In [ ]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
```

In [ ]:
```
from sklearn.datasets import load_digits
digits = load_digits()
```

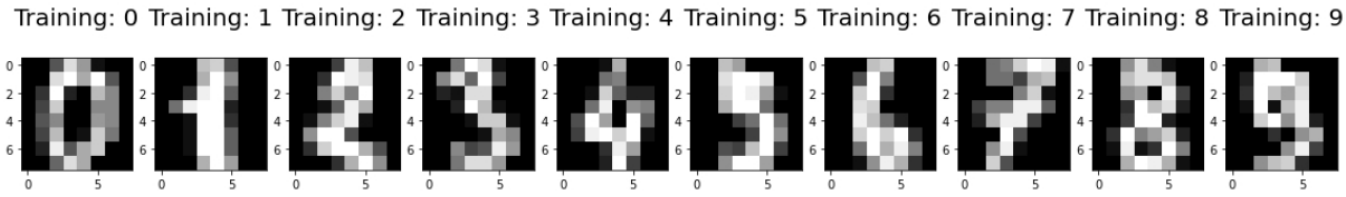
In [ ]:
```
X = digits.data
digits.data.shape
```

Out[ ]:
```
(1797, 64)
```

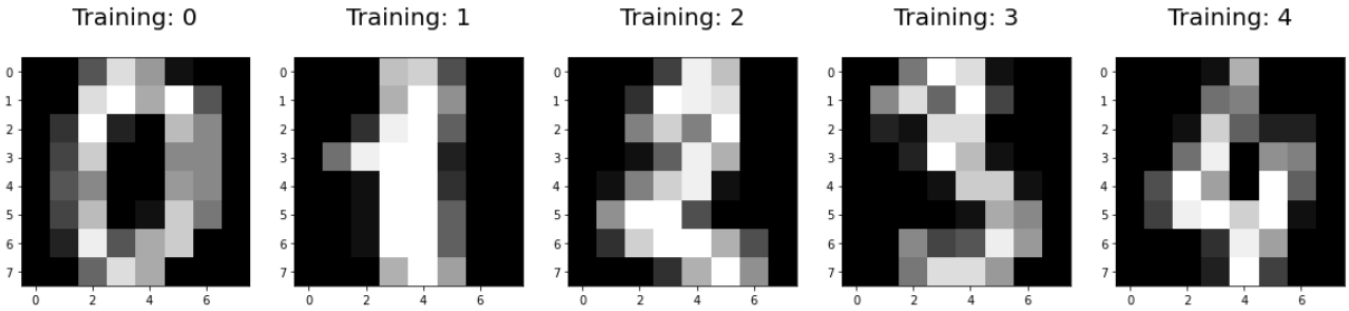
In [ ]:
```
y = digits.target
digits.target.shape
```

Out[ ]:
```
(1797,)
```

In [ ]:
```
plt.figure(figsize = (20,4))
for index, (image, label) in enumerate(zip(digits.data[0:10], digits.target[0:10])):
    plt.subplot(1, 10, index+1)
    plt.imshow(np.reshape(image,(8,8)), cmap = plt.cm.gray)
    plt.title("Training: %i\n" % label, fontsize = 20)
```



In [ ]:
```
plt.figure(figsize = (20,4))
for index, (image, label) in enumerate(zip(digits.data[0:5], digits.target[0:5])):
    plt.subplot(1, 5, index+1)
    plt.imshow(np.reshape(image,(8,8)), cmap = plt.cm.gray)
    plt.title("Training: %i\n" % label, fontsize = 20)
```



In [ ]:
```
# help(plt)
```

In [ ]:
```
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 =0)
```

In [ ]:
```
print("Trained input data: ", X_train.shape)
```

```
Trained input data:  (1437, 64)
```

In [ ]:
```
from sklearn.linear_model import LogisticRegression
model = LogisticRegression().fit(X_train, y_train)
model
```

```
C:\Users\Sehrish\anaconda3\lib\site-packages\sklearn\linear_model\_logistic.py:763: ConvergenceWarning: lbfgs failed to converge (statu
s=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:
    https://scikit-learn.org/stable/modules/linear_model.html#logistic-regression
```

