Title of Project

Handwritten Digit Prediction - Classification Analysis

Objective

The objective of this project is to build a machine learning model that can accurately predict handwritten digits.

Data Source

The dataset used for this project is the "digits" dataset from scikit-learn's built-in datasets. It contains images of handwritten digits, where each image is an 8x8 pixel matrix, and the target variable represents the actual digit value (0-9).

Import Library

In [1]:

```
from sklearn.datasets import load_digits
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import StandardScaler
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import accuracy_score, confusion_matrix, classificati
```

Import Data

In [2]:

```
# Load the digits dataset
digits = load_digits()
```

Describe Data

In [3]:

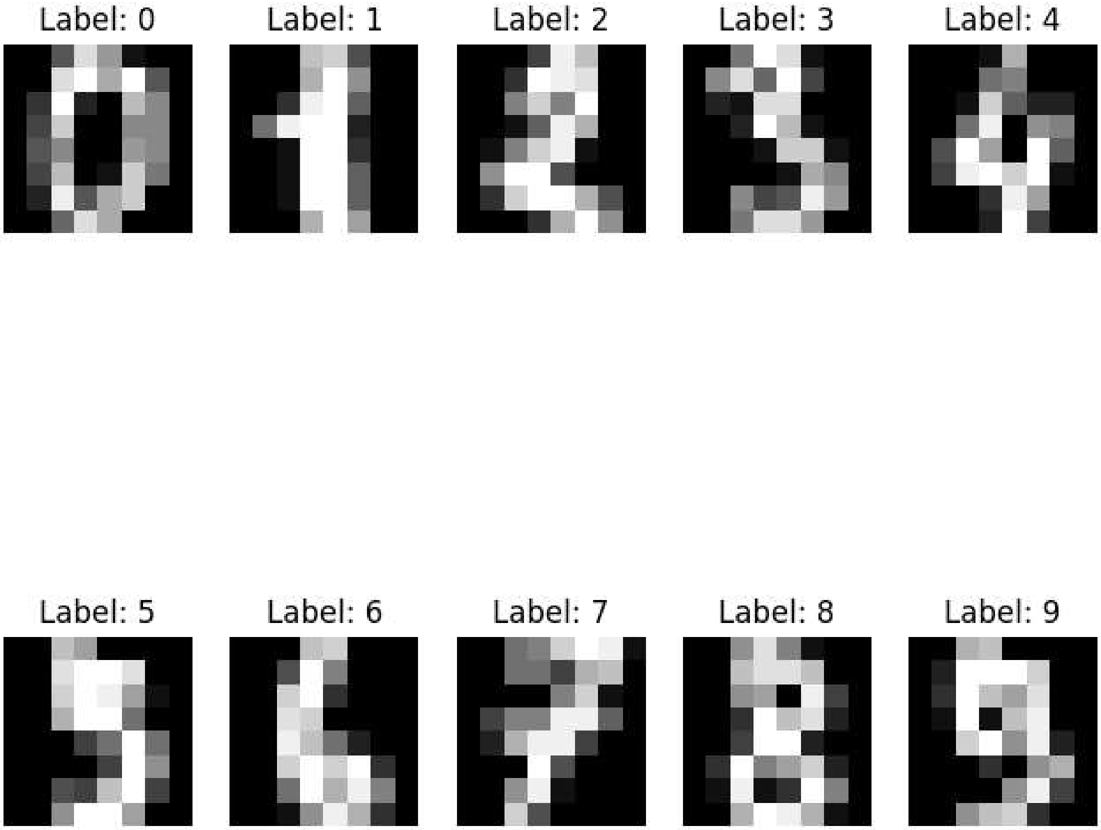
```
# Get information about the dataset
print(digits.DESCR)
```

```
.. _digits_dataset:

Optical recognition of handwritten digits dataset
--------------------------------------------------

**Data Set Characteristics:**

    :Number of Instances: 1797
    :Number of Attributes: 64
    :Attribute Information: 8x8 image of integer pixels in the range 0..1
6.
    :Missing Attribute Values: None
    :Creator: E. Alpaydin (alpaydin '@' boun.edu.tr)
    :Date: July; 1998

This is a copy of the test set of the UCI ML hand-written digits datasets
https://archive.ics.uci.edu/ml/datasets/Optical+Recognition+of+Handwritte
n+Digits (https://archive.ics.uci.edu/ml/datasets/Optical+Recognition+of+
Handwritten+Digits)

The data set contains images of hand-written digits: 10 classes where
each class refers to a digit.

Preprocessing programs made available by NIST were used to extract
normalized bitmaps of handwritten digits from a preprinted form. From a
total of 43 people, 30 contributed to the training set and different 13
to the test set. 32x32 bitmaps are divided into nonoverlapping blocks of
4x4 and the number of on pixels are counted in each block. This generates
an input matrix of 8x8 where each element is an integer in the range
0..16. This reduces dimensionality and gives invariance to small
distortions.

For info on NIST preprocessing routines, see M. D. Garris, J. L. Blue, G.
T. Candela, D. L. Dimmick, J. Geist, P. J. Grother, S. A. Janet, and C.
L. Wilson, NIST Form-Based Handprint Recognition System, NISTIR 5469,
1994.

.. topic:: References

  - C. Kaynak (1995) Methods of Combining Multiple Classifiers and Their
    Applications to Handwritten Digit Recognition, MSc Thesis, Institute
of
    Graduate Studies in Science and Engineering, Bogazici University.
  - E. Alpaydin, C. Kaynak (1998) Cascading Classifiers, Kybernetika.
  - Ken Tang and Ponnuthurai N. Suganthan and Xi Yao and A. Kai Qin.
    Linear dimensionalityreduction using relevance weighted LDA. School o
f
    Electrical and Electronic Engineering Nanyang Technological Universit
y.
    2005.
  - Claudio Gentile. A New Approximate Maximal Margin Classification
    Algorithm. NIPS. 2000.
```

