3.0-jo-building-predictive-model

November 23, 2020

1 Building Predictive Models

[1]:
```
import os
import pandas as pd
import numpy as np
import sklearn
```

1.1 Import Data

Train and test data were randomly split within R, using 0.80 ratio. The two dataframes were written to independent csv files, and will be brought into the Python notebook now.

[2]:
```
# set path to processed train/test data
processed_data_path = os.path.join(os.path.pardir, 'data', 'processed')
train_file_path = os.path.join(processed_data_path, 'train.txt')
test_file_path = os.path.join(processed_data_path, 'test.txt')
```

[3]:
```
df_train = pd.read_csv(train_file_path, index_col='Obs')
df_test = pd.read_csv(test_file_path, index_col='Obs')
```

[4]:
```
print('Train data:')
df_train.info()
print('\n')
print('Test data:')
df_test.info()
```

```
Train data:
<class 'pandas.core.frame.DataFrame'>
Int64Index: 76 entries, 1 to 97
Data columns (total 9 columns):
Unnamed: 0                    76 non-null int64
Y_HighGradeCancer             76 non-null int64
PSALevel                      76 non-null float64
CancerVol                     76 non-null float64
Weight                        76 non-null float64
Age                           76 non-null float64
BenignProstaticHyperplasia    76 non-null float64
SeminalVesicleInvasion        76 non-null int64
```

```
CapsularPenetration           76 non-null float64
dtypes: float64(6), int64(3)
memory usage: 5.9 KB


Test data:
<class 'pandas.core.frame.DataFrame'>
Int64Index: 21 entries, 5 to 95
Data columns (total 9 columns):
Unnamed: 0                    21 non-null int64
Y_HighGradeCancer             21 non-null int64
PSALevel                      21 non-null float64
CancerVol                     21 non-null float64
Weight                        21 non-null float64
Age                           21 non-null float64
BenignProstaticHyperplasia    21 non-null float64
SeminalVesicleInvasion        21 non-null int64
CapsularPenetration           21 non-null float64
dtypes: float64(6), int64(3)
memory usage: 1.6 KB
```

[5]:
```
df_train.columns
```

[5]:
```
Index(['Unnamed: 0', 'Y_HighGradeCancer', 'PSALevel', 'CancerVol', 'Weight',
       'Age', 'BenignProstaticHyperplasia', 'SeminalVesicleInvasion',
       'CapsularPenetration'],
      dtype='object')
```

It looks like R appended an additional "Unnamed: 0" column, most likely related to indexing. I will remove that now.

[6]:
```
# drop the redudent columns (R auto-created an index column of its own); can be␣
 ↪seen in info() cell above
df_train = df_train.drop(columns='Unnamed: 0')
df_test = df_test.drop(columns='Unnamed: 0')
```

[7]:
```
# examine train set
df_train.head()
```

[7]:

Obs	Y_HighGradeCancer	PSALevel	CancerVol	Weight	Age	BenignProstaticHyperplasia	SeminalVesicleInvasion	CapsularPenetration
1	0	-2.533700	-1.645747	-1.785921	-1.872101			
2	0	-2.299250	-1.995368	-0.673281	-0.791989			
3	0	-2.299250	-1.586043	-1.947772	1.368234			
4	0	-2.299250	-2.174506	-0.754163	-0.791989			
6	0	-1.488689	-2.046685	-0.855308	-1.872101			

```
Obs
1                    -0.840562                         0           -0.596573
2                    -0.840562                         0           -0.596573
3                    -0.840562                         0           -0.596573
4                    -0.840562                         0           -0.596573
6                    -0.840562                         0           -0.596573
```

[8]:
```
# examine test set
df_test.head()
```

[8]:
```
     Y_HighGradeCancer  PSALevel  CancerVol    Weight       Age  \
Obs
5                    0 -1.837148  -0.511447 -0.450690 -0.251933
8                    0 -1.418947  -0.562625 -0.228166 -0.791989
14                   0 -0.983519   0.111131 -1.320605  0.423137
17                   0 -0.878912  -1.509353 -0.268658  0.828178
23                   0 -0.678455  -1.611706 -0.551853 -0.656975

     BenignProstaticHyperplasia  SeminalVesicleInvasion  CapsularPenetration
Obs
5                    -0.840562                       0           -0.596573
8                     0.706307                       0           -0.596573
14                   -0.840562                       0           -0.596573
17                    0.305380                       0           -0.450762
23                   -0.691566                       0           -0.596573
```

[9]:
```
# create a list which captures fields to ommit from model
skip = ['Y_HighGradeCancer'
        , 'Age'
        , 'Weight'
        , 'BenignProstaticHyperplasia'
        , 'SeminalVesicleInvasion'
        , 'CapsularPenetration'
       ]
cols_model = [col for col in df_train.columns if col not in skip]
cols_model
```

[9]:
```
['PSALevel', 'CancerVol']
```

1.2 Data Preperation

Because R has already prepared the training and test sets, I will manually assign the split data to appropriate variables now.

[10]:
```
# train-test split
X_train = df_train.loc[:, cols_model]
y_train = df_train['Y_HighGradeCancer']
X_test = df_test.loc[:, cols_model]
```

```
y_test = df_test['Y_HighGradeCancer']
```

[11]:
```
print(X_train.shape, y_train.shape)
print(X_test.shape, y_test.shape)
```

```
(76, 2) (76,)
(21, 2) (21,)
```

[12]:
```
# average survival in train and test sets
print(f'Mean y in train set: {round(np.mean(y_train), 3)}')
print(f'Mean y in test set: {round(np.mean(y_test), 3)}')
```

```
Mean y in train set: 0.184
Mean y in test set: 0.333
```

1.3 Baseline Model

Developing a basline model: - Here, I will feed the dummy model training data, and sklearn will determine the most frequent classification within the Y_HighGradeCancer field (via prior analysis we know this to value to be 0). Because Y_HighGradeCancer = 0 most freqently, the model will be designed to predict 0 on every single observation. - After the design of the baseline model, I will implement it on both the training and testing data, and calculate accuracy scores and confusion matrixes for good measure. - Subsequent model fittings can therefore be compared to the baseline model.

