Homeowrk 3

April 2, 2025

1 Objective

In this assignment, you will build and compare various classification models on the MNIST dataset—a collection of handwritten digit images. You will implement and evaluate the following classic machine learning methods:

- Logistic Regression
- Quadratic Discriminant Analysis (QDA)
- Support Vector Machine (SVM)
- Random Forest
- Any other classification model you know from the class (Optional)

The goal is to understand how different algorithms perform on the same classification task and to analyze their strengths and limitations.

2 Model Evaluation

2.1 Evaluation Metrics

Evaluate each model using accuracy, and optionally, compute a confusion matrix and a full classification report (precision, recall, F1-score).

2.2 Visualization

- Plot confusion matrices using `matplotlib` to visually inspect where the models are making errors.
- For each model, visualize a few correctly and incorrectly classified images.

3 Compare Performance

3.1 Summary Table

Create a table summarizing the performance (accuracy and other metrics) of all models.

3.2 Discussion

Discuss the relative performance:

- Which model performed best and why?
- Were there any models that struggled with the high-dimensional nature of the data?

4 Write-Up

Prepare a detailed report that includes:

- A brief introduction to the MNIST dataset and the classification problem.
- If you performed any data preprocessing, provide a description of the steps you took.
- A presentation of the evaluation results (tables, graphs, and confusion matrices).
- A comparative analysis of the models with discussions on potential improvements.

5 Parameter Tuning

Experiment with hyperparameter tuning (e.g., using grid search or random search) for one or more models to see if performance can be improved.

6 Code to Load the Data

```
from sklearn.datasets import fetch_openml
mnist = fetch_openml('mnist_784', version=1)
X, y = mnist["data"], mnist["target"]
```