Assignment 3 Report: Fashion-MNIST FFN vs. CNN

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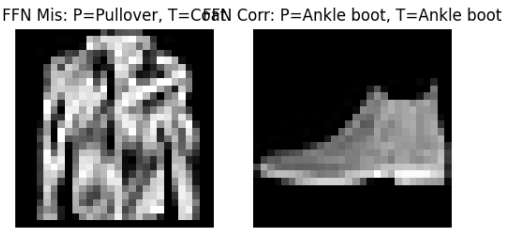
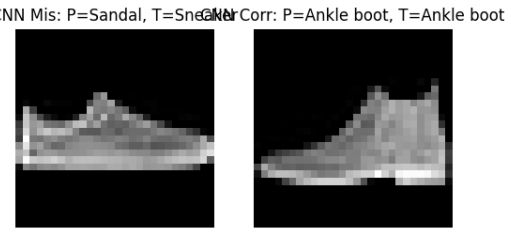
1 Prediction Examples



(a) FFN: one correct / one incorrect



(b) CNN: one correct / one incorrect

Figure 1: Example predictions (true vs. predicted labels).

2 Training Loss Plot

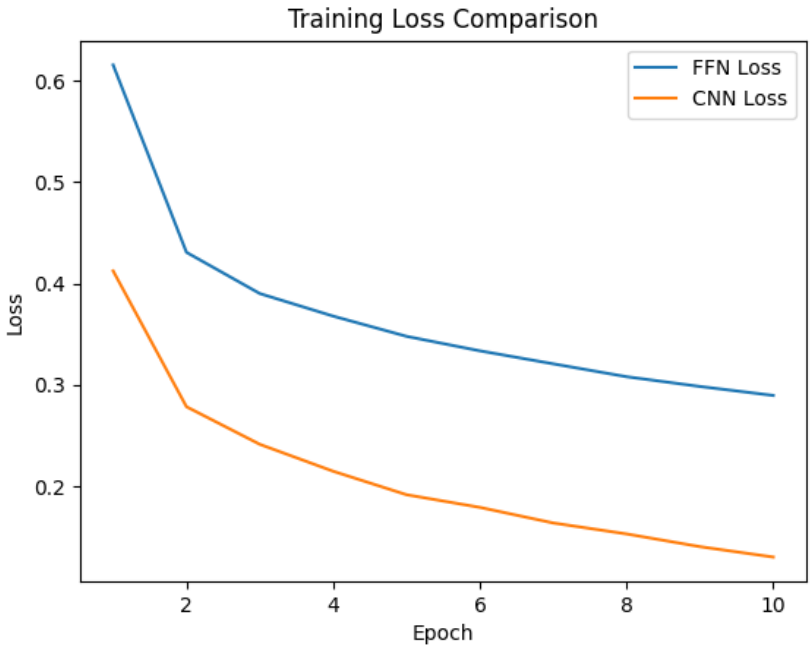
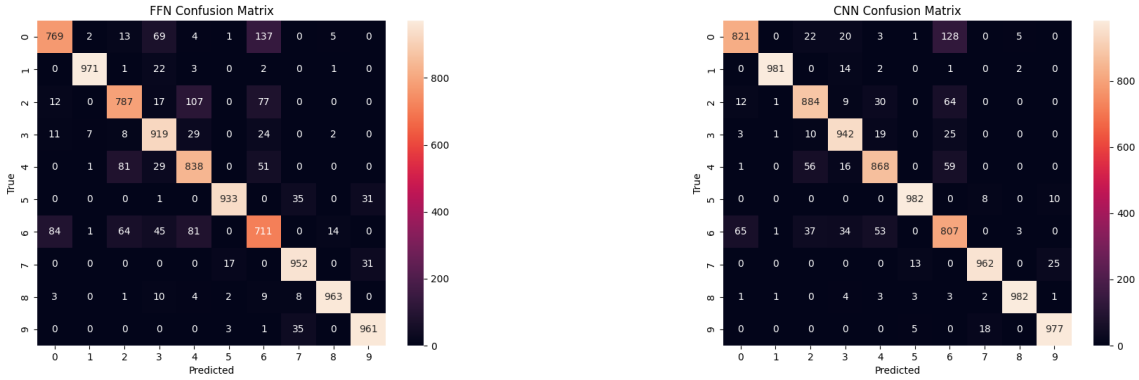


Figure 2: Training loss comparison for FFN (blue) and CNN (orange) over 10 epochs.

3 Parameter Counts

- **FFN total parameters:** 235,146
- **CNN total parameters:** 390,858

4 Confusion Matrices



(a) FFN confusion matrix

(b) CNN confusion matrix

Figure 3: Normalized confusion matrices on test data. Rows = true; columns = predicted.

