

Space X Falcon 9 First Stage Landing Prediction

Assignment: Machine Learning Prediction

Estimated time needed: **60** minutes

Space X advertises Falcon 9 rocket launches on its website with a cost of 62 million dollars; other providers cost upward of 165 million dollars each, much of the savings is because Space X can reuse the first stage. Therefore if we can determine if the first stage will land, we can determine the cost of a launch. This information can be used if an alternate company wants to bid against space X for a rocket launch. In this lab, you will create a machine learning pipeline to predict if the first stage will land given the data from the preceding labs.



Several examples of an unsuccessful landing are shown here:



Most unsuccessful landings are planned. Space X; performs a controlled landing in the oceans.

Objectives

Perform exploratory Data Analysis and determine Training Labels

- create a column for the class
- Standardize the data
- Split into training data and test data

-Find best Hyperparameter for SVM, Classification Trees and Logistic Regression

- Find the method performs best using test data

Import Libraries and Define Auxiliary Functions

We will import the following libraries for the lab

```
In [1]: # Pandas is a software library written for the Python programming language for data manipulation and analysis
import pandas as pd
# NumPy is a library for the Python programming language, adding support for large, multi-dimensional arrays and matrices, along with a large library of high-level mathematical functions to operate on these arrays
import numpy as np
# Matplotlib is a plotting library for python and pyplot gives us a MatLab like plotting interface
import matplotlib.pyplot as plt
#Seaborn is a Python data visualization library based on matplotlib. It provides a high-level interface for creating attractive and informative statistical plots
import seaborn as sns
# Preprocessing allows us to standardize our data
from sklearn import preprocessing
# Allows us to split our data into training and testing data
from sklearn.model_selection import train_test_split
# Allows us to test parameters of classification algorithms and find the best one
from sklearn.model_selection import GridSearchCV
# Logistic Regression classification algorithm
from sklearn.linear_model import LogisticRegression
# Support Vector Machine classification algorithm
from sklearn.svm import SVC
# Decision Tree classification algorithm
```

```

from sklearn.tree import DecisionTreeClassifier
# K Nearest Neighbors classification algorithm
from sklearn.neighbors import KNeighborsClassifier

```

This function is to plot the confusion matrix.

```

In [2]: def plot_confusion_matrix(y,y_predict):
        "this function plots the confusion matrix"
        from sklearn.metrics import confusion_matrix

        cm = confusion_matrix(y, y_predict)
        ax= plt.subplot()
        sns.heatmap(cm, annot=True, ax = ax); #annot=True to annotate cells
        ax.set_xlabel('Predicted labels')
        ax.set_ylabel('True labels')
        ax.set_title('Confusion Matrix');
        ax.xaxis.set_ticklabels(['did not land', 'land']); ax.yaxis.set_ticklabels(['did not land', 'land'])
        plt.show()

```

Load the dataframe

Load the data

```

In [3]: data = pd.read_csv("dataset_part_final.csv")

```

```

In [4]: data.head()

```

```

Out[4]:

```

	FlightNumber	Date	BoosterVersion	PayloadMass	Orbit	LaunchSite	Outcome	Flights	GridFins
0	1	2010-06-04	Falcon 9	6104.959412	LEO	CCAFS SLC 40	None None	1	False
1	2	2012-05-22	Falcon 9	525.000000	LEO	CCAFS SLC 40	None None	1	False
2	3	2013-03-01	Falcon 9	677.000000	ISS	CCAFS SLC 40	None None	1	False
3	4	2013-09-29	Falcon 9	500.000000	PO	VAFB SLC 4E	False Ocean	1	False
4	5	2013-12-03	Falcon 9	3170.000000	GTO	CCAFS SLC 40	None None	1	False



```

In [5]: X = pd.read_csv('data_set_part2.csv')

```

```

In [6]: X.head(100)

```

Out[6]:

	FlightNumber	PayloadMass	Flights	Block	ReusedCount	Orbit_ES-L1	Orbit_GEO	Orbit_GTO	Orbi
0	1.0	6104.959412	1.0	1.0	0.0	0.0	0.0	0.0	
1	2.0	525.000000	1.0	1.0	0.0	0.0	0.0	0.0	
2	3.0	677.000000	1.0	1.0	0.0	0.0	0.0	0.0	
3	4.0	500.000000	1.0	1.0	0.0	0.0	0.0	0.0	
4	5.0	3170.000000	1.0	1.0	0.0	0.0	0.0	1.0	
...
85	86.0	15400.000000	2.0	5.0	2.0	0.0	0.0	0.0	
86	87.0	15400.000000	3.0	5.0	2.0	0.0	0.0	0.0	
87	88.0	15400.000000	6.0	5.0	5.0	0.0	0.0	0.0	
88	89.0	15400.000000	3.0	5.0	2.0	0.0	0.0	0.0	
89	90.0	3681.000000	1.0	5.0	0.0	0.0	0.0	0.0	

90 rows × 83 columns

TASK 1

Create a NumPy array from the column `Class` in `data`, by applying the method `to_numpy()` then assign it to the variable `Y`, make sure the output is a Pandas series (only one bracket `df['name of column']`).

```
In [7]: Y=data['Class'].to_numpy()
Y
```

```
Out[7]: array([0, 0, 0, 0, 0, 0, 1, 1, 0, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 1, 1, 1,
        1, 1, 0, 1, 1, 0, 1, 1, 0, 1, 1, 1, 0, 1, 1, 1, 1, 1, 1, 1, 1, 1,
        1, 0, 0, 0, 1, 1, 0, 0, 1, 1, 1, 1, 1, 1, 1, 0, 0, 1, 1, 1, 1, 1,
        1, 0, 1, 1, 1, 1, 0, 1, 0, 1, 0, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1,
        1, 1])
```

TASK 2

Standardize the data in `X` then reassign it to the variable `X` using the transform provided below.

```
In [8]: # students get this
transform = preprocessing.StandardScaler().fit(X).transform(X)
```

We split the data into training and testing data using the function `train_test_split`. The training data is divided into validation data, a second set used for training data; then the models are trained and hyperparameters are selected using the function `GridSearchCV`.

TASK 3

Use the function `train_test_split` to split the data `X` and `Y` into training and test data. Set the parameter `test_size` to 0.2 and `random_state` to 2. The training data and test data should be assigned to the following labels.

```
X_train, X_test, Y_train, Y_test
```

```
In [9]: 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=2)
```

we can see we only have 18 test samples.

```
In [10]: Y_test.shape
```

```
Out[10]: (18,)
```

TASK 4

Create a logistic regression object then create a `GridSearchCV` object `logreg_cv` with `cv = 10`. Fit the object to find the best parameters from the dictionary `parameters`.

```
In [11]: parameters = {'C':[0.01,0.1,1],
                        'penalty':['l2'],
                        'solver':['lbfgs']}
```

```
In [12]: parameters = {"C":[0.01,0.1,1], 'penalty':['l2'], 'solver':['lbfgs']}# L1 Lasso L2 ridge
from sklearn.linear_model import LogisticRegression

lr=LogisticRegression()
gridsearch=GridSearchCV(lr,parameters,cv=10)
logreg_cv=gridsearch.fit(X_train,Y_train)
```

```
/opt/conda/lib/python3.8/site-packages/sklearn/linear_model/_logistic.py:814: ConvergeWarning: 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:
  https://scikit-learn.org/stable/modules/preprocessing.html
Please also refer to the documentation for alternative solver options:
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We output the `GridSearchCV` object for logistic regression. We display the best parameters using the data attribute `best_params_` and the accuracy on the validation data using the data attribute `best_score_`.

