SKIN DISEASE DETECTION USING DEEP LEARNING

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1. Introduction

- Skin cancer is among the most common and dangerous cancers globally, with early detection being a key factor in improving survival rates. Traditional diagnostic methods often depend on dermatologists' visual assessment, which can be subjective, error-prone, and unavailable in remote areas. Leveraging advancements in deep learning, particularly Convolutional Neural Networks (CNNs), this project introduces a robust, automated classification system that detects seven types of skin lesions using the HAM10000 dataset. The system is designed to aid healthcare professionals by offering consistent and accurate diagnostics while making advanced medical tools accessible in under-resourced settings via a web-based platform.

2. Problem Statement

- Despite technological progress in healthcare, the diagnosis of skin diseases remains largely manual and heavily reliant on professional expertise. This leads to:
- **High risk of diagnostic error**
- **Limited access in rural or resource-constrained regions**
- **Delays in initiating treatment**
- **Lack of standardized evaluation criteria**
- This project seeks to address these issues by building an intelligent, scalable, and accessible diagnostic tool capable of identifying multiple skin diseases through image analysis, thereby improving diagnostic accuracy and enabling early intervention.

3. STANFORD DESIGN THINKING MODEL

- The methodology follows Stanford's human-centered design thinking approach:
- **Empathize**: Understanding the challenges faced by patients and clinicians in timely diagnosis through interviews and research.
- **Define**: Pinpointing the need for a non-invasive, scalable tool to assist with skin lesion classification.
- **Ideate**: Brainstorming solutions such as CNN models, mobile/web apps, and explainable AI features like Grad-CAM.
- **Prototype**: Developing a real-time skin disease classification system integrated with a clean web-based UI.
- **Test**: Validating the system with dermoscopic images and assessing usability, performance, and interpretability.
- This iterative model ensures that the final product meets user needs while being technically robust.

4. Features of the Project

- **Automated Skin Disease Detection**: Detects 7 types of skin lesions from dermoscopic images.
- **CNN-based Classification**: Uses a deep learning model with high accuracy (~92.6%).
- **Real-time Prediction**: Users upload images via a web interface and receive immediate results.
- **Grad-CAM Heatmaps**: Visual explanation of model predictions.
- **Metadata Integration**: Considers patient attributes (age, lesion site, etc.) for future development.
- **Portable and Scalable**: Web app deployable on cloud platforms or integrated into mobile apps.

5. Pain Points Identified

- **Subjectivity in Visual Diagnosis**: Inconsistent results depending on dermatologist experience.
- **Geographic Limitations**: Scarcity of dermatologists in rural/remote areas.
- **Delays in Diagnosis**: Late detection reduces survival rates, especially for aggressive lesions like melanoma.
- **Data Imbalance**: Some lesion types are underrepresented in datasets, causing classification challenges.
- **Image Quality Issues**: Artifacts like hair, markings, and poor lighting reduce diagnostic clarity.

6. Technologies Used

- **Dataset**: HAM10000 (10,000+ dermoscopic images)
- **Programming Language**: Python
- **Deep Learning Frameworks**: TensorFlow, Keras
- **Libraries**: NumPy, OpenCV, Matplotlib, Scikit-learn
- **Model Architecture**: Custom CNN with dropout, ReLU, max-pooling, and softmax layers
- **UI & Deployment**: Flask for web UI, Grad-CAM for explainability
- **Data Storage**: TFRecords, NumPy arrays for optimized I/O
- **Tools for Testing**: Confusion matrix, F1-score, precision, recall

7. Comparative Analysis of Existing System

Feature	Manual Diagnosis	Existing Mobile Apps	Proposed AI System
Diagnostic Accuracy	Variable	Moderate	High (~92.6%)
Real-time Feedback	❌	✅	✅
Multi-class Classification	❌	❌	✅
Explainability	❌	❌	✅
Scalability and Cloud Deployment	❌	❌	✅
Metadata Use	❌	❌	UNDER DEVELOPMENT

8. Proposed Method (Design Thinking Approach)

- The design thinking-based development process emphasizes continuous user involvement and validation:
- **User-Centric Research**: Understanding needs of clinicians and patients through surveys.
- **Ideation Workshops**: Brainstorming sessions with dermatologists, ML experts, and patients.
- **Low-Fidelity Prototyping**: Rapid sketches and web mockups to validate workflows.
- **High-Fidelity Implementation**: Developed a CNN model and interactive web UI.
- **Iterative Testing**: Feedback from early users helped refine the system’s usability and prediction feedback.

9. Proposed Method (Implementation / Prototype Developed)

- The final prototype integrates:
- A CNN trained on preprocessed HAM10000 images.
- Input images resized to 224x224, normalized, and augmented.
- Regularization with dropout layers to avoid overfitting.
- Output softmax layer delivering probability scores across 7 classes.
- Flask-based web interface with file upload and prediction dashboard.
- Backend logs for user queries (for model improvement).
- Integration of Grad-CAM for visual feedback.
- This prototype demonstrates high performance, real-time interaction, and user-friendly design, suitable for pilot testing in medical environments.

10. Target Audience Benefitted

- **Dermatologists**: Assisting in diagnosis and second opinions.
- **General Physicians**: For triaging skin lesion cases.
- **Patients in Remote Areas**: Enables early screening and care-seeking.
- **Healthcare Startups**: Offers integration-ready modules.
- **Academic and Research Institutions**: As a tool for education and medical AI research.

11. Conclusion

The project successfully demonstrates how deep learning, combined with a user-centered design approach, can revolutionize dermatological diagnostics. The system achieves a 92.6% accuracy in classifying skin lesions and incorporates explainability, accessibility, and scalability—key features for real-world adoption. With further validation, integration with electronic health systems, and potential mobile deployment, this tool can serve as a reliable ally in global skin cancer prevention and care.