Data Visualization

In [4]:

```
# Visualize a few sample images from the dataset
plt.figure(figsize=(8, 8))
for i in range(10):
    plt.subplot(2, 5, i + 1)
    plt.imshow(digits.images[i], cmap='gray')
    plt.title(f"Label: {digits.target[i]}")
    plt.axis('off')
plt.show()
```



Data Preprocessing

In [5]:

```
# Flatten the 8x8 images into a 1D array for feature variables
X = digits.data

# Normalize feature variables
scaler = StandardScaler()
X = scaler.fit_transform(X)

# Define the target variable (y)
y = digits.target
```

Train Test Split

In [6]:

```
# Split the dataset into training and testing sets
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, r
```

Modeling

In [7]:

```
# Initialize the logistic regression model
model = LogisticRegression()

# Train the model on the training data
model.fit(X_train, y_train)
```

Out[7]:

```
LogisticRegression()
```

In a Jupyter environment, please rerun this cell to show the HTML representation or trust the notebook.
On GitHub, the HTML representation is unable to render, please try loading this page with nbviewer.org.

Model Evaluation

In [8]:

```
# Make predictions on the test data
y_pred = model.predict(X_test)

# Evaluate the model's accuracy
accuracy = accuracy_score(y_test, y_pred)
print("Accuracy:", accuracy)

# Generate confusion matrix and classification report
conf_matrix = confusion_matrix(y_test, y_pred)
class_report = classification_report(y_test, y_pred)
print("Confusion Matrix:")
print(conf_matrix)
print("Classification Report:")
print(class_report)
```

```
Accuracy: 0.9722222222222222
Confusion Matrix:
[[33  0  0  0  0  0  0  0  0  0]
 [ 0 28  0  0  0  0  0  0  0  0]
 [ 0  0 33  0  0  0  0  0  0  0]
 [ 0  0  0 33  0  1  0  0  0  0]
 [ 0  1  0  0 45  0  0  0  0  0]
 [ 0  0  0  0  0 44  1  0  0  2]
 [ 0  0  0  0  0  1 34  0  0  0]
 [ 0  0  0  0  0  0  0 33  0  1]
 [ 0  0  0  0  0  1  0  0 29  0]
 [ 0  0  0  1  0  0  0  0  1 38]]
Classification Report:
              precision    recall  f1-score   support

           0       1.00      1.00      1.00        33
           1       0.97      1.00      0.98        28
           2       1.00      1.00      1.00        33
           3       0.97      0.97      0.97        34
           4       1.00      0.98      0.99        46
           5       0.94      0.94      0.94        47
           6       0.97      0.97      0.97        35
           7       1.00      0.97      0.99        34
           8       0.97      0.97      0.97        30
           9       0.93      0.95      0.94        40

    accuracy                           0.97       360
   macro avg       0.97      0.97      0.97       360
weighted avg       0.97      0.97      0.97       360
```

Prediction

In [9]:

```
from PIL import Image

# Load the image and convert it to grayscale
image = Image.open('download.png').convert('L')

# Resize the image to 8x8 pixels (the same size as the dataset images)
image = image.resize((8, 8))

# Convert the image to a numpy array
new_image = np.array(image)

# Flatten the 8x8 image into a 1D array for prediction
new_image_flattened = new_image.flatten().reshape(1, -1)

# Scale the feature variables using the previously defined scaler
new_image_scaled = scaler.transform(new_image_flattened)

# Make a prediction using the model
predicted_digit = model.predict(new_image_scaled)

print("Predicted Digit:", predicted_digit[0])
```

```
Predicted Digit: 4
```