OncoNET: Comparative Analysis of CNN and ResNet for Skin Lesion Classification

WIDS 5.0 Mid-Term Project

1. Executive Summary

This report evaluates the performance of two deep learning architectures—a baseline Convolutional Neural Network (CNN) and a pre-trained ResNet-50—in classifying skin lesions from the HAM10000 dataset. The study highlights the effectiveness of **Transfer Learning** and explores the conceptual shift from local feature extraction (CNNs) to the global processing logic of Transformers.

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2. Model Performance (Task 1 & 2)

Metric	Task 1: Baseline CNN (Scratch)	Task 2: ResNet-50 (Transfer Learning)
Final Accuracy	**73%**	**84%**
Training Speed	Slower; required more epochs to stabilize.	Rapid; achieved peak performance quickly.
Feature Extraction	Learned from scratch using random weights.	Fine-tuned from pre-trained ImageNet weights.

Analysis:

The 11% accuracy gap confirms that Transfer Learning is essential for medical imaging tasks. The Baseline CNN struggled because it had to learn basic visual features (lines, textures) simultaneously with complex diagnostic patterns. ResNet-50, however, leveraged a "pre-trained" visual vocabulary, allowing it to distinguish subtle lesion features more effectively.

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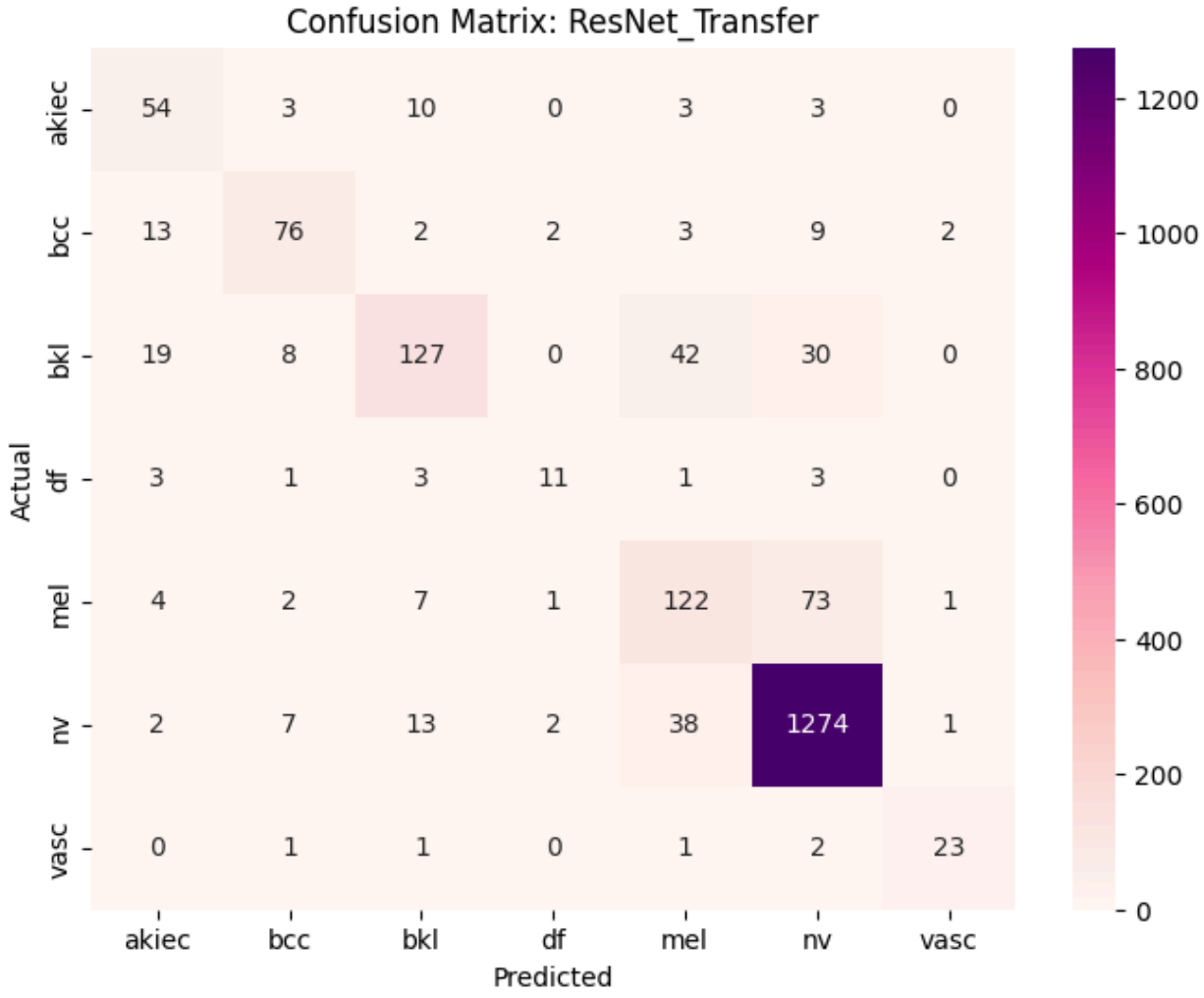
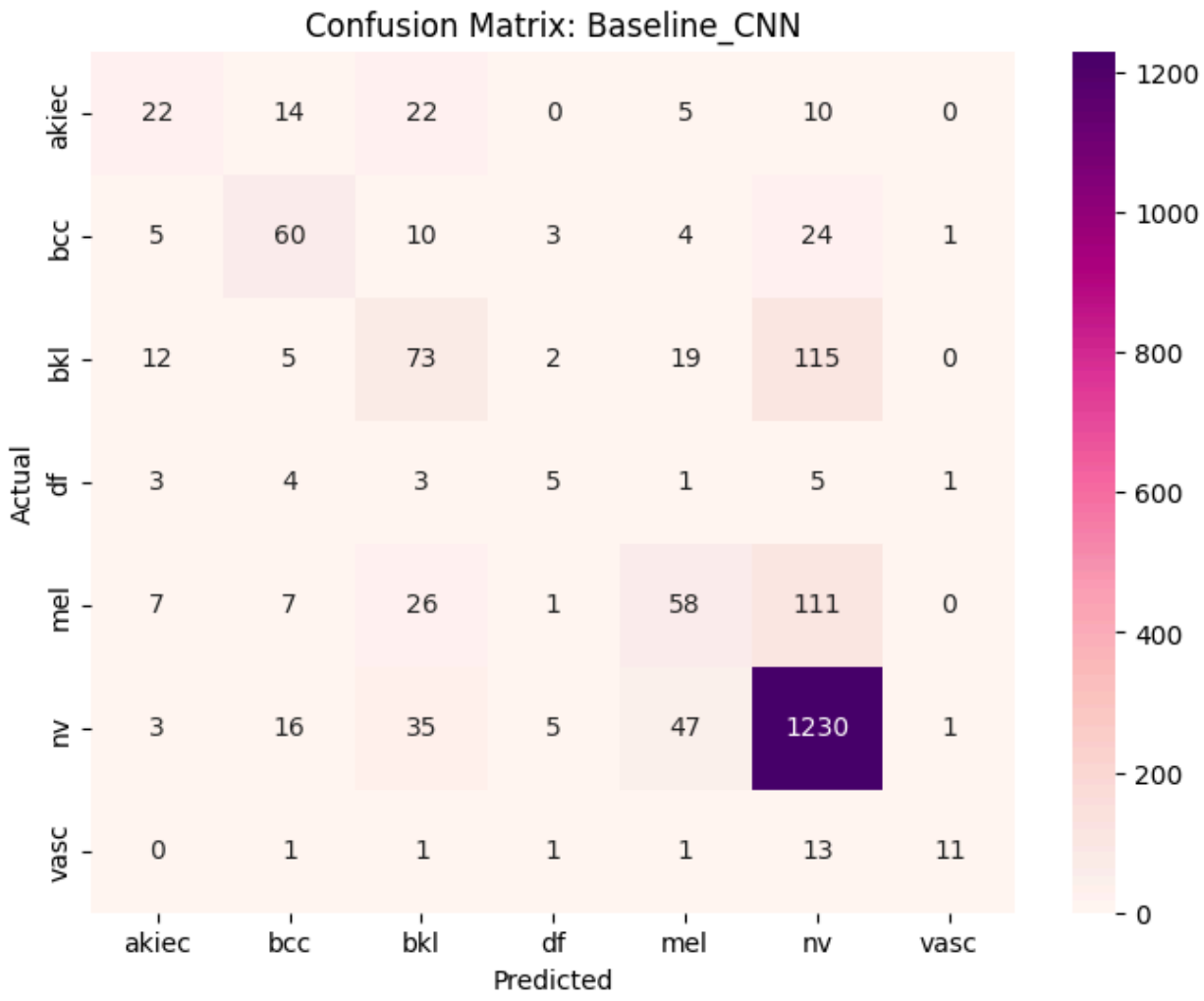
3. Evaluation & Confusion Matrix Observations (Task 4)