5 Exploring Kernels

5.1 First-Layer Kernels

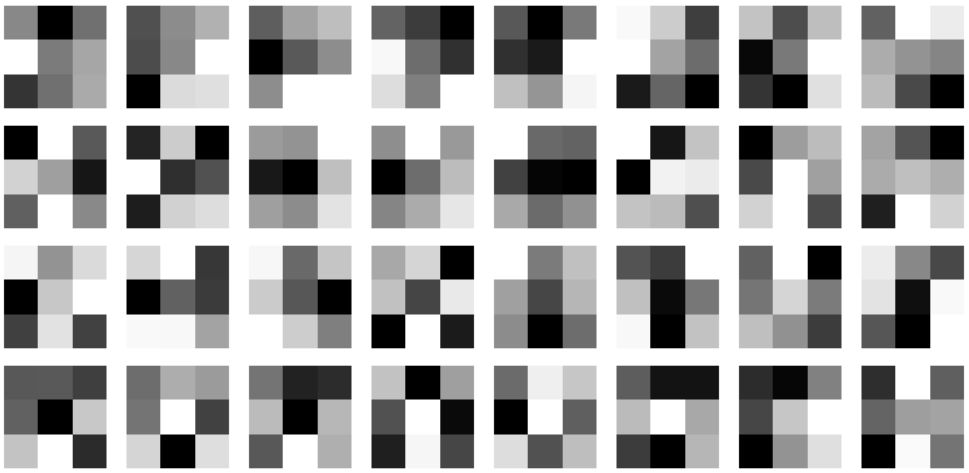


Figure 4: Learned filters from the first convolutional layer (normalized to [0,1]).

5.2 Kernel Feature Maps

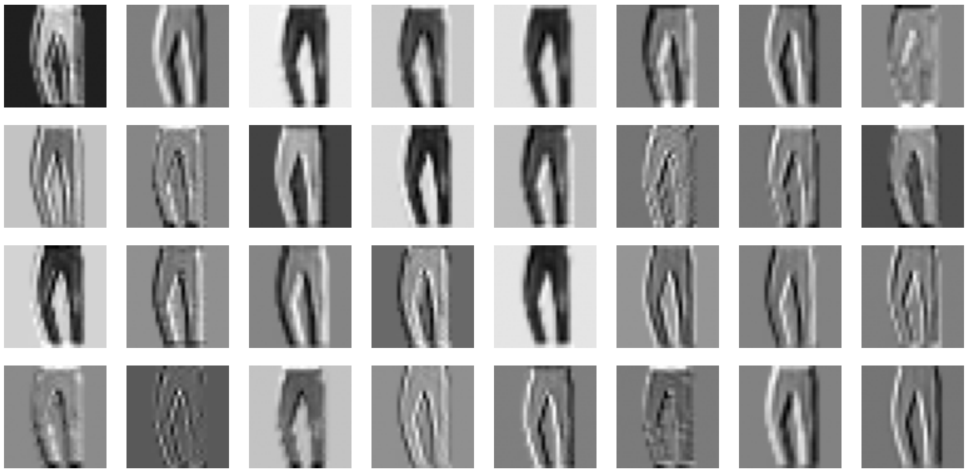


Figure 5: Feature maps from applying each first-layer kernel to the sample image.

5.3 Feature Map Progression

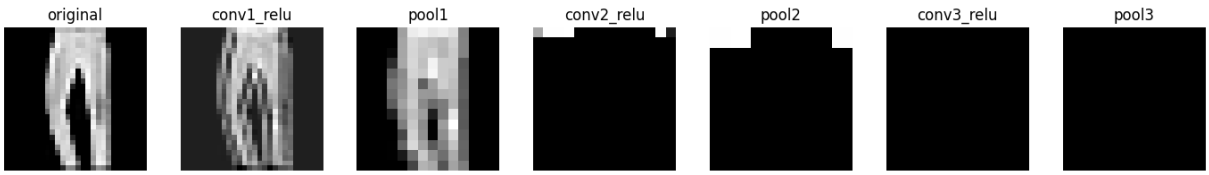


Figure 6: Evolution of the first channel through each conv+ReLU and pooling stage.

6 Conceptual Questions

6.1 Q8: Why does the CNN achieve better performance on image classification tasks?

Convolutional networks exploit *local receptive fields* and *weight sharing* to detect spatially localized patterns (edges, textures) invariant to translation. Stacking layers builds a feature hierarchy with far fewer parameters than a fully connected network, yielding more robust, generalizable representations for images.

6.2 Q9: How do features evolve through the CNN layers?

Figure 6 shows:

- **Conv1+ReLU:** Extracts low-level edges and gradients.
- **Pool1:** Retains strongest edges while downsampling.

- **Conv2+ReLU:** Combines edges into simple textures (corners, curves).
- **Pool2:** Further abstracts these mid-level features.
- **Conv3+ReLU:** Detects higher-level motifs (combinations of textures).
- **Pool3:** Produces a condensed, semantically rich map.

This hierarchical progression transforms raw pixels into abstract representations, simplifying final classification.