EEP 596 Computer Vision - Assignment 4 Report

Task 1: CIFAR-10 Dataset

Dataset Statistics

Parameter	Value
num_train_batches	**5**
num_test_batches	**1**
num_img_per_batch	**10000**
num_train_img	**50000**
num_test_img	**10000**
size_batch_bytes (Binary file, KB)	**30009.77**
size_batch_bytes (Python unpickled dict, KB)	**30992.83**
size_image_bytes (KB)	**3**
size_batchimage_bytes (10k images, KB)	**30000**

Binary Size Analysis

Binary file size: 30009.77 KB (30000 KB data + 9.77 KB labels)

Python unpickled dict size: 30992.83 KB

> **Size difference explanation:** The Python unpickled dictionary is larger due to Python's data structure overhead. When the binary file is loaded into Python, list objects add additional memory overhead for storing elements, making the in-memory representation larger than the original binary file.

Detailed Unpickled Dictionary Size Breakdown

```
Detailed size breakdown:
  - b'batch_label': 54 bytes (0.05 KB)
  - b'labels': 90104 bytes (list overhead)
    → Total with elements: 370104 bytes (361.43 KB)
    → Number of items: 10000
  - b'data': 128 bytes (object overhead)
    → Actual data size: 30720000 bytes (30000.00 KB)
    → Shape: (10000, 3072), dtype: uint8
  - b'filenames': 90104 bytes (list overhead)
    → Total with elements: 646276 bytes (631.13 KB)
    → Number of items: 10000

Total estimated size: 31736658 bytes (30992.83 KB)
```

1a. Sample Mini-batch (4 random images)

Image tensor shape: torch.Size([4, 3, 32, 32])

Labels tensor shape: torch.Size([4])

Task 2: Train Classifier

Network Architecture

```
Net(
  (conv1): Conv2d(3, 6, kernel_size=(5, 5), stride=(1, 1))
  (pool): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1, ceil_mode=False)
  (conv2): Conv2d(6, 16, kernel_size=(5, 5), stride=(1, 1))
  (fc1): Linear(in_features=400, out_features=120, bias=True)
  (fc2): Linear(in_features=120, out_features=84, bias=True)
  (fc3): Linear(in_features=84, out_features=10, bias=True)
)
```

Test Accuracy

Test Accuracy on 10,000 images: 52.42%

Model weights loaded from: `cifar_net_2epoch.pth`

Task 3: Visualize Weights

3a. First Layer (conv1) Weights

Shape: [6, 3, 5, 5]

Description: 6 filters, 3 input channels, 5x5 kernel size

3b. Second Layer (conv2) Weights

Shape: [16, 6, 5, 5]

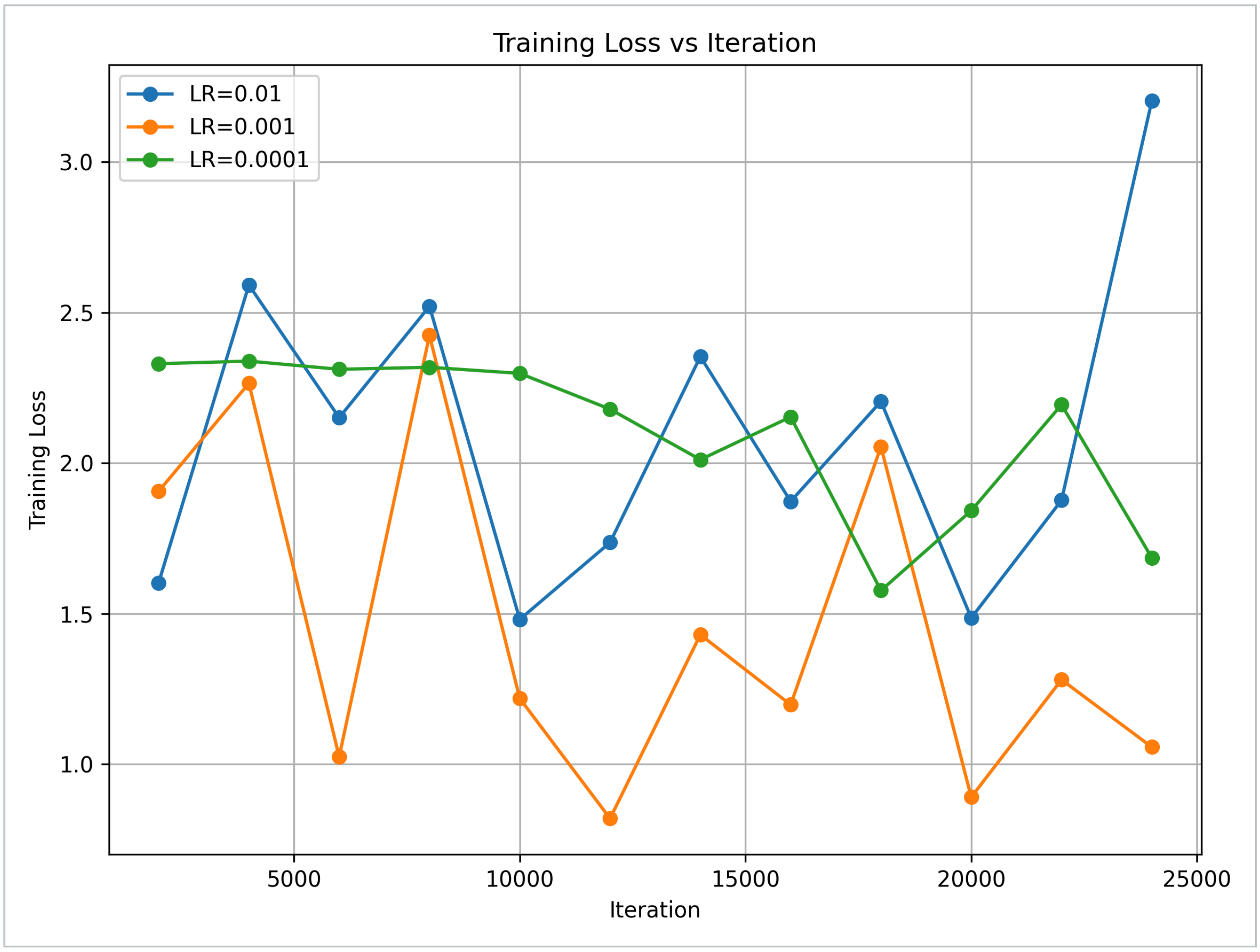
Description: 16 filters, 6 input channels, 5x5 kernel size

Task 4: Hyperparameter Sweep

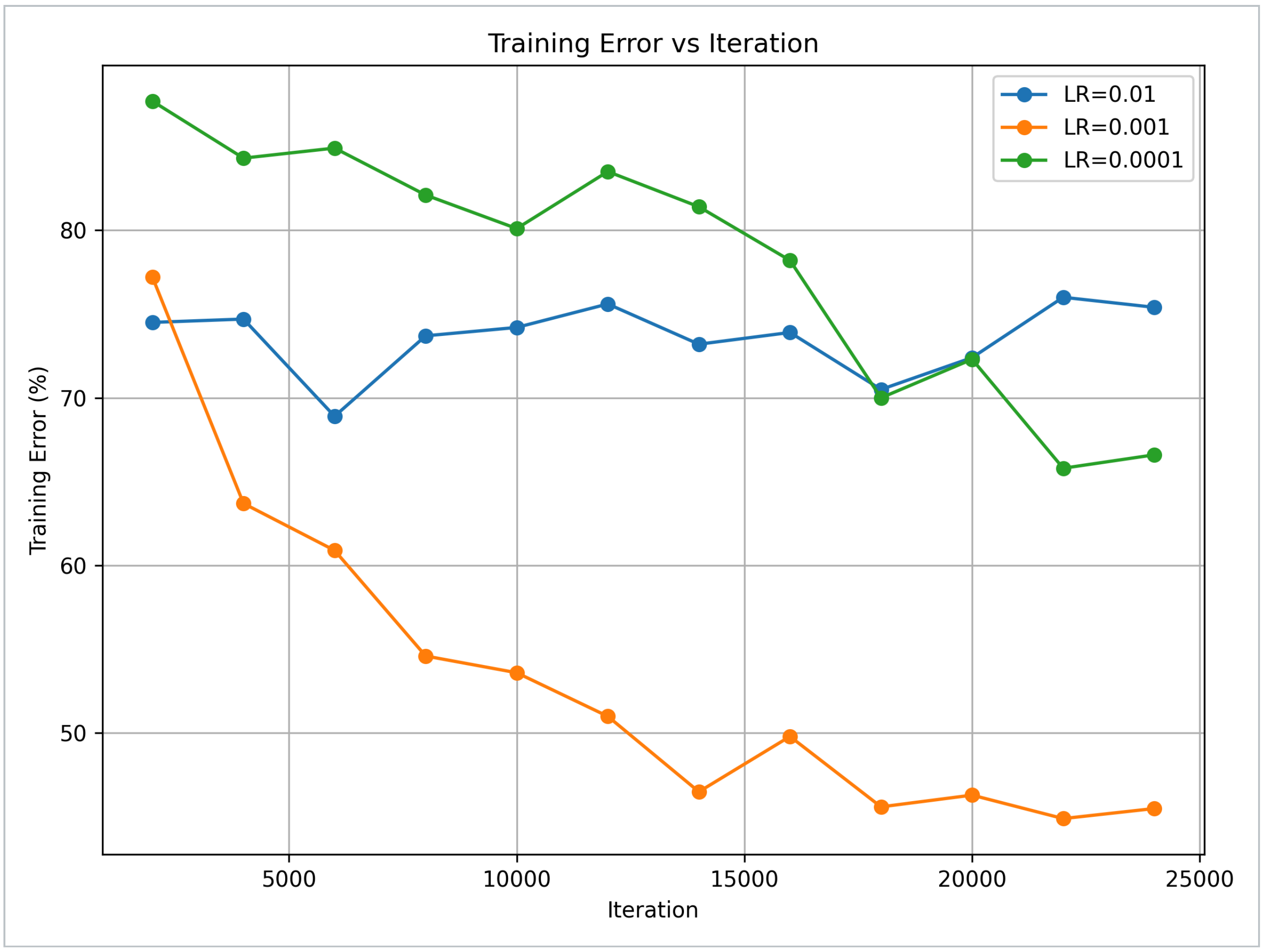
4c. Training with Different Learning Rates

The network was trained for 2 epochs using three different learning rates: 0.01, 0.001, and 0.0001. Training loss and error rates were recorded every 2000 iterations.

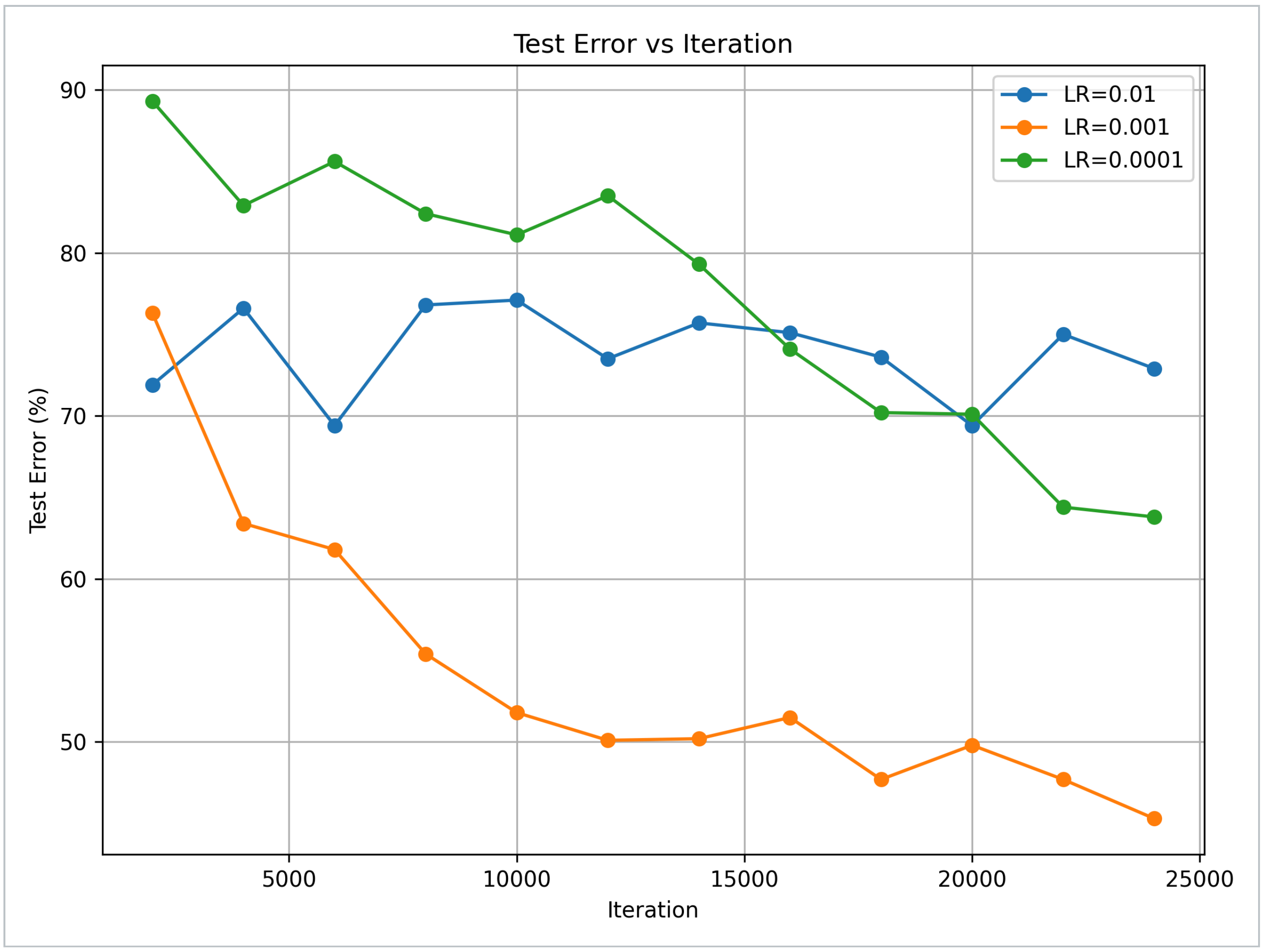
i. Training Loss vs Iteration



ii. Training Error vs Iteration



iii. Test Error vs Iteration



4d. Results Description

Observations:

- **Learning Rate = 0.01 (High):** Higher learning rate didn't bring faster convergence. Shows severe oscillation throughout training. In final iterations, it even jumps out of the current valley, making the result worse than the other two learning rates.
- **Learning Rate = 0.001 (Medium):** Shows steady, consistent decrease in both training loss and error. This learning rate provides a good balance between convergence speed and stability.
- **Learning Rate = 0.0001 (Low):** Training progresses slowly with gradual decrease in loss and error. The convergence is more stable but requires more iterations to reach comparable performance.
- **Test Error:** The test error patterns generally follow the training error trends, indicating the models generalize reasonably well without severe overfitting. The medium learning rate (0.001) typically achieves the best test performance within 2 epochs.

- **Conclusion:** The learning rate of 0.001 appears to be optimal for this network and dataset, providing stable convergence and good test performance within the limited training time.

End of Report