Executive Summary

Title: Fashion-MNIST Classification Using Artificial Neural Networks (ANN) and Convolutional Neural Networks (CNN)

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Context and Problem
The increasing integration of artificial intelligence (AI) into daily life has made image recognition an essential technology for modern automation. However, industries such as fashion retail continue to face challenges in applying accurate and efficient visual classification systems.
This project investigates those challenges through the Fashion-MNIST dataset, containing 70,000 grayscale images (28 × 28 pixels) across ten apparel categories. The study aimed to evaluate two neural architectures, Artificial Neural Networks (ANNs) and Convolutional Neural Networks (CNNs) to determine which model delivers stronger performance and why design elements such as activation functions, normalization, and regularization affect classification accuracy.

Key Findings
Two models were implemented using PyTorch:

- **ANN model:** Two hidden layers (512 and 256 neurons) with ReLU activations, Batch Normalization, and 30% Dropout.
- **CNN model:** Three convolutional layers (32, 64, 128 filters) with ReLU**,** Batch Normalization**,** max-pooling, and 25% Dropout, followed by fully connected layers.

Both models were trained for 15 epochs using the Adam optimizer**,** Cross-Entropy Loss (with an implicit Softmax), and a StepLR learning-rate scheduler.

The results highlight that CNNs significantly outperform ANNs due to their ability to preserve spatial information within images.

Model Comparison:

ANN Test Accuracy: = 88.15% — Struggles with spatially similar classes (e.g., shirt vs coat)

CNN Test Accuracy: = 93.11% Captures texture and shape features effectively

he confusion matrix revealed that most errors occurred between closely related classes such as shirts, pullover and coats.

Recommendations
The analysis suggests several strategies for improvement:

- **Enhanced Data Augmentation:** Apply random zoom, brightness, and affine transformations to improve generalization.
- **Regularization Tuning:** Combine Dropout with Weight Decay to balance bias and variance.
- **Optimization Strategies:** Experiment with AdamW or RMSProp and adaptive schedulers like ReduceLROnPlateau.
- **Model Expansion:** Explore transfer learning through pre-trained models such as ResNet-18 or VGG-16.

  These steps could strengthen the model's adaptability to real-world retail environments and improve long-term scalability.

Conclusion
This project demonstrates that Convolutional Neural Networks provide a superior framework for visual pattern recognition compared with Artificial Neural Networks. The integration of ReLU activations**,** Batch Normalization, and Dropout proved essential for stability and accuracy.
The findings reinforce the value of CNNs for automated image classification and provide a foundation for future research into advanced deep-learning architectures within the fashion technology sector.