PhD Research Proposal

Designing Interpretable and Lightweight Deep Learning Systems for Early Melanoma Detection in Clinical and Telemedicine Applications

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1 Introduction

My academic and professional journey has been defined by an interdisciplinary approach, blending computer science, entrepreneurship, and mentorship to address complex challenges. Graduating at the top of my computer science class while managing a freelance graphic design business and exploring hospitality ventures taught me to navigate diverse domains and uncover innovative solutions at their intersections. These experiences, coupled with my masters research in AI, have fueled my passion for developing practical, impactful technologies. This proposal outlines my plan to pursue a PhD focused on creating deep learning systems for early melanoma detection, combining clinical accuracy with real-world applicability.

Melanoma, a deadly form of skin cancer, is treatable if detected early, yet access to reliable diagnostic tools remains limited, particularly in underserved regions. My proposed research aims to develop interpretable deep learning models for melanoma detection that clinicians can trust and lightweight systems suitable for telemedicine applications.

2 Research Background

The intersection of AI and medical diagnostics has seen significant advancements, yet challenges persist in making deep learning models interpretable and deployable in resource-constrained settings. My masters research, collaborating with Dr. Karthikey L on economic AI and Dr. Siddheshwari D. Mishra on medical image enhancement, demonstrated how interdisciplinary perspectives can enhance AIs practical impact. For instance, my work on medical image enhancement improved diagnostic accuracy by optimizing image preprocessing pipelines, revealing the

potential of tailored AI solutions in healthcare.

Current melanoma detection systems often rely on complex convolutional neural networks (CNNs) that achieve high accuracy but lack interpretability, reducing clinician trust. Additionally, heavyweight models are impractical for telemedicine in low-resource areas. My background in managing complex projects and mentoring students equips me to bridge these gaps, combining technical rigor with a focus on accessibility.

3 Research Questions and Objectives

This research addresses the following questions:

1. How can deep learning models for melanoma detection be designed to maximize interpretability without sacrificing clinical accuracy?
2. What techniques can optimize lightweight models for deployment in telemedicine platforms?
3. How can interdisciplinary approaches enhance the usability of AI-driven diagnostic tools for clinicians and patients?

Objectives:

- Develop interpretable deep learning models using techniques like attention mechanisms and feature visualization to ensure clinicians can understand model decisions.
- Design lightweight CNN architectures optimized for mobile and telemedicine platforms, balancing accuracy and computational efficiency.
- Validate models through clinical datasets and user studies to ensure practical applicability and trustworthiness.

4 Methodology

The proposed research will follow a structured methodology:

4.1 Data Collection and Preprocessing

Utilize publicly available datasets like the ISIC Archive and collaborate with medical institutions (if feasible) to access annotated dermoscopic images. Preprocess images to enhance quality (e.g., contrast adjustment, noise reduction) based on techniques from my masters work.

4.2 Model Development

- **Interpretable Models**: Implement CNNs with attention mechanisms (e.g., Grad-CAM) to highlight regions of interest in dermoscopic images, aiding clinician understanding.
- **Lightweight Models**: Explore model compression techniques like pruning and quantization to develop efficient architectures (e.g., MobileNet-based) suitable for telemedicine.
- **Hybrid Approach**: Combine interpretable and lightweight models to optimize both trust and deployability.

4.3 Validation and Testing

Evaluate models using metrics like sensitivity, specificity, and area under the ROC curve (AUC). Conduct user studies with clinicians to assess interpretability and usability, iterating based on feedback.

4.4 Tools and Technologies

Use Python with TensorFlow/PyTorch for model development, and leverage Overleaf for collaborative documentation. Experiments will be conducted on cloud-based GPU platforms to ensure scalability.

5 Significance of the Research

This research addresses critical gaps in melanoma detection by prioritizing interpretability and accessibility. Interpretable models will foster clinician trust, increasing adoption in clinical

settings, while lightweight models will enable deployment in telemedicine, particularly in underserved regions. By democratizing advanced diagnostics, this work aligns with global health equity goals. Additionally, my interdisciplinary backgroundspanning computer science, entrepreneurship, and mentorshippositions me to translate technical innovations into practical solutions.

6 Timeline

Phase	**Duration**
Literature Review	Year 1, Months 1–6
Data Collection	Year 1, Months 6–12
Model Development	Year 2, Months 1–12
Validation and Testing	Year 3, Months 1–9
Thesis Writing	Year 3, Months 9–12

Table 1: Proposed Timeline for PhD Research

7 Conclusion

My diverse experiences have prepared me to tackle the technical and practical challenges of developing AI for melanoma detection. By creating interpretable and lightweight deep learning systems, I aim to advance medical diagnostics while mentoring future researchers. I am eager to contribute to and grow within a dynamic research community.