[13]:
```
# import function
from sklearn.dummy import DummyClassifier
```

[14]:
```
# create model
# because mean y in train = 0.184 (shown above), this "most frequent" model␣
↪will predict y=0 for all test observations
model_dummy = DummyClassifier(strategy='most_frequent', random_state=0)
```

[15]:
```
# train model
model_dummy.fit(X_train, y_train)
```

[15]:
```
DummyClassifier(constant=None, random_state=0, strategy='most_frequent')
```

[16]:
```
# run dummy_model with training data
print(f'Score for baseline model (TRAINING): {round(model_dummy.score(X_train,␣
↪y_train), 2)}')

# run dummy_model with testing data
print(f'Score for baseline model (TESTING): {round(model_dummy.score(X_test,␣
↪y_test), 2)}')
```

```
Score for baseline model (TRAINING): 0.82
Score for baseline model (TESTING): 0.67
```

[17]:
```
# performance metrics
from sklearn.metrics import accuracy_score, confusion_matrix, precision_score,␣
↪recall_score
```

[18]:
```
# training confusion matrix
print(f'Confusion matrix for baseline model (TRAINING): \n␣
↪{confusion_matrix(y_train, model_dummy.predict(X_train))} \n')

# testing confusion matrix
print(f'Confusion matrix for baseline model (TESTING): \n␣
↪{confusion_matrix(y_test, model_dummy.predict(X_test))}')
```

```
Confusion matrix for baseline model (TRAINING):
 [[62  0]
 [14  0]]

Confusion matrix for baseline model (TESTING):
 [[14  0]
 [ 7  0]]
```

1.4 Statsmodels Library

1.4.1 Full Logistics Model

[19]:
```
import statsmodels.api as sm
```

[20]:
```
X_model = sm.add_constant(X_train)
model = sm.Logit(y_train, X_model)
```

```
C:\Users\jaosi\Anaconda3\envs\datSci\lib\site-
packages\numpy\core\fromnumeric.py:2389: FutureWarning: Method .ptp is
deprecated and will be removed in a future version. Use numpy.ptp instead.
  return ptp(axis=axis, out=out, **kwargs)
```

[21]:
```
results = model.fit()
```

```
Optimization terminated successfully.
         Current function value: 0.293604
         Iterations 8
```

[22]:
```
### full model statistical output
print(results.summary2(alpha=0.10))
```

```
                          Results: Logit
=================================================================
Model:              Logit            Pseudo R-squared: 0.385
Dependent Variable: Y_HighGradeCancer AIC:             50.6278
Date:               2020-11-23 02:07  BIC:             57.6200
No. Observations:   76               Log-Likelihood:   -22.314
Df Model:           2                LL-Null:          -36.307
```

```
Df Residuals:       73                LLR p-value:      8.3761e-07
Converged:          1.0000            Scale:            1.0000
No. Iterations:     8.0000
------------------------------------------------------------------
                Coef.   Std.Err.     z     P>|z|    [0.05    0.95]
------------------------------------------------------------------
const          -2.6867    0.6186  -4.3429  0.0000  -3.7042  -1.6691
PSALevel        1.0577    0.6198   1.7067  0.0879   0.0383   2.0772
CancerVol       1.5502    0.6859   2.2599  0.0238   0.4219   2.6784
==================================================================
```

[23]:
```
PSALevel_list = X_train['PSALevel'].tolist()
CancerVol_list = X_train['CancerVol'].tolist()
Y_HighGradeCancer_list = y_train.tolist()
```

[24]:
```
type(np.arange(1, 2, 0.5))
```

[24]:
```
numpy.ndarray
```

1.5 Advanced Visualizations Using Matplotlib

[25]:
```
import math
import matplotlib.pyplot as plt
from mpl_toolkits.mplot3d import Axes3D
import numpy as np
```

1.5.1 Logistic Regression Plot

[26]:
```
%matplotlib inline

# bring in and store the coefficients of the fitted model
const_coeff, x1_coeff, x2_coeff = results.params

# define a sigmoid function of 2 variables
def sigmoid(x1, x2):
    func = 1.0 / (1.0 + math.exp(-(const_coeff + x1_coeff*x1 + x2_coeff*x2)))
    return func

# design plot
fig = plt.figure()
ax = fig.add_subplot(111, projection='3d')
plt.tight_layout()
x = y = np.arange(-3.0, 4.0, 0.05)
X, Y = np.meshgrid(x, y)
zs = np.array([sigmoid(x,y) for x,y in zip(np.ravel(X), np.ravel(Y))])
Z = zs.reshape(X.shape)
```

```
# draw plots
ax.plot_surface(X, Y, Z, alpha=0.5)
ax.scatter(PSALevel_list, CancerVol_list, Y_HighGradeCancer_list, c='red',␣
 ↪marker='o')

# modify axes and labels
ax.set_xticklabels([])
ax.set_yticklabels([])
ax.set_zticklabels([0, 0, '', '', '', '', 1])
ax.set_xlabel('PSALevel')
ax.set_ylabel('CancerVol')
ax.set_zlabel('Y_HighGradeCancer')
ax.set_title('Prostate Cancer: Logistic Regression')
```

[26]: Text(0.5, 0.92, 'Prostate Cancer: Logistic Regression')