Deep Learning Report on EMNIST & MNIST Classification

## Introduction

This report presents the implementation of training and testing on the EMNIST and MNIST datasets using Feedforward Neural Networks (FNNs). The EMNIST dataset consists of handwritten alphabets, whereas the MNIST dataset contains handwritten digits. The objective is to evaluate the performance of different optimizers, activation functions, learning rates, and batch sizes.

## Data Description

### EMNIST Dataset

|  |  |
| --- | --- |
| Dataset Name | EMNIST |
| Classes | 47 (if considering separate uppercase/lowercase) |
| Image Size | 784 (28x28 pixels) |

### MNIST Dataset

|  |  |
| --- | --- |
| Dataset Name | MNIST |
| Classes | 10 (Digits 0-9) |
| Image Size | 784 (28x28 pixels) |

## Model Architecture

The Feedforward Neural Networks (FNNs) used for both datasets consist of the following layers:

- \*\*Input Layer\*\*: 784 neurons (flattened image input)

- \*\*Hidden Layers\*\*: Varies between 1 and 3 layers with 128, 64, or 32 neurons per layer, using ReLU activation

- \*\*Output Layer\*\*: 47 neurons for EMNIST, 10 neurons for MNIST, using Softmax activation

## Results & Analysis

### Optimizer Performance

|  |  |  |
| --- | --- | --- |
| Optimizer | Epochs | Test Accuracy |
| SGD | 10 | 84.21% |
| MGD | 10 | 90.52% |
| NGD | 10 | 90.08% |
| ADAM | 10 | 90.61% |
| L2 | 10 | 80.09% |
| RMSprop | 10 | 90.41% |

### Activation Function Performance (SGD)

|  |  |  |
| --- | --- | --- |
| Activation Method | Epochs | Test Accuracy |
| ReLU | 10 | 84.21% |
| Sigmoid | 10 | 85.21% |

### Effect of Learning Rate on Accuracy

|  |  |  |
| --- | --- | --- |
| Epochs | Learning Rate | Test Accuracy |
| 5 | 0.001 | 89.70% |
| 5 | 0.01 | 75.81% |
| 5 | 0.1 | 3.85% |

### Effect of Batch Size on Accuracy (L2 Regularization)

|  |  |  |  |
| --- | --- | --- | --- |
| Batch Size | Epochs | Optimizer | Test Accuracy |
| 64 | 10 | L2 | 80.09% |
| 32 | 10 | L2 | 79.86% |
| 128 | 10 | L2 | 81.30% |

## Conclusion

From the results, the Adam optimizer achieved the highest accuracy of 90.61% for EMNIST, while for MNIST, it reached 97.54%. The number of hidden layers, batch size, and learning rate all played a crucial role in accuracy. A lower learning rate (0.001) yielded the best results, while a higher learning rate (0.1) significantly reduced accuracy. The ReLU activation function performed better than Sigmoid for this task.