Comparing the **Baseline CNN** and **ResNet-50** matrices reveals critical diagnostic improvements:

- **Clinical Criticality (Melanoma Recall):** * The Baseline CNN correctly identified only **58** melanoma cases while dangerously misclassifying **111** as benign nevi.
    - The ResNet-50 model correctly identified **122** melanoma cases—**more than double** the baseline's performance—and reduced "mel-to-nv" false negatives to **73**.
- **Class Imbalance Sensitivity:** Both models show a bias towards **"nv" (Melanocytic nevi)** due to dataset distribution, with ResNet achieving **1,274** correct nevi predictions compared to the baseline's **1,230**.
- **Minority Class Accuracy:** ResNet showed superior performance in identifying rarer classes; for example, it correctly classified **54** "akiec" cases compared to only **22** by the baseline.





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5. Key Architectural Takeaways

- **Inductive Bias:** CNNs have a strong bias toward **locality**, which is excellent for textures but can miss large-scale structural patterns.
- **Residual Learning:** ResNet's **Skip Connections** prevent the "vanishing gradient" problem, allowing a 50-layer deep network to train safely where deeper scratch CNNs often fail to converge.
- **Model Failures:** "Worst Predictions" (e.g., indices 1020, 1309) likely involved artifacts like body hair or low contrast, proving AI requires clean, pre-processed data for clinical reliability.

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6. Conclusion

The ResNet-50 model is the clear winner due to the power of **Transfer Learning**, specifically in its ability to significantly increase **Melanoma recall**. For future development, integrating **Global Attention** (Transformers) could further improve the detection of asymmetrical malignant structures to enhance patient safety.