```
In [13]: print("tuned hpyerparameters :(best parameters) ",logreg_cv.best_params_)  
print("accuracy :",logreg_cv.best_score_)  
  
tuned hpyerparameters :(best parameters) {'C': 0.1, 'penalty': 'l2', 'solver': 'lbfg  
s'}  
accuracy : 0.8196428571428571
```

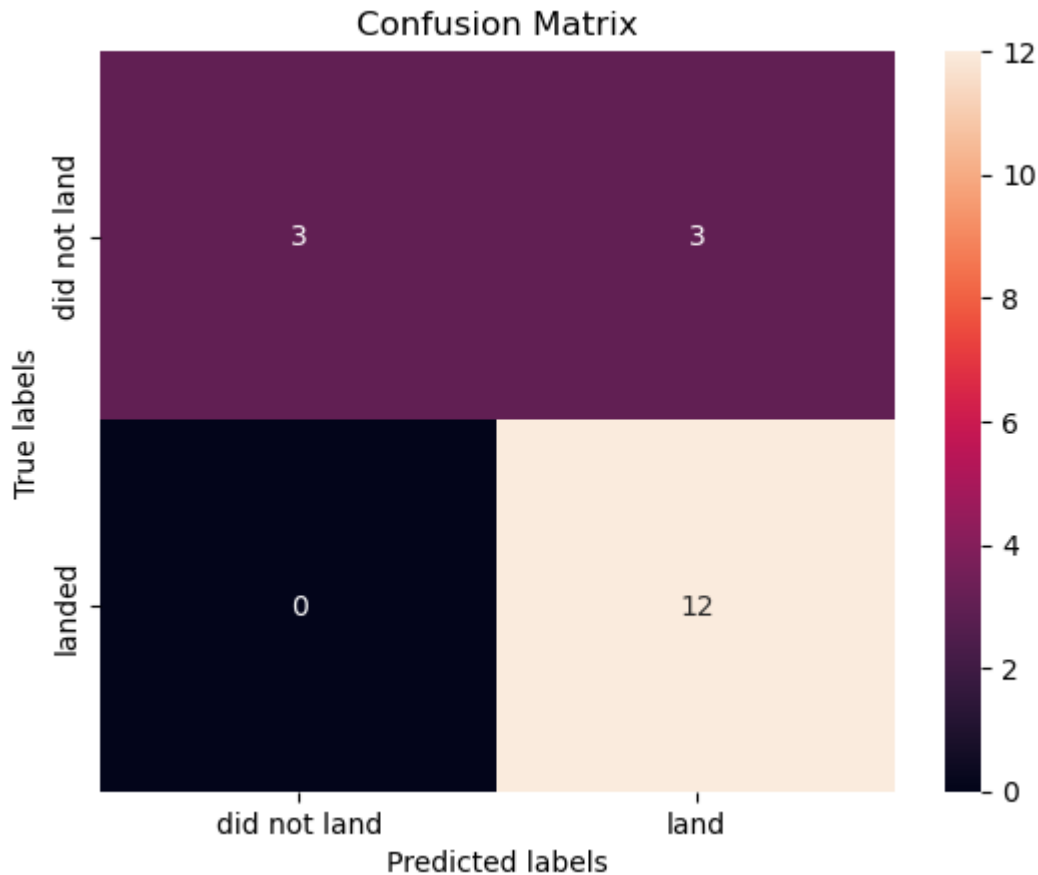
TASK 5

Calculate the accuracy on the test data using the method `score`:

```
In [14]: logreg_cv.score(X_test,Y_test)  
  
Out[14]: 0.8333333333333334
```

Lets look at the confusion matrix:


```
In [15]: yhat=logreg_cv.predict(X_test)
plot_confusion_matrix(Y_test,yhat)
```



Examining the confusion matrix, we see that logistic regression can distinguish between the different classes. We see that the major problem is false positives.

TASK 6

Create a support vector machine object then create a `GridSearchCV` object `svm_cv` with `cv = 10`. Fit the object to find the best parameters from the dictionary `parameters`.