```
  n_iter_i = _check_optimize_result(
```

Out[ ]:
```
LogisticRegression()
```

In [ ]:
```
model.predict(X_test[0:5])
# model.predict(X_test)
```

Out[ ]:
```
array([2, 8, 2, 6, 6])
```

In [ ]:
```
score = model.score(X_test, y_test)
print("Acuuracy score is : " ,score)
```

```
Acuuracy score is :  0.9666666666666667
```

In [ ]:
```
from sklearn import metrics
# from sklearn.metrics import confusion_matrix
predictions = model.predict(X_test)
cm = metrics.confusion_matrix(y_test, predictions)
cm
```

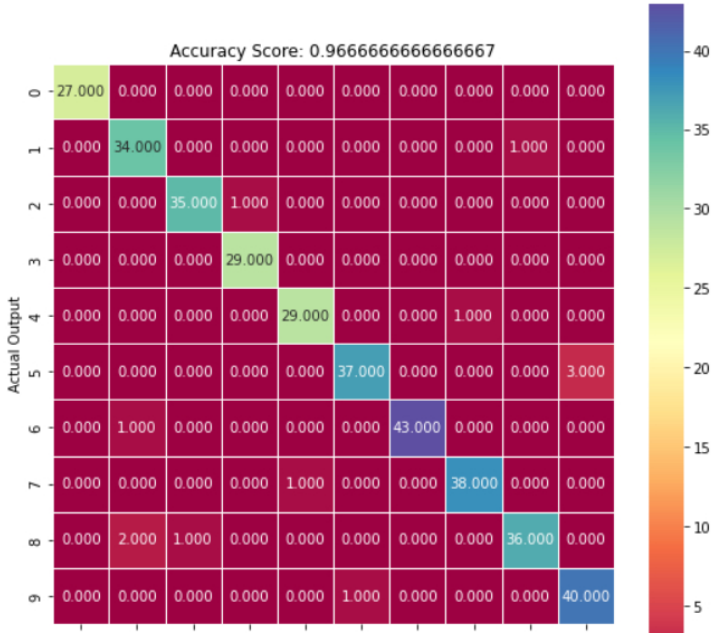
Out[ ]:
```
array([[27,  0,  0,  0,  0,  0,  0,  0,  0,  0],
       [ 0, 34,  0,  0,  0,  0,  0,  0,  1,  0],
       [ 0,  0, 35,  1,  0,  0,  0,  0,  0,  0],
       [ 0,  0,  0, 29,  0,  0,  0,  0,  0,  0],
       [ 0,  0,  0,  0, 29,  0,  0,  1,  0,  0],
       [ 0,  0,  0,  0,  0, 37,  0,  0,  0,  3],
       [ 0,  1,  0,  0,  0,  0, 43,  0,  0,  0],
       [ 0,  0,  0,  0,  1,  0,  0, 38,  0,  0],
       [ 0,  2,  1,  0,  0,  0,  0,  0, 36,  0],
       [ 0,  0,  0,  0,  0,  1,  0,  0,  0, 40]], dtype=int64)
```

In [ ]:
```
print(pd.crosstab(y_test, predictions))
```

