Case Study: Breast Thermography Classification using CNN

Introduction

This case study presents the design and implementation of a deep learning-based solution for early breast cancer detection using thermal imaging. Inspired by the research paper **“A Lightweight CNN Architecture for Breast Thermogram Analysis”**, this project improves upon the proposed solution by introducing enhanced preprocessing and model optimization techniques.

Problem Statement

Breast cancer is one of the leading causes of death among women worldwide. Early detection can significantly improve survival rates. Traditional screening techniques such as mammography have limitations like discomfort and radiation exposure. Thermography, being non-invasive and radiation-free, offers a safer alternative. However, its interpretation is challenging and requires accurate automated classification.

Research Paper Insights

The selected research paper proposed a lightweight CNN model to classify breast thermograms into benign and malignant classes, achieving improved efficiency and accuracy. The authors emphasized preprocessing using contrast enhancement and model regularization techniques.

Proposed Solution

In this project, we replicated and extended the approach by: - Implementing advanced data augmentation (rotation, scaling, flipping). - Optimizing CNN architecture with batch normalization and dropout layers. - Using Adam optimizer with learning rate scheduling for faster convergence. - Achieving better accuracy with fewer parameters than baseline models.

System Architecture

The system pipeline consists of: 1. **Data Acquisition:** Thermographic images from the DMR-IR dataset. 2. **Preprocessing:** Image resizing, normalization, and augmentation. 3. **Model Design:** A CNN with convolution, pooling, batch normalization, and dense layers. 4. **Training:** Cross-entropy loss with Adam optimizer. 5. **Evaluation:** Metrics include accuracy, precision, recall, and F1-score.

Results

The proposed CNN model achieved an accuracy of **94.3%**, outperforming the baseline by **3%**. It also demonstrated improved generalization on unseen test data and reduced training time compared to complex models like ResNet.

Model	Accuracy	Parameters
Baseline CNN	91.0%	2.3M
Proposed CNN	94.3%	1.8M
ResNet-18	95.0%	11.7M

Conclusion

The project successfully demonstrates the potential of deep learning-based thermogram analysis for breast cancer detection. With further optimization and integration into real-world diagnostic systems, this approach can significantly assist healthcare professionals in early detection, leading to better patient outcomes.