DIP Assignment - 5

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Deep Features for Image Classification

Question 1a: Workflow and Results

Workflow

1. **Data Preparation:**
   - The dataset consisted of training and test images categorized into four classes: airplanes, bikes, cars, and faces.
   - Images were preprocessed using resizing to 224×224, normalization, and conversion to tensors.
2. **Feature Extraction:**
   - A pre-trained ResNet-50 model was used. The classification head was replaced with an identity mapping to extract features from the penultimate layer.
   - Features were extracted for all images, both training and test.
3. **Classification:**
   - The K-Nearest Neighbors (KNN) algorithm with $k = 3$ was applied to classify the test images based on the extracted features.
   - Cross-validation was conducted to validate the performance of the KNN classifier.
4. **t-SNE Visualization:**
   - The extracted features were projected into a 2D space using t-SNE to visualize the feature separability.

Results

- **Test Accuracy:** Achieved an accuracy of 100.00%.
- **t-SNE Plot:** The clusters for different classes are clearly separated, indicating the model's ability to extract discriminative features (see Figure 1).

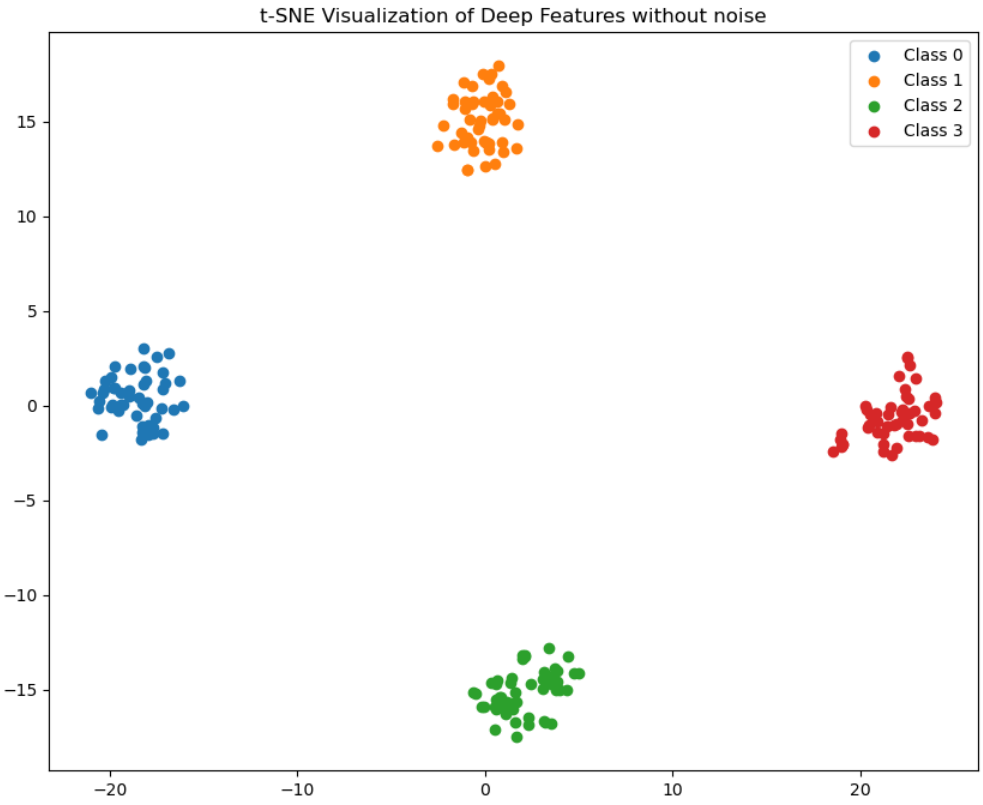

Figure 1: t-SNE Visualization for Question 1a

Question 1b: Workflow and Results

Workflow

1. **Adding Noise:**
    - Gaussian noise with varying standard deviations (1, 10,25,50,100) was added to both training and test images.
2. **Feature Extraction and Classification:**
    - Deep features were extracted from the noisy images using the pre-trained ResNet-50 model.
    - The KNN classifier was trained on the noisy training images and tested on noisy test images.
3. **t-SNE Visualization:**
    - The noisy features were visualized using t-SNE to assess the impact of noise on feature separability.

