AUTOMATED BREAST CANCER CLASSIFICATION USING CONVNEXT AND TRANSFER LEARNING

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1 Abstract

This project proposes a deep learning system to automate the diagnosis of breast cancer from mammograms using the CBIS-DDSM dataset. We employ **ConvNeXt**, a modern Convolutional Neural Network, combined with **Transfer Learning** to extract high-level features from high-resolution medical images. To improve efficiency, we introduce a custom **ELM-style classification head**. The methodology also incorporates advanced extensions such as **U-Net for segmentation**, **Grad-CAM for visual explainability**, and **Knowledge Distillation** for lightweight deployment. The proposed system aims to assist radiologists by providing high-sensitivity predictions for Benign and Malignant tumors.

2 Introduction

Breast cancer is a leading cause of mortality among women worldwide, making early detection critical for survival. While mammography is the gold standard for screening, manual interpretation is time-consuming and prone to human error due to the complexity of identifying subtle tissue anomalies. Existing AI solutions often struggle with the noise and high resolution of mammograms. This project addresses these challenges by leveraging **ConvNeXt**, which offers superior global shape recognition compared to traditional CNNs, and implementing a robust pipeline for preprocessing, augmentation, and explainable classification.

3 Methodology

The study follows a four-stage pipeline: (1) **Preprocessing:** Metadata mapping is used to clean the CBIS-DDSM dataset, followed by resizing and normalization. (2) **Augmentation:** Random rotations, zooms, and flips are applied to prevent overfitting. (3) **Feature Extraction:** A frozen **ConvNeXtBase** backbone extracts 1024-dimensional feature vectors. (4) **Classification:** A Global Average Pooling layer feeds into a custom Dense layer with GELU activation and Softmax output. Extensions include segmentation using U-Net and explainability using Saliency Maps.

4 Literature Survey

Ref No	Title and Year	Algorithms	Datasets	Advantages	Limitations	Objective	Metrics
1	Mammography with Deep Learning for Breast Cancer Detection (L. Wang, 2024)	Deep Learning, Radiomics	Mammography Datasets	Customizes screening per patient; High accuracy	Requires large annotated datasets for training	Review DL achievements in mammography	Accuracy, Sensitivity, F1-Score
2	Deep Learning Based Breast Cancer Detection Using Decision Fusion (D. Manalı et al., 2024)	Decision Fusion, CNN, SVM	Mammography Datasets	Combines multiple channels for higher reliability (99.1%)	Complex architecture; high computational cost	Enhance accuracy via decision fusion	Accuracy (99.1%), Precision

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3	Deep Learning Applications to Breast Cancer Detection by MRI (R. Adam et al., 2023)	CNNs (Deep Learning)	Breast MRI	High sensitivity; detailed pathophysiological info	MRI is less cost-effective than mammography	Review DL applications in Breast MRI	Sensitivity, Specificity
4	Exploiting Precision Mapping and Component-Specific Feature Enhancement (V. Pandiyaraju et al., 2024)	PMAD-LinkNet, CSFEC-Net	Breast Ultrasound / Mammography	Precise pixel-level boundary refinement	Specialized for morphology analysis	Improve segmentation and classification	Accuracy (99.2%), IoU (96.9%)
5	Breast Cancer Detection and Diagnosis: A Comparative Study (B. Maistry et al., 2024)	MobileNet, DenseNet, Custom CNN	Histopathology / Mammography	Comparison of SOTA architectures; MobileNet is efficient	Performance varies significantly by resolution	Compare DL architectures for detection	Accuracy (95.54%)
6	Deep Learning in Breast Cancer Imaging: A Decade of Progress (L. Luo et al., 2024)	Multi-modal DL, Transformers	Mammograms, MRI, Ultrasound	Comprehensive review of 10 years of progress	Highlights data scarcity and noise issues	Summarize progress and identifying future gaps	AUC, F1-Score
7	Dual View Deep Learning for Enhanced Breast Cancer Screening (S. R. Kebede et al., 2024)	Ensemble EfficientNet, YOLOv5	Mammography Datasets	Uses YOLO for mass detection to explain predictions	Slightly lower F1-score when maximizing sensitivity	Assist radiologists in mass screening	Sensitivity (0.89), F1-Score (0.87)
8	The Role of Deep Learning in Advancing Breast Cancer Detection (M. Madani et al., 2022)	CNNs, Transfer Learning	Multi-modal Datasets	Systematic review of all modalities; identifies key trends	Manual detection is time-consuming	Systematic review of imaging modalities	Accuracy, Sensitivity