```
col_0   0   1   2   3   4   5   6   7   8   9
row_0
0      27   0   0   0   0   0   0   0   0   0
1       0  34   0   0   0   0   0   0   1   0
2       0   0  35   1   0   0   0   0   0   0
3       0   0   0  29   0   0   0   0   0   0
4       0   0   0   0  29   0   0   1   0   0
5       0   0   0   0   0  37   0   0   0   3
6       0   1   0   0   0   0  43   0   0   0
7       0   0   0   0   1   0   0  38   0   0
8       0   2   1   0   0   0   0   0  36   0
9       0   0   0   0   0   1   0   0   0  40
```

In [ ]:
```
# heat map
import seaborn as sns
plt.figure(figsize=(9,9))
sns.heatmap(cm, annot=True, fmt = ".3f", linewidths=.5, square = True,cmap = 'Spectral')
plt.ylabel("Actual Output");
plt.xlabel("Printed Output");
all_sample_title = "Accuracy Score: {0}".format(score)
plt.title(all_sample_title)
```

Out[ ]:
```
Text(0.5, 1.0, 'Accuracy Score: 0.9666666666666667')
```



In [ ]:
```
print(cm)
```

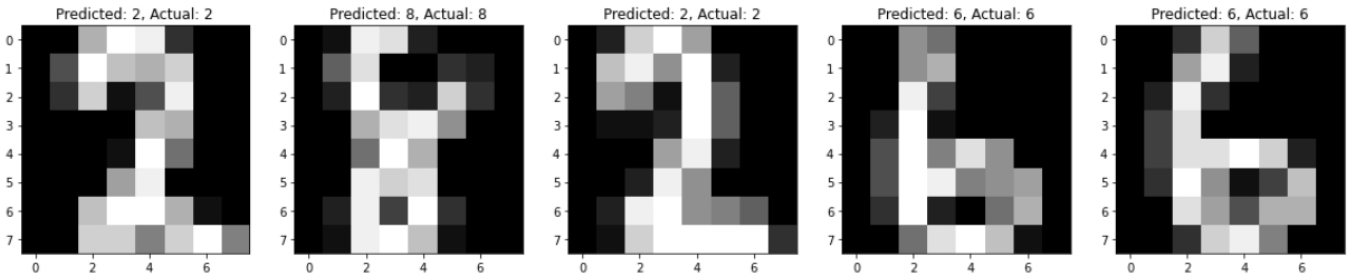
```
[[27  0  0  0  0  0  0  0  0  0]
 [ 0 34  0  0  0  0  0  0  1  0]
 [ 0  0 35  1  0  0  0  0  0  0]
 [ 0  0  0 29  0  0  0  0  0  0]
 [ 0  0  0  0 29  0  0  1  0  0]
 [ 0  0  0  0  0 37  0  0  0  3]
 [ 0  1  0  0  0  0 43  0  0  0]
 [ 0  0  0  0  1  0  0 38  0  0]
 [ 0  2  1  0  0  0  0  0 36  0]
 [ 0  0  0  0  0  1  0  0  0 40]]
```

In [ ]:
```
index = 0
misclassifiedIndexes = []
for label, predict in zip(y_test, predictions):
    if label != predict:
        misclassifiedIndexes.append(index)
        index +=1

misclassifiedIndexes
```

Out[ ]:
```
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11]
```

In [ ]:
```
plt.figure(figsize = (20,4))
for plotIndex, badIndex in enumerate(misclassifiedIndexes[0:5]):
    plt.subplot(1,5, plotIndex+1)
    plt.imshow(np.reshape(X_test[badIndex],(8,8)), cmap = plt.cm.gray)
    plt.title("Predicted: {}, Actual: {}".format(predictions[badIndex], y_test[badIndex], fontsize= 20))
```



In [ ]:
```

```

In [ ]:
```
logisticRegr = LogisticRegression(solver = 'lbfgs')
```

In [ ]:
```
logisticRegr.fit(X_train, y_train)
```

```
C:\Users\Sehrish\anaconda3\lib\site-packages\sklearn\linear_model\_logistic.py:763: ConvergenceWarning: lbfgs failed to converge (statu
s=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:
    https://scikit-learn.org/stable/modules/linear_model.html#logistic-regression
  n_iter_i = _check_optimize_result(
```

Out[ ]:
```
LogisticRegression()
```

In [ ]:
```
logisticRegr.predict(X_train[0].reshape(1,-1))
```

Out[ ]:
```
array([6])
```

In [ ]:
```
logisticRegr.predict(X_test[0:10])
```

Out[ ]:
```
array([2, 8, 2, 6, 6, 7, 1, 9, 8, 5])
```

In [ ]:
```
predictions = logisticRegr.predict(X_test)
predictions
```

Out[ ]:
```
array([2, 8, 2, 6, 6, 7, 1, 9, 8, 5, 2, 8, 6, 6, 6, 6, 1, 0, 5, 8, 8, 7,
       8, 4, 7, 5, 4, 9, 2, 9, 4, 7, 6, 8, 9, 4, 3, 1, 0, 1, 8, 6, 7, 7,
```