```
In [16]: parameters = {'kernel':('linear', 'rbf','poly','rbf', 'sigmoid'),
                        'C': np.logspace(-3, 3, 5),
                        'gamma':np.logspace(-3, 3, 5)}
```

```
In [17]: from sklearn import svm
clf=svm.SVC()
from sklearn.preprocessing import MinMaxScaler
scaling = MinMaxScaler(feature_range=(-1,1)).fit(X_train)
X_train1 = scaling.transform(X_train)
X_test1 = scaling.transform(X_test)
grids=GridSearchCV(clf,parameters,scoring='accuracy',cv=10)
svm_cv=grids.fit(X_train1,Y_train)
```

```
In [18]: print("tuned hpyerparameters :(best parameters) ",svm_cv.best_params_)
print("accuracy :",svm_cv.best_score_)
```



```
'min_samples_leaf': [1, 2, 4],  
'min_samples_split': [2, 5, 10]}
```

```
tree = DecisionTreeClassifier()
```

```
In [22]: tree_2=GridSearchCV(tree,parameters,cv=10)  
tree_cv=tree_2.fit(X_train,Y_train)
```

```
In [23]: print("tuned hpyerparameters :(best parameters) ",tree_cv.best_params_)  
print("accuracy :",tree_cv.best_score_)
```

```
tuned hpyerparameters :(best parameters) {'criterion': 'entropy', 'max_depth': 6, 'max_features': 'sqrt', 'min_samples_leaf': 4, 'min_samples_split': 10, 'splitter': 'random'}  
accuracy : 0.8857142857142858
```

TASK 9

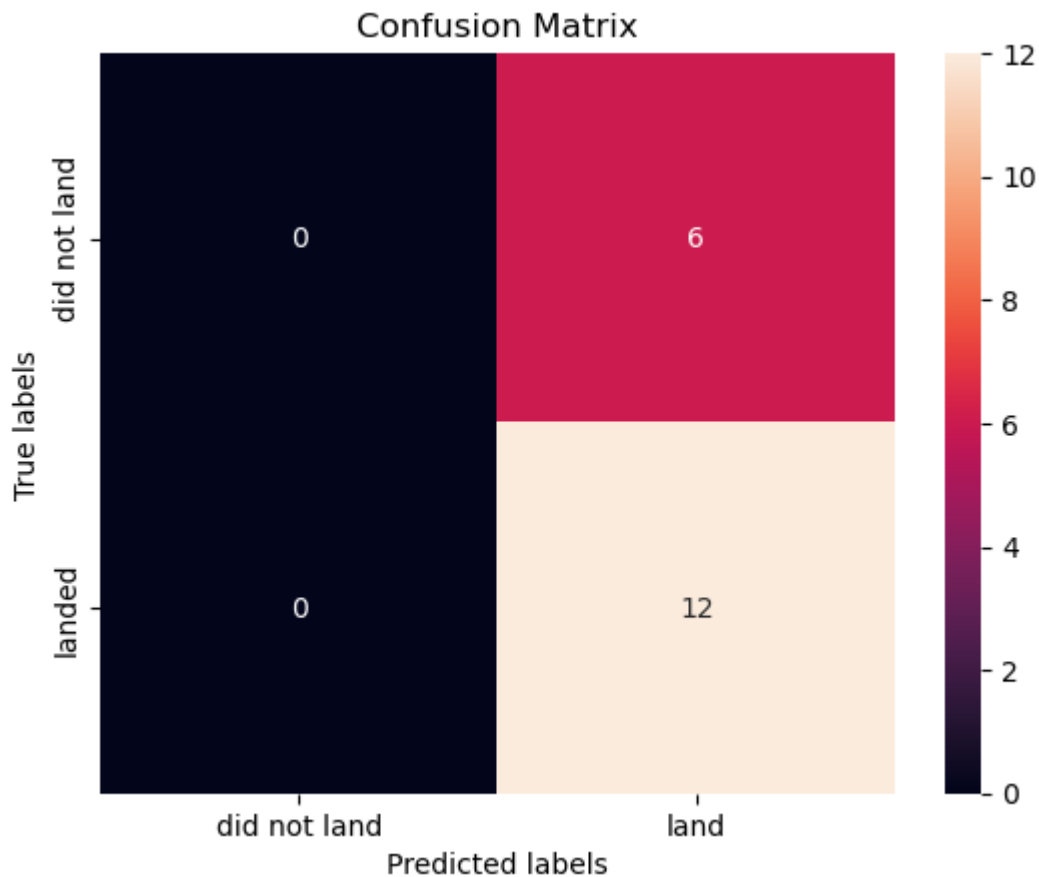
Calculate the accuracy of tree_cv on the test data using the method `score` :

