Analysis of LDA and QDA Classification Performance on MNIST Digits (0, 1, 2)

1. Dimensionality Reduction Overview
- Original input dimensionality: 784 (28x28 pixel images)
- PCA with 90% variance threshold reduced dimensions to 126
- FDA further reduced dimensions to 2 for visualization and classification

2. Classification Performance Analysis

A. PCA + LDA Performance

- Using 90% Variance Threshold (126 components):
  - Training Accuracy: 96.84%
  - Test Accuracy: 96.70%
  - Very small gap between train and test accuracy indicates good generalization
  - High accuracy suggests effective class separation
- Using First 2 PCA Components:
  - Training Accuracy: 89.38%
  - Test Accuracy: 89.74%
  - Significant drop in performance (~7% decrease) compared to 90% variance threshold
  - Still maintains decent accuracy considering massive dimension reduction (784 → 2)

3. Impact of PCA on Classification Performance

The results demonstrate several key findings about how PCA affects classification:

a) Variance Preservation vs Performance:

- Using 126 components (90% variance) achieves significantly better performance than using just 2 components
- This suggests that some discriminative information is lost when using only the first two principal components
- The 90% variance threshold finds a good balance between dimensionality reduction and information preservation

b) Dimensionality Reduction Trade-offs:

- Reducing from 784 to 126 dimensions (90% variance) maintains high accuracy while significantly reducing computational complexity
- Further reduction to 2 dimensions results in some performance degradation but still achieves reasonable accuracy

- This shows PCA's effectiveness in removing redundant or noisy features while preserving essential pattern information