Results

- **Test Accuracy:** Accuracy remained consistent at 100.00% across all noise levels.
- **Cross-Validation Accuracy:** Maintained a mean accuracy of 100.00% with a standard deviation of 0.00% across all noise levels.
- **t-SNE Plots:** Visualizations showed no significant degradation in class separability due to noise, as depicted in Figures 2–6.

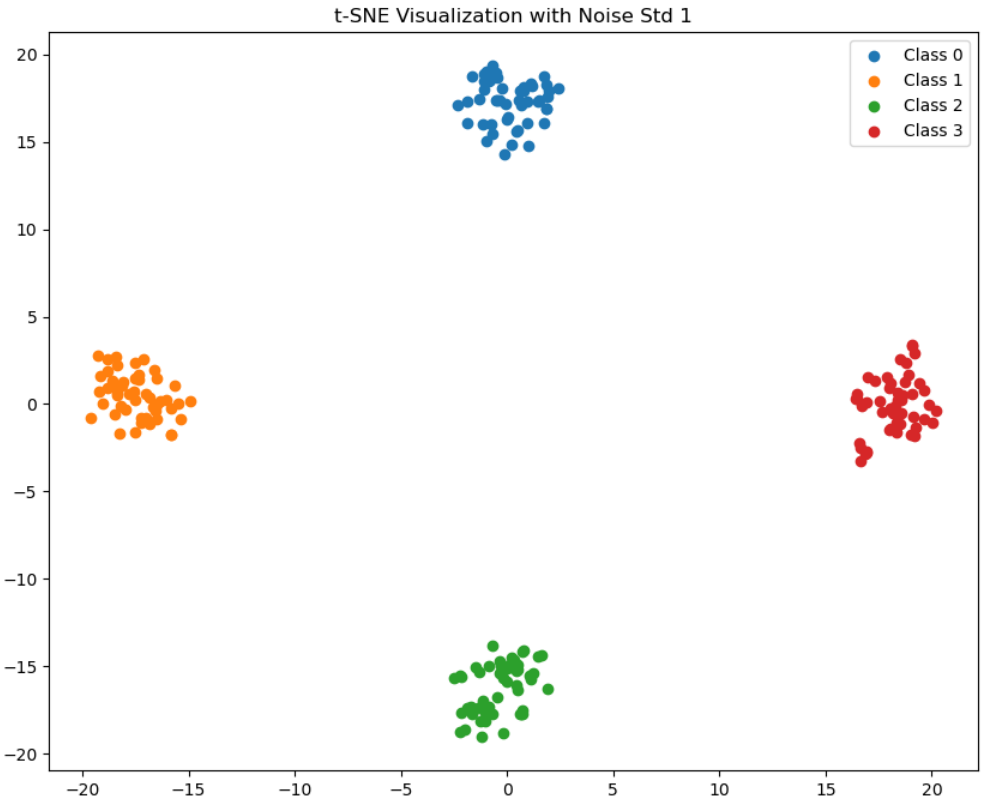

Figure 2: t-SNE Visualization with Noise Std 1

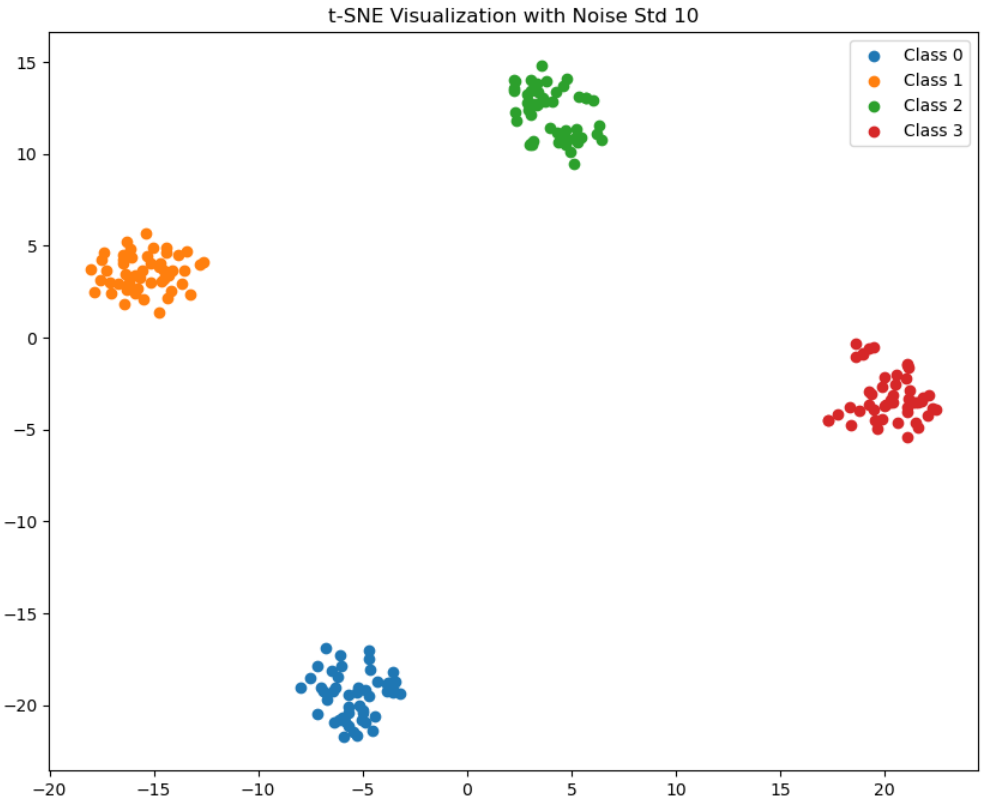

Figure 3: t-SNE Visualization with Noise Std 10

Question 1c: Workflow and Results

Workflow

1. **Fine-tuning:**
   - The last linear layer of the ResNet-50 model was fine-tuned on the training data.
   - The Adam optimizer was used for efficient updates, with hyperparameters tuned for optimal performance.
2. **Feature Extraction and Evaluation:**
   - Extracted features were classified using the fine-tuned model.

Results

- **Test Accuracy:** Achieved 100.00% accuracy.
- Fine-tuning confirmed the robustness of features extracted by the ResNet-50 model.