```
1, 0, 7, 6, 2, 1, 9, 6, 7, 9, 0, 0, 9, 1, 6, 3, 0, 2, 3, 4, 1, 9,
2, 6, 9, 1, 8, 3, 5, 1, 2, 8, 2, 2, 9, 7, 2, 3, 6, 0, 9, 3, 7, 5,
1, 2, 9, 9, 3, 1, 4, 7, 4, 8, 5, 8, 5, 5, 2, 5, 9, 0, 7, 1, 4, 7,
3, 4, 8, 9, 7, 9, 8, 2, 1, 5, 2, 5, 8, 4, 1, 7, 0, 6, 1, 5, 5, 9,
9, 5, 9, 9, 5, 7, 5, 6, 2, 8, 6, 9, 6, 1, 5, 1, 5, 9, 9, 1, 5, 3,
6, 1, 8, 9, 8, 7, 6, 7, 6, 5, 6, 0, 8, 8, 9, 8, 6, 1, 0, 4, 1, 6,
3, 8, 6, 7, 4, 9, 6, 3, 0, 3, 3, 3, 0, 7, 7, 5, 7, 8, 0, 7, 1, 9,
6, 4, 5, 0, 1, 4, 6, 4, 3, 3, 0, 9, 5, 9, 2, 1, 4, 2, 1, 6, 8, 9,
2, 4, 9, 3, 7, 6, 2, 3, 3, 1, 6, 9, 3, 6, 3, 3, 2, 0, 7, 6, 1, 1,
9, 7, 2, 7, 8, 5, 5, 7, 5, 2, 3, 7, 2, 7, 5, 5, 7, 0, 9, 1, 6, 5,
9, 7, 4, 3, 8, 0, 3, 6, 4, 6, 3, 2, 6, 8, 8, 8, 4, 6, 7, 5, 2, 4,
5, 3, 2, 4, 6, 9, 4, 5, 4, 3, 4, 6, 2, 9, 0, 1, 7, 2, 0, 9, 6, 0,
4, 2, 0, 7, 9, 8, 5, 7, 8, 2, 8, 4, 3, 7, 2, 6, 9, 1, 5, 1, 0, 8,
2, 8, 9, 5, 6, 2, 2, 7, 2, 1, 5, 1, 6, 4, 5, 0, 9, 4, 1, 1, 7, 0,
8, 9, 0, 5, 4, 3, 8, 8])
```

In [ ]:
```
score = logisticRegr.score(X_test, y_test)
print(score)
```

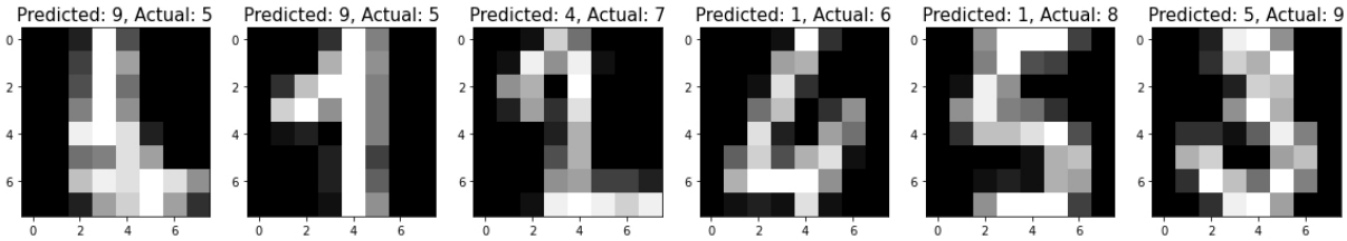
```
0.9666666666666667
```

In [ ]:
```
index = 0
misclassifiedIndexes = []
for label, predict in zip(y_test, predictions):
    if label != predict:
        misclassifiedIndexes.append(index)
    index +=1

misclassifiedIndexes
```

Out[ ]:
```
[56, 84, 94, 118, 124, 130, 181, 196, 235, 315, 331, 335]
```

In [ ]:
```
plt.figure(figsize=(20,4))
for plotIndex, badIndex in enumerate(misclassifiedIndexes[0:6]):
 plt.subplot(1,6, plotIndex + 1)
 plt.imshow(np.reshape(X_train[badIndex], (8,8)), cmap=plt.cm.gray)
 plt.title("Predicted: {}, Actual: {}".format(predictions[badIndex], y_test[badIndex]), fontsize = 15)
```



In [ ]:
```
plt.figure(figsize=(20,4))
for plotIndex, badIndex in enumerate(misclassifiedIndexes[6:13]):
 plt.subplot(1,6, plotIndex + 1)
 plt.imshow(np.reshape(X_train[badIndex], (8,8)), cmap=plt.cm.gray)
 plt.title("Predicted: {}, Actual: {}".format(predictions[badIndex], y_test[badIndex]), fontsize = 15)
```