib\site-packages\sklearn\linear_model\logistic.py:433: FutureWarning
  FutureWarning)
C:\ProgramData\Anaconda3\lib\site-packages\sklearn\linear_model\logistic.py:433: FutureWarning
  FutureWarning)
C:\ProgramData\Anaconda3\lib\site-packages\sklearn\linear_model\logistic.py:433: FutureWarning
  FutureWarning)
C:\ProgramData\Anaconda3\lib\site-packages\sklearn\linear_model\logistic.py:433: FutureWarning
  FutureWarning)
```

Therefore, the error rate for mpg_high=0 is 1 - 0.92 = 0.08. The error rate for mpg_high=1 is 1 - 0.89 = 0.11.

(b)

```
In [36]: param_dist3 = {"n_estimators": [10, 200],
                        "max_depth": [3, 8],
                        "min_samples_split": sp_randint(2, 20),
                        "min_samples_leaf": sp_randint(2, 20),
                        "max_features": sp_randint(1, 8)}
         random_search3 = RandomizedSearchCV(RandomForestRegressor(), param_distributions=paran
                                             n_iter=100, n_jobs=-1, cv=4, random_state=25, scor:
         rs_fit3 = random_search3.fit(Xvars, yvals)
         print(rs_fit3.best_params_)
         print('MSE = ', abs(rs_fit3.best_score_))
```

```
{'max_depth': 8, 'max_features': 3, 'min_samples_leaf': 15, 'min_samples_split': 2, 'n_estimato
MSE =  0.09062757253378131
```

(c)

```
In [39]: from scipy.stats import uniform as sp_uniform
         from sklearn.svm import SVC
         param_dist4 = {"C": sp_uniform(loc=0.2, scale=4.0),
                        "gamma": ["scale", "auto"],
                        "shrinking": [True, False]}
         random_search4 = RandomizedSearchCV(SVC(kernel='rbf'), param_distributions=param_dist4
                                             n_iter=100, n_jobs=-1, cv=4, random_state=25, scor:
         rs_fit4 = random_search4.fit(Xvars, yvals)
         print(rs_fit4.best_params_)
         print('MSE = ', abs(rs_fit4.best_score_))
```

```
{'C': 1.1775180640974197, 'gamma': 'scale', 'shrinking': False}
MSE =  0.11734693877551021
```

(d)

Comparing the mse of each model, I think the random forest model is the best predictor of mpg high since its mse is around 0.090, which is the smallest.

```
In [ ]:
```