```
In [41]: tree_cv.score(X_test,Y_test)
```

```
Out[41]: 0.6666666666666666
```

We can plot the confusion matrix

```
In [25]: yhat = tree_cv.predict(X_test)  
plot_confusion_matrix(Y_test,yhat)
```



TASK 10

Create a k nearest neighbors object then create a `GridSearchCV` object `knn_cv` with `cv = 10`. Fit the object to find the best parameters from the dictionary `parameters`.

```
In [26]: parameters = {'n_neighbors': [1, 2, 3, 4, 5, 6, 7, 8, 9, 10],  
                      'algorithm': ['auto', 'ball_tree', 'kd_tree', 'brute'],  
                      'p': [1,2]}
```

```
In [30]: from sklearn.neighbors import KNeighborsClassifier  
KNN = KNeighborsClassifier()  
grido=GridSearchCV(KNN,parameters,scoring='accuracy',cv=10)  
knn_cv=grido.fit(X_train,Y_train)
```



```
r which the statistic is taken will be eliminated, and the value None will no longer
be accepted. Set `keepdims` to True or False to avoid this warning.
mode, _ = stats.mode(y[neigh_ind, k], axis=1)
/opt/conda/lib/python3.8/site-packages/sklearn/neighbors/_classification.py:228: Futu
reWarning: Unlike other reduction functions (e.g. `skew`, `kurtosis`), the default be
havior of `mode` typically preserves the axis it acts along. In SciPy 1.11.0, this be
havior will change: the default value of `keepdims` will become False, the `axis` ove
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```

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```

```
mode, _ = stats.mode(y[neigh_ind, k], axis=1)
```

```
In [31]: print("tuned hpyerparameters :(best parameters) ",knn_cv.best_params_)
print("accuracy :",knn_cv.best_score_)
```

```
tuned hpyerparameters :(best parameters) {'algorithm': 'auto', 'n_neighbors': 3,
'p': 1}
accuracy : 0.6642857142857143
```

TASK 11

Calculate the accuracy of knn_cv on the test data using the method `score` :

```
In [36]: knn_cv.score(X_test,Y_test)
```

```
/opt/conda/lib/python3.8/site-packages/sklearn/neighbors/_classification.py:228: FutureWarning: Unlike other reduction functions (e.g. `skew`, `kurtosis`), the default behavior of `mode` typically preserves the axis it acts along. In SciPy 1.11.0, this behavior will change: the default value of `keepdims` will become False, the `axis` over which the statistic is taken will be eliminated, and the value None will no longer be accepted. Set `keepdims` to True or False to avoid this warning.
```

```
mode, _ = stats.mode(y[neigh_ind, k], axis=1)
```

