Optical Recognition of Handwritten Digits: Classification Performance Comparison using Machine Learning Algorithms

Student Details

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Machine Configuration

- GPU: NVIDIA GEFORCE RTX
- RAM: 16GB
- OS: Windows
- Processor: Intel Core i5

Dataset Description

The Optical Recognition of Handwritten Digits (OptDigits) dataset consists of:

- Total samples: 5,620
- Features: 64 (8x8 pixel values representing grayscale intensity)
- No. of Classes: 10 (digits 0-9)
- Type: Classification

Objectives

The objective of this project is to implement and evaluate different machine learning classifiers on the OptDigits database to determine the most effective classifier. This involves comparing various performance metrics across classifiers to identify the one with the best F1 Score, indicating the most balanced accuracy and precision-recall performance.

Methodology

The following classifiers were applied to the dataset:

1. Naive Bayes: A probabilistic classifier based on Bayes' theorem.

2. K-Nearest Neighbours (KNN): A non-parametric method that classifies a sample based on the majority class among its nearest neighbors.

3. Decision Tree: A model that splits data based on feature values, constructing a tree of decisions.

4. Random Forest: An ensemble of decision trees that enhances performance by aggregating multiple trees' predictions.

The performance metrics (Accuracy, Precision, Recall, and F1 Score) were calculated for each model, and the results were presented in tabular and graphical formats.

Process

1. Data Loading and Preprocessing: The dataset was loaded from provided paths, and features and labels were separated for both training and testing data.

2. Model Training and Testing: Each classifier was trained on the training data and evaluated on the test data. Predictions were recorded for comparison.

3. Performance Evaluation: Key performance metrics were calculated using accuracy_score and classification_report from sklearn. These metrics were compiled into a DataFrame for easy comparison and plotted for visual representation.

Experimental Results

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Classifier	Accuracy	Precision	Recall	F1 Score
K-Nearest Neighbors	97.88 %	0.979	0.979	0.979
Naive Bayes	78.63 %	0.831	0.786	0.785
Decision Tree	85.25 %	0.857	0.853	0.853
Random Forest	97.05 %	0.971	0.971	0.971

Discussion

Based on the F1 Score, the K-Nearest Neighbours classifier achieved the highest performance, indicating that it is the best model for this particular classification task on the OptDigitsataset. The KNN model had a balanced performance between precision and recall, reflected in a high F1 Score of 0.979, making it preferable for recognizing handwritten digits with high accuracy. The Random Forest classifier was close in performance but slightly lower in F1 Score, making it a strong alternative. Naive Bayes performed the least effectively, likely due to its assumptions that may not align with the dataset's distribution.