Introduction to Logistic Regression and Support Vector Machine Models

In [83]:
```
import pandas as pd
import numpy as np
from pandas import DataFrame
from sklearn.datasets import load_boston
X, y = load_boston(return_X_y=True)
X.shape, y.shape
```

Out[83]:
```
((506, 13), (506,))
```

In [84]:
```
from sklearn.linear_model import LogisticRegression
from sklearn.model_selection import train_test_split
#binary_y = np.array(y >= 40).astype(int)
X_train, X_test, y_train, y_test = train_test_split(X,
            binary_y, test_size=0.33, random_state=5)
logistic = LogisticRegression()
logistic.fit(X_train,y_train)
from sklearn.metrics import accuracy_score
print('In-sample accuracy: %0.3f' %
      accuracy_score(y_train, logistic.predict(X_train)))
print('Out-of-sample accuracy: %0.3f' %
      accuracy_score(y_test, logistic.predict(X_test)))
```

```
In-sample accuracy: 0.982
Out-of-sample accuracy: 0.964

/Users/admin/opt/anaconda3/lib/python3.7/site-packages/sklearn/linear_model/_logistic.py:940: Converge
nceWarning: lbfgs failed to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as shown in:
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Please also refer to the documentation for alternative solver options:
    https://scikit-learn.org/stable/modules/linear_model.html#logistic-regression (https://scikit-lear
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  extra_warning_msg=_LOGISTIC_SOLVER_CONVERGENCE_MSG)
```

In [85]:
```
boston=load_boston()
```

In [86]:
```
for var,coef in zip(boston.feature_names,
                    logistic.coef_[0]):
        print ("%7s : %7.3f" %(var, coef))
```

```
   CRIM :   0.070
     ZN :   0.004
  INDUS :   0.106
   CHAS :  -0.151
    NOX :   0.012
     RM :   1.084
    AGE :  -0.006
    DIS :  -0.258
    RAD :   0.541
    TAX :  -0.013
PTRATIO :  -0.936
      B :   0.031
  LSTAT :  -0.907
```

In [87]:
```
print('\nclasses:',logistic.classes_)
print('\nProbs:\n',logistic.predict_proba(X_test)[:3,:])
```

```

classes: [0 1]

Probs:
 [[2.41596449e-01 7.58403551e-01]
 [9.88748862e-01 1.12511385e-02]
 [9.99866981e-01 1.33018891e-04]]
```

Introduction to SVC Model

In [88]:

```python
import pandas as pd
import numpy as np
from pandas import Series,DataFrame
from sklearn.datasets import load_boston
boston=load_boston()
# Reset data as pandas DataFrame
boston_df = pd.DataFrame(boston.data)
# Label columns
boston_df.columns = boston.feature_names
# Show first five rows
boston_df.head()
```

Out[88]:

	CRIM	ZN	INDUS	CHAS	NOX	RM	AGE	DIS	RAD	TAX	PTRATIO	B	LSTAT
0	0.00632	18.0	2.31	0.0	0.538	6.575	65.2	4.0900	1.0	296.0	15.3	396.90	4.98
1	0.02731	0.0	7.07	0.0	0.469	6.421	78.9	4.9671	2.0	242.0	17.8	396.90	9.14
2	0.02729	0.0	7.07	0.0	0.469	7.185	61.1	4.9671	2.0	242.0	17.8	392.83	4.03
3	0.03237	0.0	2.18	0.0	0.458	6.998	45.8	6.0622	3.0	222.0	18.7	394.63	2.94
4	0.06905	0.0	2.18	0.0	0.458	7.147	54.2	6.0622	3.0	222.0	18.7	396.90	5.33

In [89]:

```python
# Define the label 'TAX CATEGORY'

def value_check(x):
    if x > 225:
        return 1
    else:
        return 0
boston_df['TAX_CAT'] = boston_df['TAX'].apply(value_check)
boston_df
```

Out[89]:

	CRIM	ZN	INDUS	CHAS	NOX	RM	AGE	DIS	RAD	TAX	PTRATIO	B	LSTAT	TAX_CAT
0	0.00632	18.0	2.31	0.0	0.538	6.575	65.2	4.0900	1.0	296.0	15.3	396.90	4.98	1
1	0.02731	0.0	7.07	0.0	0.469	6.421	78.9	4.9671	2.0	242.0	17.8	396.90	9.14	1
2	0.02729	0.0	7.07	0.0	0.469	7.185	61.1	4.9671	2.0	242.0	17.8	392.83	4.03	1
3	0.03237	0.0	2.18	0.0	0.458	6.998	45.8	6.0622	3.0	222.0	18.7	394.63	2.94	0
4	0.06905	0.0	2.18	0.0	0.458	7.147	54.2	6.0622	3.0	222.0	18.7	396.90	5.33	0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
501	0.06263	0.0	11.93	0.0	0.573	6.593	69.1	2.4786	1.0	273.0	21.0	391.99	9.67	1
502	0.04527	0.0	11.93	0.0	0.573	6.120	76.7	2.2875	1.0	273.0	21.0	396.90	9.08	1
503	0.06076	0.0	11.93	0.0	0.573	6.976	91.0	2.1675	1.0	273.0	21.0	396.90	5.64	1
504	0.10959	0.0	11.93	0.0	0.573	6.794	89.3	2.3889	1.0	273.0	21.0	393.45	6.48	1
505	0.04741	0.0	11.93	0.0	0.573	6.030	80.8	2.5050	1.0	273.0	21.0	396.90	7.88	1