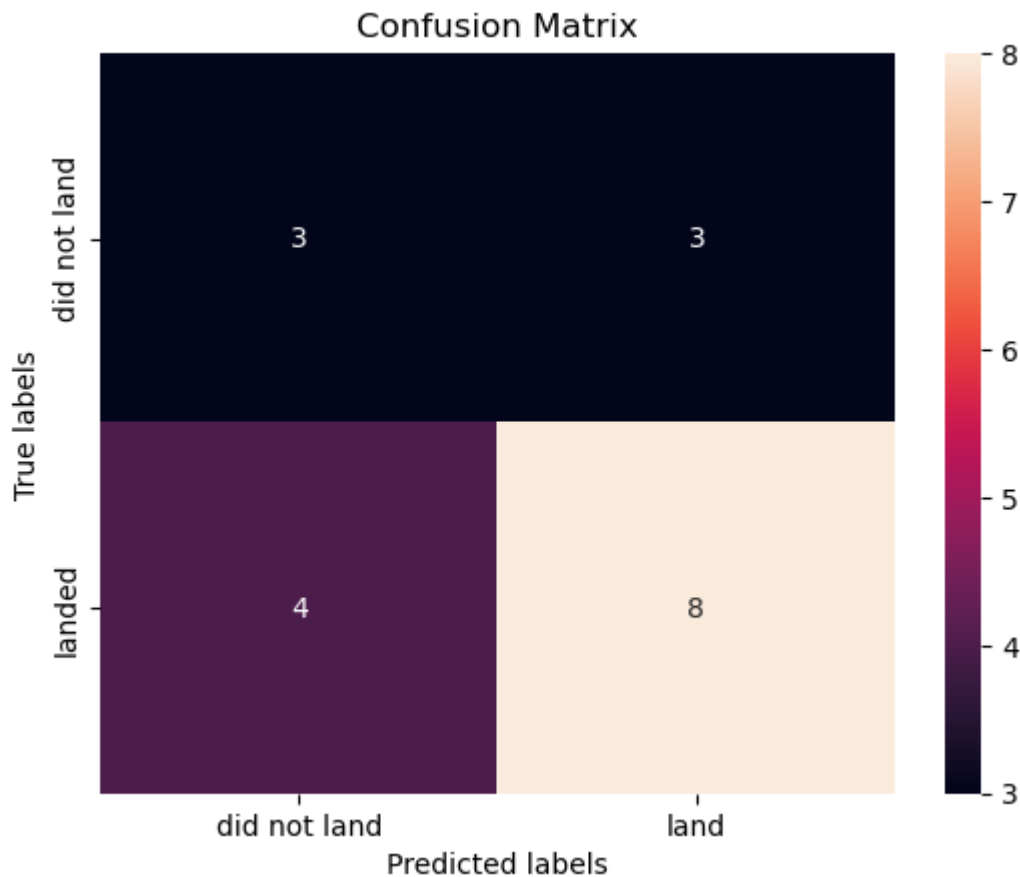
```
Out[36]: 0.6111111111111112
```

We can plot the confusion matrix

```
In [35]: yhat = knn_cv.predict(X_test)
plot_confusion_matrix(Y_test,yhat)
```

```
/opt/conda/lib/python3.8/site-packages/sklearn/neighbors/_classification.py:228: FutureWarning: Unlike other reduction functions (e.g. `skew`, `kurtosis`), the default behavior of `mode` typically preserves the axis it acts along. In SciPy 1.11.0, this behavior will change: the default value of `keepdims` will become False, the `axis` over which the statistic is taken will be eliminated, and the value None will no longer be accepted. Set `keepdims` to True or False to avoid this warning.
```

```
mode, _ = stats.mode(y[neigh_ind, k], axis=1)
```



TASK 12

Find the method performs best:

```
In [43]: print('accuracy logistic regresion: ', logreg_cv.score(X_test,Y_test))
print('accuracy support vector machine: ', svm_cv.score(X_test1,Y_test))
print ('accuracy tree: ', tree_cv.score(X_test,Y_test))
print ('accuracy k nearest neighbors: ', knn_cv.score(X_test,Y_test))
print('best is logistic and svm')
```

```
accuracy logistic regresion:  0.8333333333333334
accuracy support vector machine:  0.8333333333333334
accuracy tree:  0.6666666666666666
accuracy k nearest neighbors:  0.6111111111111112
best is logistic and svm
```

```
/opt/conda/lib/python3.8/site-packages/sklearn/neighbors/_classification.py:228: FutureWarning: Unlike other reduction functions (e.g. `skew`, `kurtosis`), the default behavior of `mode` typically preserves the axis it acts along. In SciPy 1.11.0, this behavior will change: the default value of `keepdims` will become False, the `axis` over which the statistic is taken will be eliminated, and the value None will no longer be accepted. Set `keepdims` to True or False to avoid this warning.
  mode, _ = stats.mode(_y[neigh_ind, k], axis=1)
```

Authors

Pratiksha Verma

Change Log

Date (YYYY-MM-DD)	Version	Changed By	Change Description
2022-11-09	1.0	Pratiksha Verma	Converted initial version to Jupyterlite

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