CNN Experiments on CIFAR-10

Devansh Sharma

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1. Introduction

This project evaluates how increasing CNN depth affects classification accuracy on the CIFAR-10 dataset. Three different convolutional neural networks were implemented:

- **CNN_Small** – 3 convolutional layers + 2 fully connected layers

- **CNN_Large** – 6 convolutional layers + 2 fully connected layers

- **CNN_XL** – 9 convolutional layers with BatchNorm + 2 fully connected layers

All experiments used:

- Cross-entropy loss

- SGD optimizer (lr=0.01, momentum=0.9, weight decay=5e-4)

- StepLR scheduler

- 30 training epochs

Performance was tracked using Weights & Biases (W&B).

2. Model Architectures

2.1 CNN_Small

- Conv(3 → 32), Conv(32 → 32), MaxPool

- Conv(32 → 64), Conv(64 → 64), MaxPool

- Fully-connected: 1024 → 256 → 10

2.2 CNN_Large

- Same structure as Small, but an additional block:

- Conv(64 → 128), Conv(128 → 128), MaxPool

- Fully-connected: 2048 → 256 → 10

2.3 CNN_XL

- All blocks upgraded with BatchNorm

- 64-channel, 128-channel, and 256-channel double conv blocks

- Fully-connected: $4096 \rightarrow 512 \rightarrow 10$

3. Results

Final test accuracy after 30 epochs:

Model	Train Accuracy	Test Accuracy
CNN_Small	0.8183	0.8050
CNN_Large	0.8291	0.8216
CNN_XL	**0.9412**	**0.8942**

Table 1: Accuracy comparison across CNN model depths.

Observations:

- Adding depth improves performance (Small $\rightarrow$ Large).

- Adding depth + BatchNorm dramatically improves accuracy (XL model).

- CNN_XL shows both the highest training stability and lowest loss curves.
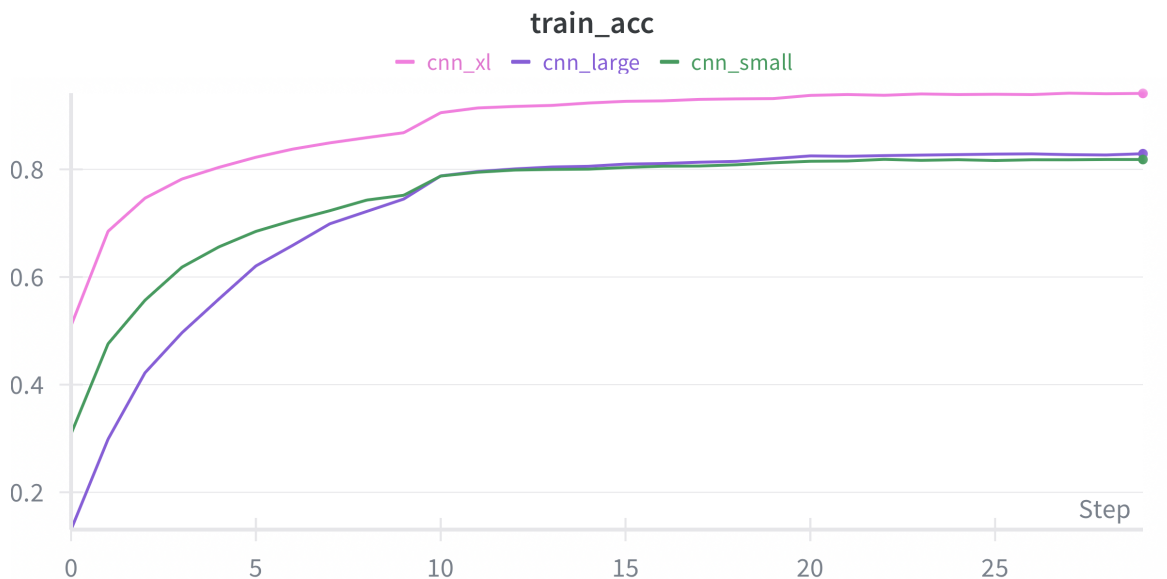
4. Training Curves

4.1 Accuracy Curves
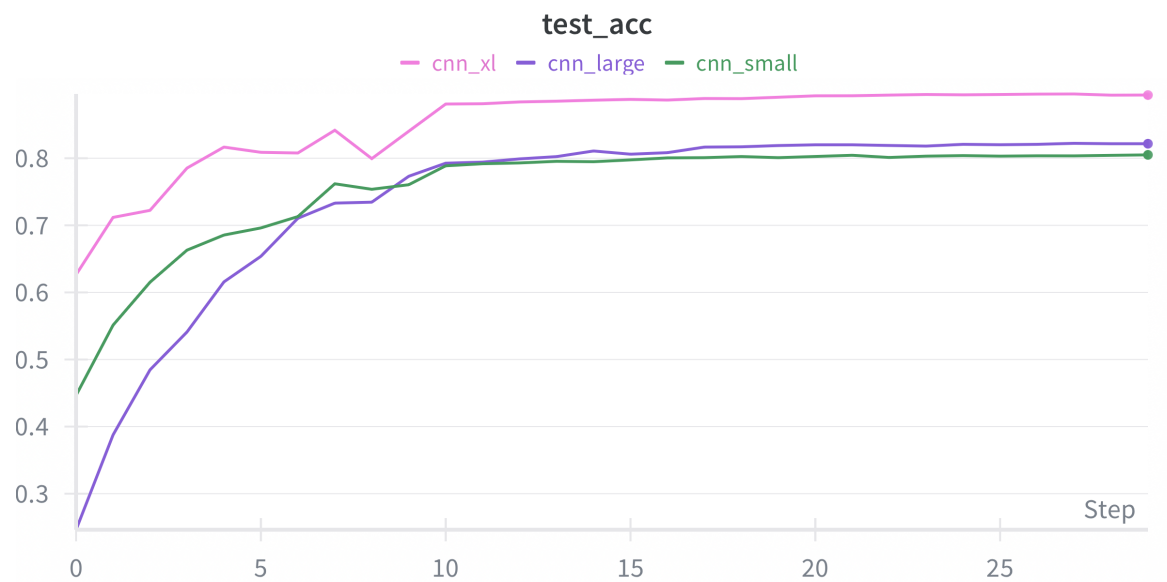

Figure 1: Training Accuracy

Figure 2: Test Accuracy
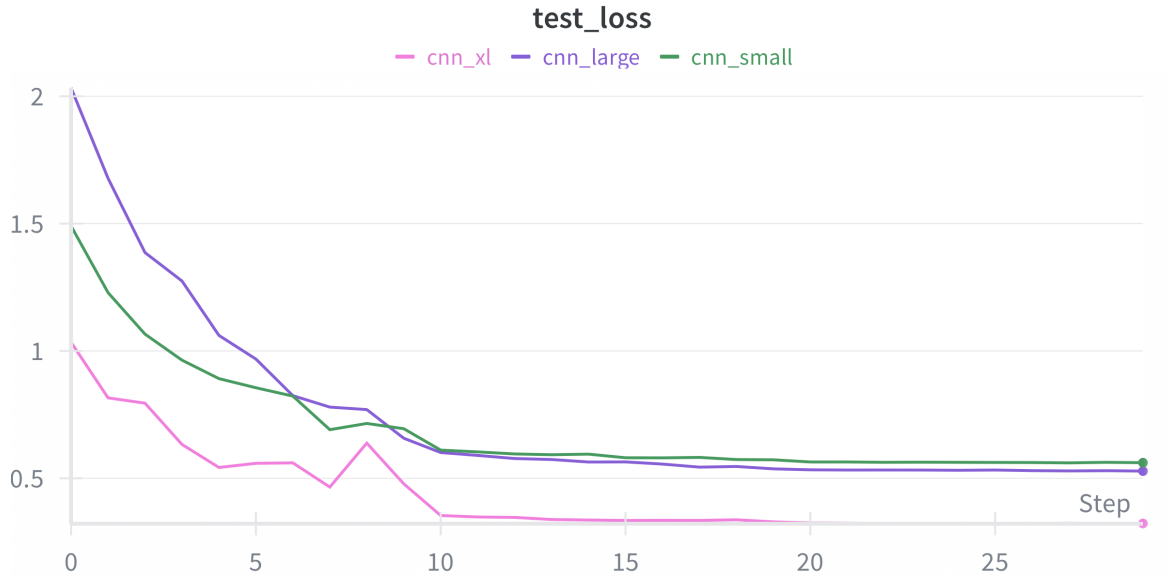
4.2 Loss Curves

Figure 3: Training Loss

Figure 4: Test Loss

5. Conclusion

The experiments clearly show that increasing CNN depth improves accuracy on CIFAR-10. However, the largest improvement came from adding Batch Normalization to each block in the CNN_XL model. This resulted in:

- Faster convergence

- Higher final accuracy

- More stable loss curves

CNN_XL achieved a strong **89.4%** test accuracy in only 30 epochs, demonstrating the importance of deeper and properly normalized architectures.