506 rows × 14 columns

In [90]:

```python
y=boston_df['TAX_CAT']
```

In [91]:

```python
from sklearn.model_selection import train_test_split, cross_val_score
from sklearn.preprocessing import MinMaxScaler
# We keep 30% random examples for test
X_train, X_test, y_train, y_test = train_test_split(X,
                    y, test_size=0.3, random_state=101)
# We scale the data in the range [-1,1]
scaling = MinMaxScaler(feature_range=(-1, 1)).fit(X_train)
X_train = scaling.transform(X_train)
X_test  = scaling.transform(X_test)

from sklearn.svm import SVC
svm = SVC()
cv_performance = cross_val_score(svm, X_train, y_train,
                                 cv=10)
test_performance = svm.fit(X_train, y_train).score(X_test,
                                                   y_test)
print ('Cross-validation accuracy score: %0.3f,'
       ' test accuracy score: %0.3f'
       % (np.mean(cv_performance),test_performance))
```

```
Cross-validation accuracy score: 0.921, test accuracy score: 0.941
```

In [99]:
```
from sklearn.model_selection import train_test_split, cross_val_score
from sklearn.preprocessing import MinMaxScaler
# We keep 30% random examples for test
X_train, X_test, y_train, y_test = train_test_split(X,
                    y, test_size=0.3, random_state=101)
# We scale the data in the range [-1,1]
scaling = MinMaxScaler(feature_range=(-1, 1)).fit(X_train)
X_train = scaling.transform(X_train)
X_test  = scaling.transform(X_test)

from sklearn.linear_model import LogisticRegression
lr = LogisticRegression()
cv_performance_lr = cross_val_score(lr, X_train, y_train,
                                 cv=10)
test_performance_lr = lr.fit(X_train, y_train).score(X_test,
                                                  y_test)
print ('Cross-validation accuracy score: %0.3f,'
       ' test accuracy score: %0.3f'
       % (np.mean(cv_performance_lr),test_performance_lr))
```

```
Cross-validation accuracy score: 0.921, test accuracy score: 0.961
```

In [100]:
```
from sklearn.metrics import confusion_matrix, classification_report
from sklearn.model_selection import GridSearchCV
param_grid = {'C': [0.001, 0.01, 0.1, 0.5, 1, 10, 100]}
grid = GridSearchCV(lr, param_grid, scoring="roc_auc", cv=5)
lr_train = grid.fit(X_train, y_train)
pred_lr = lr_train.predict(X_test)
confusion = confusion_matrix(y_test, pred_lr)
print('Confusion Matrix: \n', confusion[::-1,::1])
print('Classification Report: ',classification_report(y_test, pred_lr))
```

```
Confusion Matrix:
 [[  3 140]
 [  8   1]]
Classification Report:                precision    recall  f1-score   support

           0       0.73      0.89      0.80         9
           1       0.99      0.98      0.99       143

    accuracy                           0.97       152
   macro avg       0.86      0.93      0.89       152
weighted avg       0.98      0.97      0.97       152


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n.org/stable/modules/linear_model.html#logistic-regression)
  extra_warning_msg=_LOGISTIC_SOLVER_CONVERGENCE_MSG)
```
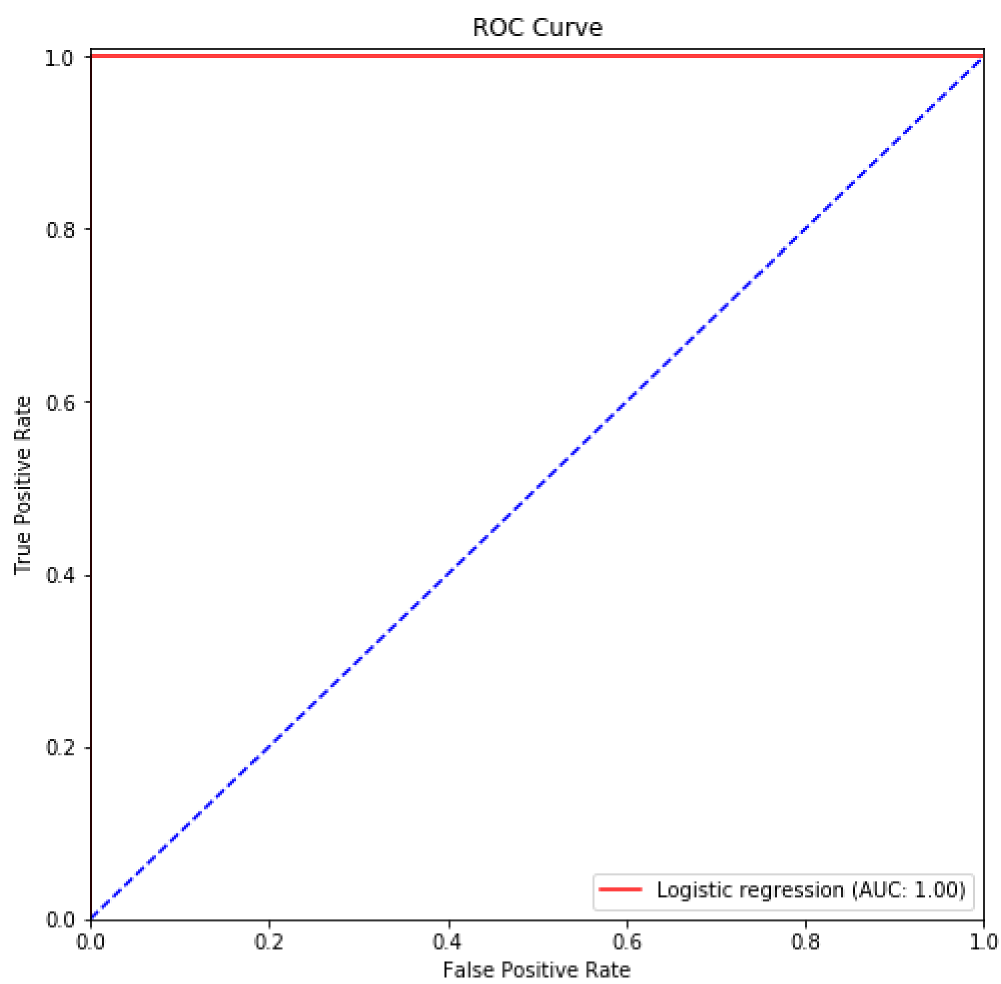