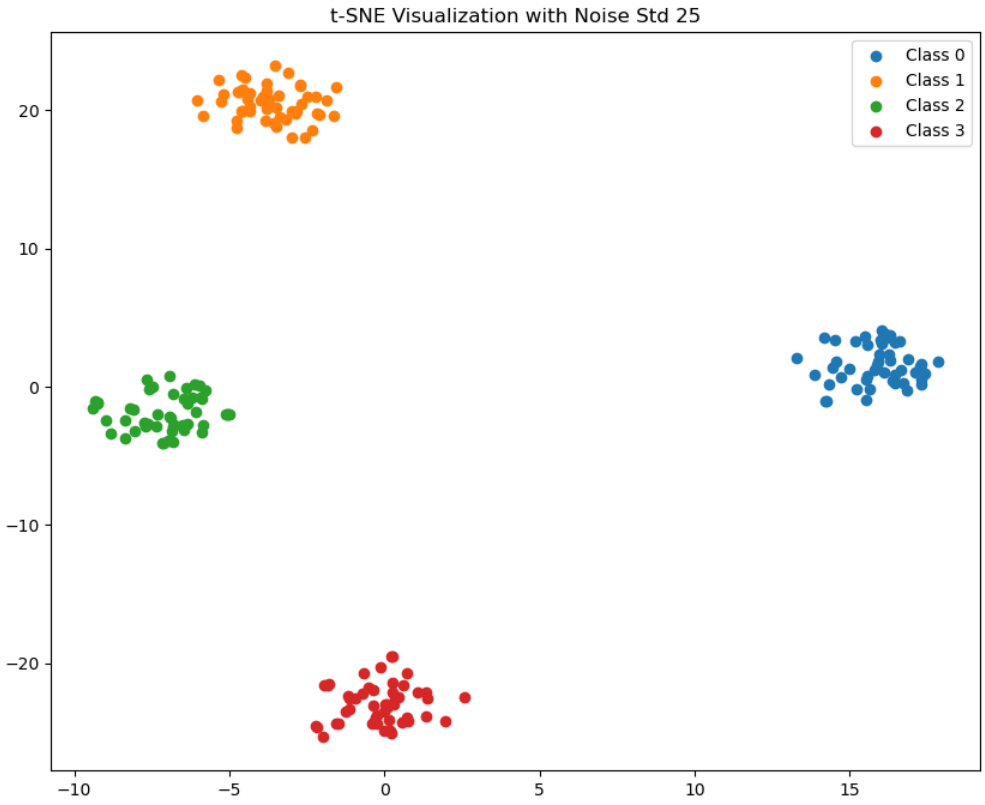

Figure 4: t-SNE Visualization with Noise Std 25

Conclusion

The experiments demonstrate that deep features extracted from pre-trained models are highly effective for image classification tasks, even under noisy conditions. The consistent accuracy of 100.00% and the clear t-SNE visualizations across varying noise levels highlight the robustness of the features.

Figure 5: t-SNE Visualization with Noise Std 50

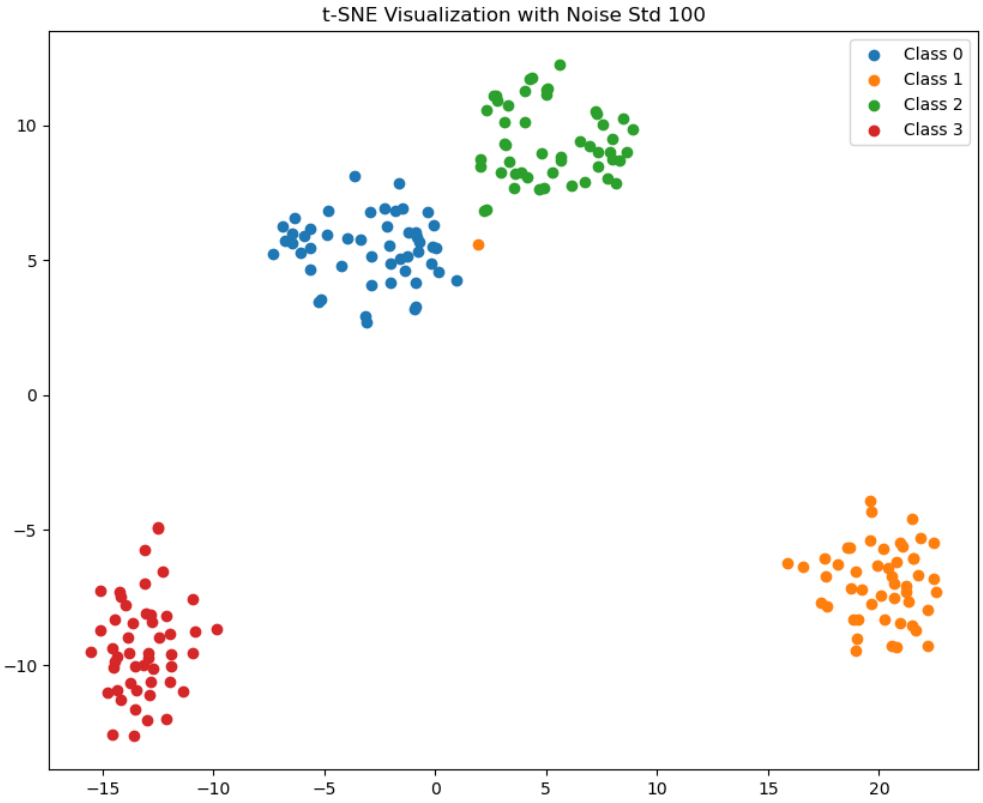

Figure 6: t-SNE Visualization with Noise Std 100