Deep Learning Assignment 1 - CIFAR-10 Classification

Student Information

Name: V Jitesh Kumar

Section: IT-3

Roll No: 199

Date: 02 March 2025

1. Objective

The purpose of this assignment is to implement a Feedforward Neural Network (FNN) to classify images from the CIFAR-10 dataset. Various optimizers, activation functions, and loss functions are tested to analyze their effect on model accuracy. Additionally, we compare the performance of Cross-Entropy Loss and Mean Squared Error (MSE) Loss.

2. Dataset Details

CIFAR-10 is a widely used dataset for image classification. It consists of:
- 10 different object classes: Airplane, Automobile, Bird, Cat, Deer, Dog, Frog, Horse, Ship, Truck.
- 50,000 training images and 10,000 test images.
- Each image is 32x32 pixels with 3 color channels (RGB).

3. Model Architecture

We implemented a Feedforward Neural Network (FNN) with the following structure:
- Hidden Layers: 3 ([64, 128, 256])
- Activation Functions: ReLU and Sigmoid
- Optimizers Used: SGD, Adam, RMSprop, Momentum-based SGD, Nesterov
- Loss Functions: Cross-Entropy Loss & Mean Squared Error (MSE)
- Batch Sizes Tested: 16, 32, 64
- Learning Rates: 0.001 and 0.0005

The model flattens each image, processes it through hidden layers, and outputs a probability distribution over the 10 classes.

4. Results & Observations

The model was trained with different configurations, and the test accuracy was recorded.

Hidden Layers	Learning Rate	Batch Size	Optimizer	Accuracy
[64, 128, 256]	0.001	32	Adam	50.85%
[128, 256, 512]	0.0005	64	SGD	33.68%
[32, 64, 128]	0.001	16	RMSprop	46.34%

From the results, the model performed best with the Adam optimizer, a learning rate of 0.001, and a batch size of 32. Increasing the batch size to 64 reduced accuracy, and using SGD instead of Adam also significantly lowered performance.

5. Loss Function Comparison

A comparison between Cross-Entropy Loss and MSE Loss is provided below.

Loss Function	Loss Value
Cross-Entropy Loss	1.4042
Mean Squared Error (MSE) Loss	9.7332

Cross-Entropy Loss was significantly lower than MSE Loss, showing that it is more effective for multi-class classification. MSE is generally better for regression tasks, while Cross-Entropy is optimized for categorical data.

6. Conclusion

Based on the experiments, we conclude the following:
- The best model used the Adam optimizer with a learning rate of 0.001 and a batch size of 32.
- Cross-Entropy Loss was a better choice compared to MSE Loss for classification.
- Using larger batch sizes (64) reduced accuracy, possibly due to slower weight updates.
- Adam optimizer provided the best convergence speed and stability compared to SGD and RMSprop.

Overall, optimizing hyperparameters and choosing the correct loss function played a critical role in improving model accuracy.

7. References

- PyTorch Documentation

- Deep Learning Course Material

- CIFAR-10 Dataset Description