In [101]:
```
# Accuracy score
from sklearn.metrics import accuracy_score
print('LR Classification Accuracy Score: %0.2f'% accuracy_score(pred_lr, lr.predict(X_test)))
```

```
LR Classification Accuracy Score: 0.95
```

In [102]:
```
# Compute true and false predictions
i = confusion.shape
truePred = 0
falsePred = 0
for row in range(i[0]):
      for j in range(i[1]):
            if row == j:
                truePred +=confusion[row,j]
            else:
                falsePred += confusion[row,j]

print('True predictions: ', truePred)
print('\nFalse predictions', falsePred)
print('\nAccuracy of the model is: ', round(truePred/(confusion.sum()),2))
```

```
True predictions:  148

False predictions 4

Accuracy of the model is:  0.97
```

In [103]:
```
# Receiver Operating Curve (ROC)
Y_scores = lr.decision_function(X_test)
from sklearn.metrics import roc_curve
fpr, tpr, thresholds = roc_curve(pred_lr, Y_scores)

# Area Under the Curve (AUC)
from sklearn.metrics import auc
auc(fpr, tpr)

# ROC curve with Matplotlib
import matplotlib.pyplot as plt
%matplotlib inline
plt.figure(figsize=(8, 8))
plt.plot(fpr, tpr, color='red', label='Logistic regression (AUC: %.2f)'
% auc(fpr, tpr))
plt.plot([0, 1], [0, 1], color='blue', linestyle='--')
plt.xlim([0.0, 1.0])
plt.ylim([0.0, 1.01])
plt.title('ROC Curve')
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.legend(loc="lower right")
plt.show()
```



Using Pipeline to group tasks

In [113]:
```
from sklearn.pipeline import Pipeline
pipe = Pipeline([('scaling', MinMaxScaler()), ('lr', LogisticRegression())])
pipe.fit(X_train, y_train)
Pipeline(steps=[('scaling', MinMaxScaler()), ('lr', LogisticRegression())])
print('Pipe Score: \n%0.2f'% pipe.score(X_test, y_test))
```

```
Pipe Score:
0.94
```

Finding the Optimal SVC Model

In [114]:
```
from sklearn.model_selection import GridSearchCV
import numpy as np
best_SVC = SVC(kernel='linear', random_state=101)
search_space = [{'kernel': ['linear'],
                 'C': np.logspace(-3, 3, 7)},
                {'kernel': ['rbf'],
                 'C':np.logspace(-3, 3, 7),
                 'gamma': np.logspace(-3, 2, 6)}]
gridsearch = GridSearchCV(best_SVC,
                          param_grid=search_space,
                          refit=True, cv=10)
gridsearch.fit(X_train,y_train)
print ('Best parameter: %s'
       % str(gridsearch.best_params_))
print ('Best score: %s'
       % str(gridsearch.best_score_))
print ('Best index: %s'
       % str(gridsearch.best_index_))
```

```
Best parameter: {'C': 100.0, 'kernel': 'linear'}
Best score: 0.9971428571428571
Best index: 5
```

In [ ]: