

MILS Assignment I Report

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GitHub Repository: https://github.com/IanKu304/2025S_DL_HW1_RE6131066_Ianku

Dataset

The mini-ImageNet dataset was used for all experiments. It consists of 50 classes with training, validation, and test sets defined in `train.txt`, `val.txt`, and `test.txt`. All images were resized to 32x32 or 224x224 as appropriate for the network architecture.

Problem A: Dynamic Convolution Module

Design Objective

We designed a convolutional module that:

- Handles arbitrary input channels (e.g., RGB, RG, R)
- Is spatial size invariant
- Dynamically generates convolution kernels

Training Configuration

All models were trained using the same training protocol to ensure fair comparison. The key hyperparameters and strategies are summarized below:

- **Optimizer:** Adam optimizer with an initial learning rate of 1×10^{-3}
- **Loss Function:** Cross-Entropy Loss for multi-class classification
- **Batch Size:** 10
- **Max Epochs:** 40 epochs
- **Early Stopping:** Enabled, with a patience of 5 epochs based on validation loss in Section A and 10 in Section B
- **Learning Rate Scheduler:** Not used
- **Input Size:**

- 32×32 for DynamicCNN and BaselineCNN (Problem A)
- 224×224 for ResNet34 and custom 2/4-layer CNNs (Problem B)
- **Channel Robustness:** For Problem A, optional RandomChannelDrop was used with probability 0.3 to simulate partial channel inputs (e.g., RG, R)
- **Weight Initialization:** PyTorch default initialization

Architectures

DynamicCNN v1

Input Channels: 1{3
 → MLP (input channel as condition) → Dynamic Kernel
 → Conv2D → BN → ReLU → GAP → FC(32→50)

DynamicCNN v2

Input Channels: 1{3
 → CNN-based kernel generator → Dynamic Kernel
 → Conv2D → BN → ReLU
 → Conv(32→64) → BN → ReLU → GAP
 → FC(64→128) → ReLU → FC(128→50)

Baseline CNN

Conv(3→32, 3x3) → ReLU → BN → MaxPool
 Conv(32→64, 3x3) → ReLU → BN → GAP
 FC(64→50)

Results on Test Set (32x32)

Without Channel Dropout:

Model	Accuracy	FLOPs	Params
DynamicCNN v1	0.2422	180.39 KMac	31.57 K
DynamicCNN v2	0.1422	19.49 MMac	63.31 K
Baseline CNN	0.2844	5.95 MMac	22.83 K

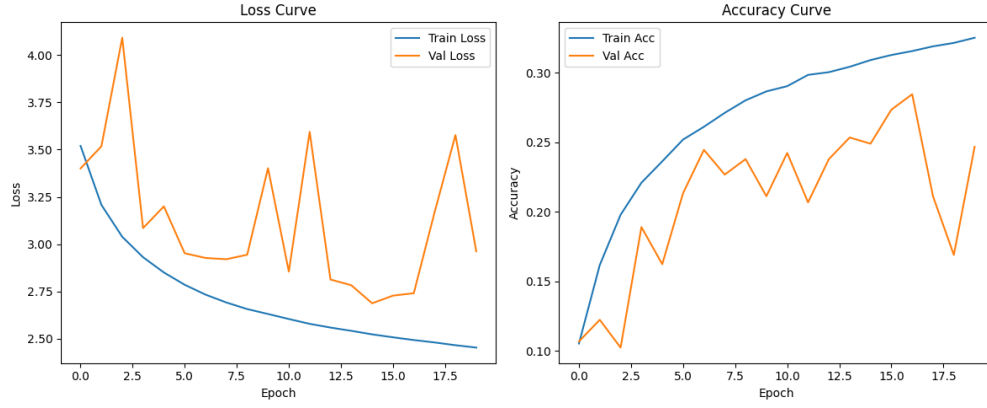


Figure 1: Training plot for Baseline CNN without random channel drop

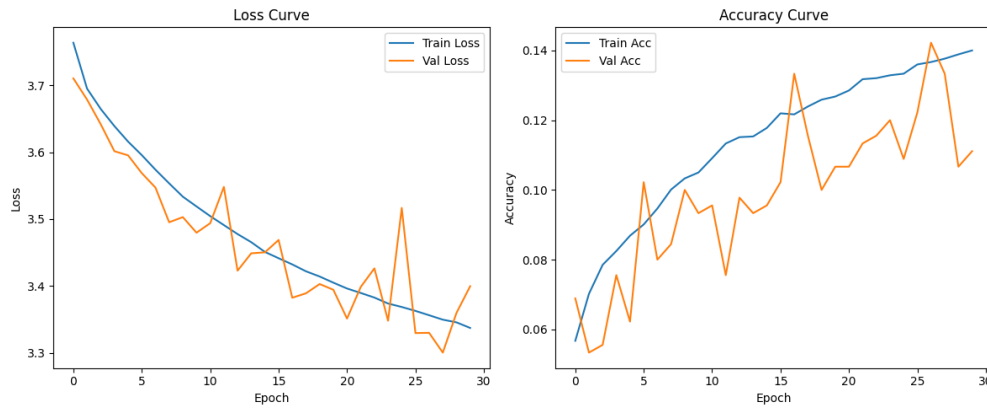


Figure 2: Training plot for DynamicCNN v1 without random channel drop

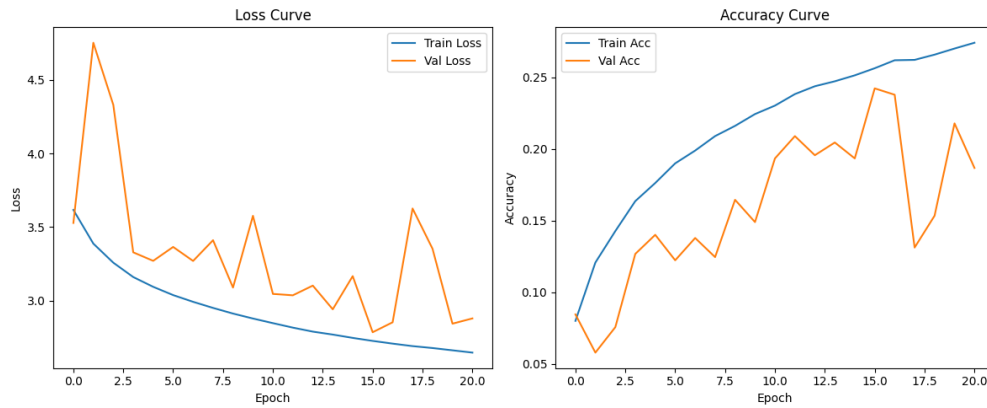


Figure 3: Training plot for DynamicCNN v without random channel drop

With RandomChannelDrop:

Model	Accuracy	FLOPs	Params
DynamicCNN v1	0.1244	180.39 KMac	31.57 K
DynamicCNN v2	0.2244	19.49 MMac	63.31 K
Baseline CNN	0.2422	5.95 MMac	22.83 K

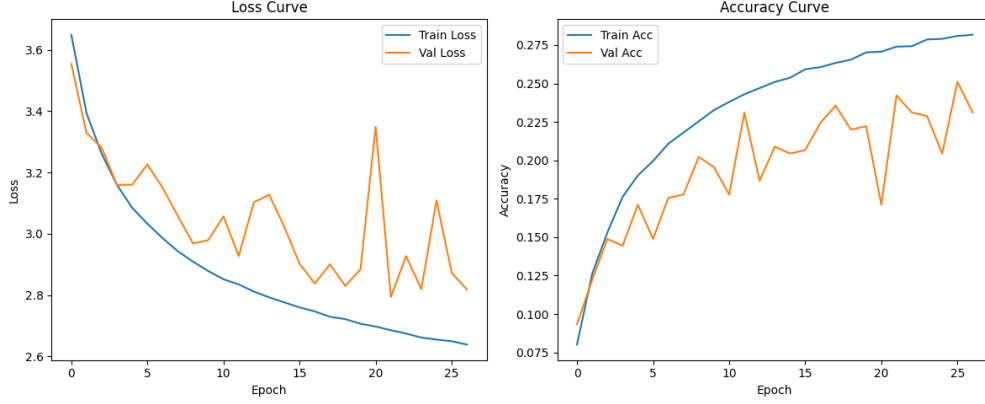


Figure 4: Training plot for Baseline CNN with random channel drop

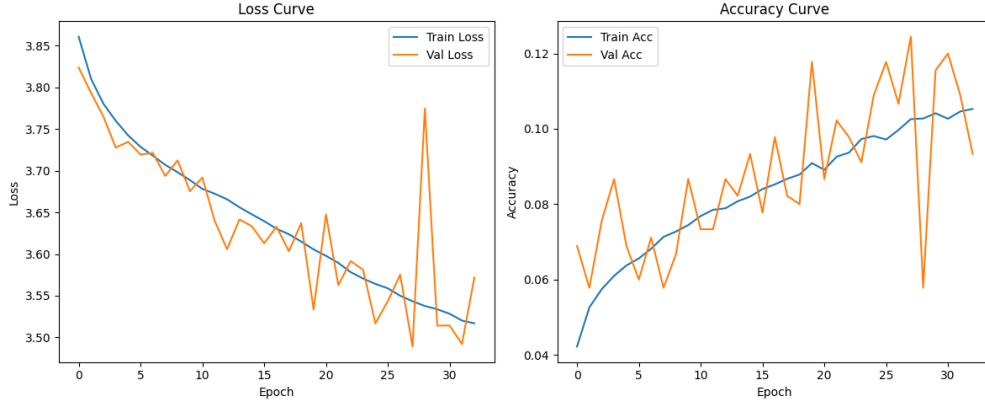


Figure 5: Training plot for DynamicCNN v1 with random channel drop

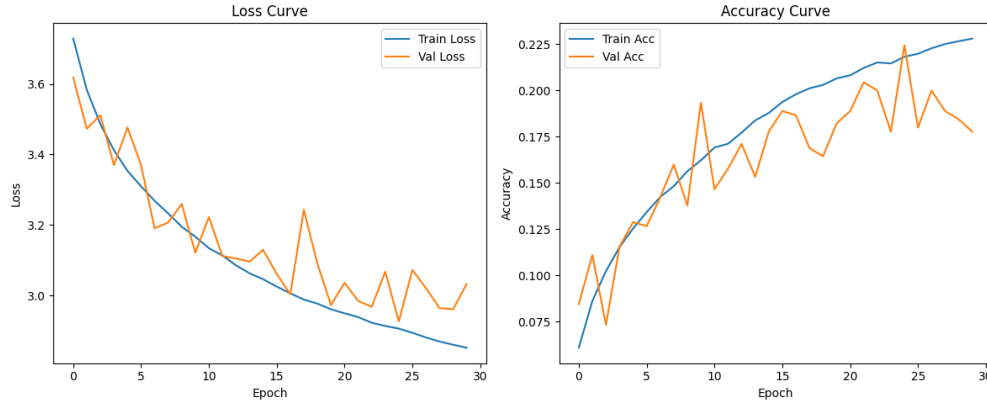


Figure 6: Training plot for DynamicCNN v2 with random channel drop

Problem B: Two-Layer Network

Design Goal

Design a 2–4 effective layer network achieving at least 90% of ResNet34’s performance on mini-ImageNet (resized to 224x224).

Architectures

ResNet34 (baseline)

Input \rightarrow Conv(7x7, 64) \rightarrow MaxPool
 [3x BasicBlock(64)]
 [4x BasicBlock(128)]
 [6x BasicBlock(256)]
 [3x BasicBlock(512)]
 \rightarrow GAP \rightarrow FC(50)

Simple2LayerCNN

Conv(3 \rightarrow 32, 7x7) \rightarrow BN \rightarrow ReLU
 Conv(32 \rightarrow 64, 5x5) \rightarrow BN \rightarrow ReLU \rightarrow SEBlock(64) \rightarrow MaxPool
 Conv(64 \rightarrow 128, 5x5) \rightarrow BN \rightarrow ReLU \rightarrow SEBlock(128) \rightarrow GAP
 FC(128 \rightarrow 128) \rightarrow ReLU \rightarrow FC(128 \rightarrow 50)

Simple4LayerCNN

Conv(3 \rightarrow 32, 3x3) \rightarrow BN \rightarrow ReLU
 Conv(32 \rightarrow 64, 3x3) \rightarrow BN \rightarrow ReLU
 Conv(64 \rightarrow 128, 3x3) \rightarrow BN \rightarrow ReLU
 Conv(128 \rightarrow 128, 3x3) \rightarrow BN \rightarrow ReLU
 GAP \rightarrow FC(128 \rightarrow 128) \rightarrow ReLU \rightarrow FC(128 \rightarrow 50)

Results (224x224)

Model	Accuracy	FLOPs	Params	Train Time
ResNet34	0.5667	3.68 GMac	21.31 M	234.85 min
Simple2LayerCNN	0.4400	43.66 MMac	237.75 K	451.15 min
Simple4LayerCNN	0.4000	285.83 MMac	301.11 K	470.57 min
SE2LayerCNN	0.4533	43.82 MMac	240.51 K	449 min

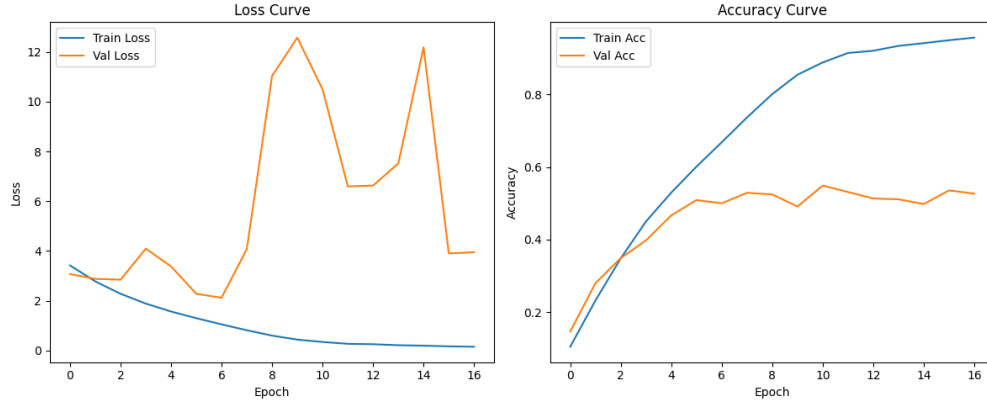


Figure 7: ResNet34

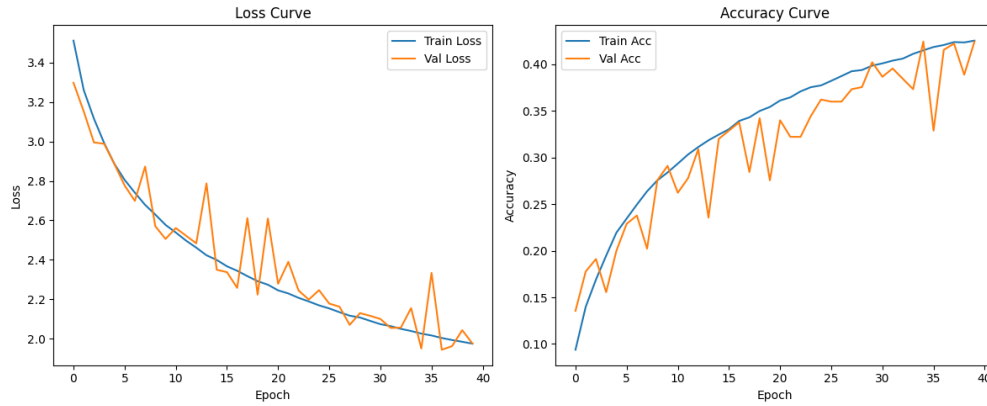


Figure 8: Attention1

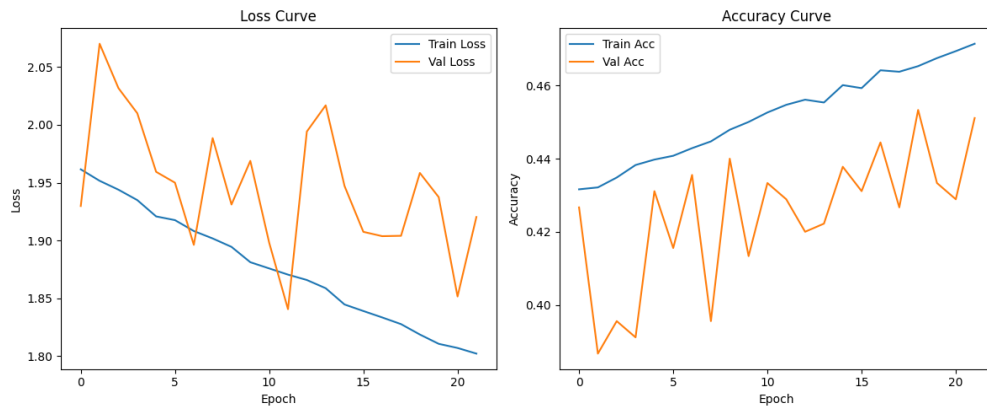


Figure 9: Attention2

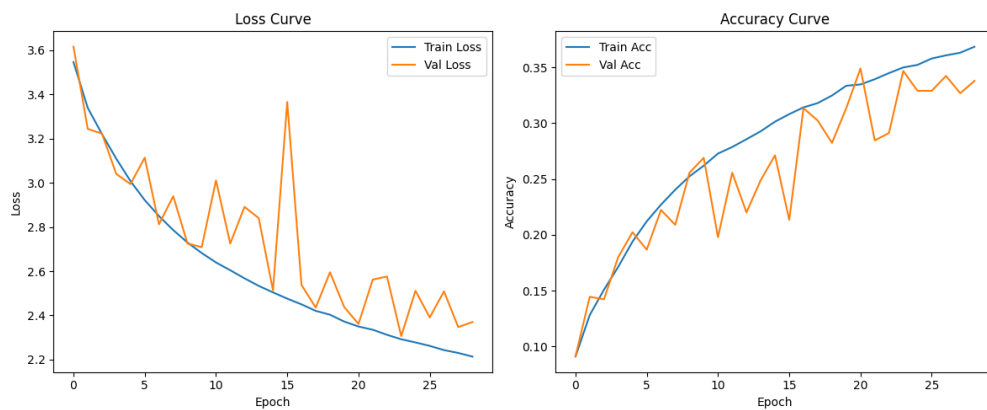


Figure 10: S2CNN 1

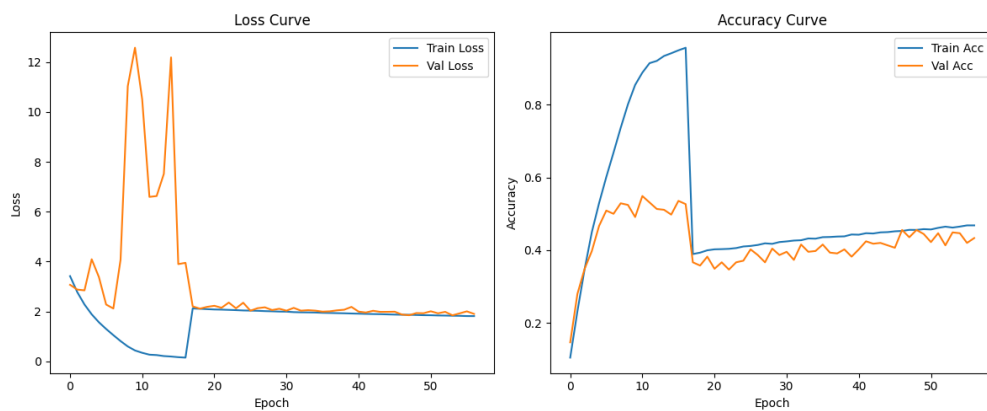


Figure 11: S2CNN 2

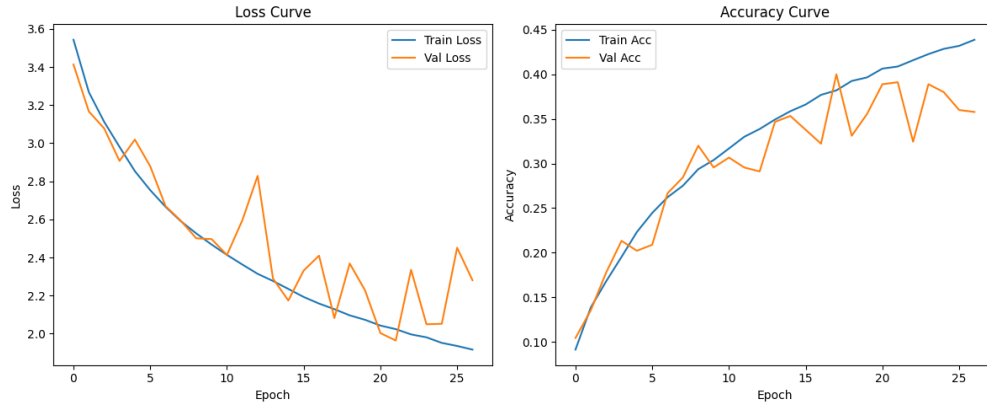


Figure 12: S4CNN

Summary and Insights

Problem A

- **DynamicCNN v1** achieves best result without channel dropout.
- **DynamicCNN v2** is more robust under channel variation.
- **BaselineCNN** provides stable performance overall.

Problem B

- **Simple2LayerCNN** achieves 77.6% of ResNet34.
- **SE2LayerCNN** boosts accuracy with minor cost.
- **Simple4LayerCNN** deeper model did not improve performance.

Appendix