Skin Cancer Detection Using Deep Learning (HAM10000 Dataset)

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Project Title

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Problem Statement

Skin cancer is one of the most common forms of cancer globally, and early diagnosis significantly improves the chances of successful treatment. However, accurate detection of skin cancer requires experienced dermatologists and specialized diagnostic tools, which are often not accessible in many regions. Manual evaluations are time-consuming and susceptible to human error, particularly when differentiating between visually similar lesion types.

The objective of this project is to develop an automated system using **deep learning techniques** to classify dermoscopic images of skin lesions into seven medically relevant categories. This AI-based system aims to support clinicians by offering **fast, consistent, and accurate predictions**, thereby acting as a diagnostic assistance tool. The project also demonstrates the application of convolutional neural networks (CNNs), transfer learning, and evaluation techniques learned in the Artificial Intelligence course.

Dataset Description and Sample

The project uses the **HAM10000 (Human Against Machine with 10,000 images)** dataset, a publicly available and widely cited benchmark dataset for skin lesion classification.

Dataset Details:

- **Source:** Kaggle / ISIC Archive
- **Total Images:** 10,015 dermoscopic images
- **Image Format:** JPG (average resolution: approximately 600 × 450 pixels)
- **Metadata File:** `HAM10000_metadata.csv`
    - Attributes include lesion ID, diagnosis label (`dx`), diagnostic method (`dx_type`), patient age, gender, and anatomical location.

Classification Categories

All images are labeled into the following **seven classes**:

1. **akiec** – Actinic keratoses
2. **bcc** – Basal cell carcinoma
3. **bkl** – Benign keratosis
4. **df** – Dermatofibroma
5. **mel** – Melanoma
6. **nv** – Melanocytic nevi
7. **vasc** – Vascular lesions

These labels represent both benign and malignant skin lesions, allowing the AI system to distinguish high-risk cancerous cases from harmless conditions.

Project Objectives

The primary objectives of this project are:

1. **To build a complete multi-class image classification system** capable of identifying seven types of skin lesions using deep learning.
2. **To apply preprocessing and data augmentation techniques** (resizing, normalization, rotation, horizontal/vertical flipping, brightness adjustments) to improve model robustness and prevent overfitting.
3. **To utilize transfer learning** by fine-tuning a pre-trained CNN architecture such as **EfficientNetB0 or ResNet50** to achieve high classification accuracy while reducing training time.
4. **To evaluate model performance** using standard metrics including:
    - Accuracy
    - Precision
    - Recall
    - F1-Score

5. **To visualize performance results** through plots of training loss/accuracy curves and confusion matrices to analyze class-wise prediction results.
6. **To produce academic-quality documentation** and optionally demonstrate inference through a web interface (Flask or Streamlit).

Proposed Methodology

The entire system is developed using Python with **TensorFlow/Keras**, NumPy, Pandas, OpenCV, and Matplotlib.

1. Data Exploration & Cleaning

- Load images and metadata.
- Identify missing or corrupt image files and remove unusable entries.
- Analyze class distributions to understand imbalance issues.

2. Data Preprocessing

- **Resize all images to 224 × 224 pixels** to match the input requirements of modern CNN models.
- **Normalize pixel values** from `[0,255]` to `[0,1]`.
- Encode categorical labels into one-hot vectors for multi-class classification.

3. Data Augmentation

To increase data diversity and improve generalization:

- Random rotations
- Horizontal and vertical flips
- Zoom and shifting
- Random brightness and contrast changes

These transformations allow the model to be invariant to orientation, lighting, and slight positional changes.

4. Model Architecture

The model is built using a **transfer learning strategy**:

- **Base Network:** EfficientNetB0 pre-trained on ImageNet
- **Frozen Layers:** Initial layers are frozen to retain learned image features.
- **Custom Classifier Head:**
    - Global Average Pooling
    - Dense layers with ReLU activation
    - Dropout for regularization
    - Final Dense layer with **Softmax activation** for classification into 7 classes

5. Model Training

Training Configuration:

- Optimizer: **Adam**
- Loss Function: **Categorical Cross-Entropy**
- Batch Size: **16 – 32**
- Epochs: **15 – 30**
- Callbacks:
    - **ModelCheckpoint:** Save best model weights
    - **ReduceLROnPlateau:** Reduce learning rate on validation stagnation

6. Evaluation

After training:

- Measure model **accuracy on unseen validation data**.
- Generate:
    - **Confusion matrix**
    - **Classification report** (precision, recall, F1-score per class)
- Plot:
    - Training vs validation accuracy curves
    - Training vs validation loss curves
- Display sample predictions on test images to verify real-world inference.

7. Optional User Interface

A lightweight **Flask or Streamlit web interface** allows users to:

- Upload a dermoscopic image.
- Receive the predicted lesion class and confidence values.
- Visualize prediction results interactively.

Expected Results or Outcomes

By implementing the proposed methodology, the project is expected to achieve:

Model Artifacts

- **Saved trained model:** `results/checkpoints/best_model.h5`
- **Training visualizations:**
  - `results/accuracy_loss.png`
  - `results/confusion_matrix.png`
- **Performance metrics:**
  - `results/classification_report.txt`

Performance Targets

- **Validation Accuracy: ≥ 80%**
- Strong recall values for melanoma (**mel**) class, as this category is clinically critical.
- Balanced classification across majority and minority classes using augmentation.

Project Deliverables

Fully functional deep learning classifier
Reproducible Python notebook with clean code
Performance charts and metric reports
Academic documentation
Live demo using Streamlit or Flask
Public GitHub repository submission

Final Outcome

This project demonstrates effective use of **Artificial Intelligence and Deep Learning** to develop a medical image analysis system capable of assisting in early skin cancer detection. The system showcases real-world application of CNNs, transfer learning, model evaluation, and data visualization. It provides a foundation for future enhancements, such as deployment in mobile health applications or integration into clinical diagnostic pipelines.