

Assignment 2: Problem Statement and Research Objectives

Course Title: Research Methodology in Computer Science (AI800)

Research Title: Dynamic Analysis of Deep Learning Architectures for Automated Skin Disease Diagnosis

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Introduction

Deep Learning (DL) has been the keystone in the evolution of modern dermatology, providing automation for the detection of complex patterns in skin with expert-level accuracy. The following literature review assesses six of the primary research papers promoting different deep learning methods; ranging from ontogenic performance reviews to complex multispectral imaging and explainable frameworks. This review covers the evolution of these models to meet real-world diagnostic needs, characterizing their technical strengths and intrinsic limitations by identifying relationships among evolving technologies in this space.

1. Problem Statement

The domain of automated dermatology has seen significant advancements through Deep Learning (DL). However, despite achieving high diagnostic accuracy—often exceeding 94%—a critical gap remains in transitioning these models from laboratory settings to real-world clinical use.

Current literature highlights three primary challenges:

1. **Dataset Homogeneity and Bias:** Most existing models are trained on highly specific datasets like ISIC, which lack diversity in skin tones and rare disease variations, leading to potential diagnostic bias.
2. **The "Black-Box" Nature of AI:** There is a significant lack of interpretability in model decision-making, which hinders clinical trust among dermatologists.
3. **High Resource Dependency:** Advanced frameworks, such as Vision Transformers and multispectral imaging systems, require humongous computational resources and expensive hardware, making them inaccessible in low-resource or standard clinical environments.

Therefore, there is an urgent need to research and propose more "dynamic" and lightweight architectures that can maintain high accuracy while ensuring interpretability and robustness across diverse, real-world datasets.

2. Research Objectives

The primary goal of this research is to evaluate and propose an optimized deep learning framework that balances diagnostic accuracy with interpretability for automated skin disease detection. To achieve this goal, the following objectives have been identified:

- To analyze the performance of various CNN and Transformer architectures in detecting non-cancerous skin diseases under noisy, real-world image conditions.
- To design a hybrid diagnostic model that effectively integrates visual image data with clinical patient metadata to reduce diagnostic uncertainty.
- To implement an explainable AI (XAI) layer using visual heatmaps to provide clinical justification for automated diagnostic decisions.
- To evaluate the efficiency of data augmentation and lightweight modeling techniques in maintaining high precision within resource-constrained environments

3. Literature Review and Synthesis

- Paper 1: Systems Performance Review (Choy et al, 2023)

This systematic review provides the first baseline in the field assessing 64 studies for non-cancerous skin diseases. Using a systematic review approach, the study evaluates how well CNNs perform on disease severity and diagnostic accuracy with a median 94% accuracy. Synthesis: Though this paper offers a strong general overview of DL potential, it also flags a persistent weakness of the field: dataset homogeneity. This is a harbinger of Paper 2, which aims to address this diagnostic gap by incorporating external clinical data

- Paper 2: Integrating Metadata into CNNs (Muhaba et al, 2022)

In response to this shortcoming in image-only models, Muhaba et al. implemented a hybrid architecture that combines clinical patient metadata (age, sex, and history) with ResNet50 architectures. This approach demonstrated that contextual data greatly decreases diagnostic uncertainty, achieving an accuracy level of 92%. Analysis: The strength of this paper is its realistic approach of setting in clinical settings; however, major weakness lies in demand for metadata which is mostly absent from digitized medical records.

- Paper 3: Multispectral Diagnostic Approaches (Jiang et al., 2024)

Jiang et al. 2022: 151) “Data quality plays a crucial role in improving the accuracy and reliability of statistics, which in turn lead to informed policy decisions.” this study investigated the use of multispectral imaging with DL for early screening and evaluation of psoriasis and warts. This method provides an objective diagnostic standard that is more nuanced than the visible light (rainbow) approach. Synthesis:

Technically, this paper builds on Papers 1 and 2 by extending the focus beyond standard RGB images to other types of hardware; however its weakness is still high cost of such specialized equipment.

- Paper 4: Explainable AI (XAI) and Trust (Gupta et al. 2024)

Since the previous papers established accuracy, Gupta et al. emphasized “interpretability” via Vision Transformers using Grad-CAM to produce visual heatmaps. This methodology solves the “black-box” challenge by demonstrating to dermatologists precisely what pixels drove the AI’s decision-making. Critical Analysis: Explainable models are relatively trustworthy by clinical personnel which is their strength however; they require humongous computational resources to run the explainable model in real time, thus becoming their weakness.

Paper 5: The comparison of DL classifiers (Khan et al., 2023)

In addition, a technical comparison of different architectures like ResNet, VGG and DenseNet on the ISIC dataset is provided in this study. A quest that aimed at finding out which architecture, when it comes to image representation, holds its ground best. Synthesis: This piece returns to the systematic review explored in Paper 1 and provides a direct performance comparison of the models discussed but shares one issue with its predecessor, relying on single yet large data set (ISIC).

Paper 6: Data Augmentation and Scarcity Solutions (Nawaz et al., 2024)

Finally, Nawaz et al. address the data shortage mentioned in Papers 1 and 5 by employing sophisticated data augmentation techniques for InceptionV3. By artificially expanding the training sets, they improved accuracy to 96.1%. Critical Analysis: While effective in boosting numbers, the methodology's weakness is the risk of "overfitting" on synthetic patterns, which may not always translate perfectly to diverse, real-world patient cases.

Summary Table

Paper	Author	Core Methodology	Key Result	Critical limitation
1	Choy et al, 2023	Systematic Review (64 student)	94% median accuracy	Dataset diversity issues
2	Muhaba et al, 2022	Hybird CNN + Metadata	92% accuracy	Metadata consistency
3	Jiang et al., 2024	Multispectral + DL	Reduced manual labor	Hardware requirements
4	Gupta et al. 2024	XAI (Grad-CAM)	96.5% accuracy	High GPU demand
5	Khan et al., 2023	RestNet/VGG/DenseNet	Precise classification	Data/Power intensity
6	Nawaz et al., 2024	Data Augmentation	96.1% Accuracy	Seed image dependency

Conclusion

A clear path in skin disease AI research can be seen by synthesizing these six papers: from general accuracy evaluations to specialized imaging and explainable models. Even though the field has attained impressive precision (92%–96%), dataset bias and high computing requirements continue to impede the shift from laboratory settings to global clinical use. Future research must focus on lightweight, comprehensible models that work well in low-resource settings and with a variety of skin types.

References

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