Deep learning Based Fusion of Multimodal Breast Cancer Data (Proposed PhD Research)

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Abstract

This study aims to develop a deep learning framework for fusing multimodal breast cancer data. A feature fusion framework will be employed to combine features from different modalities, improving the accuracy of distinguishing between benign and malignant cases. The results aims to show that this method has the potential to advance computer-aided diagnosis systems by offering more precise and reliable predictions.

Keywords: Breast Cancer classification, Feature Fusion, Multi-modal data, Medical Imaging.

Introduction

Breast cancer is one of the leading causes of death. Early detection of this deadly disease could help reduce mortality. Different machine learning and deep learning models have been used to classify breast cancer as benign or malignant. This research explores the potential of deep learning for multimodal breast cancer detection and classification by fusing features from different modalities like Mammography (MG), Magnetic Resonance Imaging (MRI), Positron Emission Tomography (PET), and Computed Tomography (CT).

Preliminary Work Summary

Conducted a thorough review of the TCIA - Breast Diagnosis dataset to assess its suitability for the study. Identified key imaging modalities (MG, MRI, PET, and CT) and evaluated their respective distributions, quality, and metadata. Reviewed recent studies on multimodal breast cancer detection and feature fusion techniques. Identified gaps, such as limited integration of diverse imaging modalities and the need for improved generalization in models.

Task	Description	Status
Dataset Exploration	Reviewed TCIA dataset, identified modalities, assessed data quality	Completed
Preprocessing	Applied cropping, normalization, and denoising on sample data	In Progress
Baseline Experiments	Tested single-modality models for baseline performance	In Progress
Literature Review	Reviewed studies on multimodal breast cancer detection	Almost Completed

Materials & Methods

The outlined methodology reflects the proposed steps for conducting this research:

- Dataset: TCIA - Breast Diagnosis dataset with four modalities; Mammography (MG), Magnetic Resonance Imaging (MRI), Positron Emission Tomography (PET), and Computed Tomography (CT).
- Data Processing: Each data modality is preprocessed by cropping, normalizing, and denoise.
- Data Augmentation: apply specific augmentation method to each modality.
- Feature Fusion: Combine extracted features from all modalities into a unified feature vector for improved classification.
- Data Training with CNN: Use pre-trained models ResNet, fine-tuned for the specific dataset, to classify breast diagnosis cases into benign and malignant.

Research Questions

- How does the integration of multimodal imaging data (MG, MRI, PET, CT) improve the sensitivity and specificity of breast cancer detection models, particularly in distinguishing between benign and malignant tumors, compared to single-modality models?
- Which data augmentation techniques (e.g., rotation, scaling, noise addition) most effectively improve model generalization across MG, MRI, PET, and CT imaging modalities, particularly in mitigating overfitting and enhancing cross-modality accuracy in breast cancer classification?
- How do specific feature extraction techniques (e.g., wavelet transformation, HOG) and pre-trained CNN models (e.g., ResNet) impact the accuracy and AUC of fused multimodal features (MG, MRI, PET, CT) in breast cancer detection models?

Conclusion

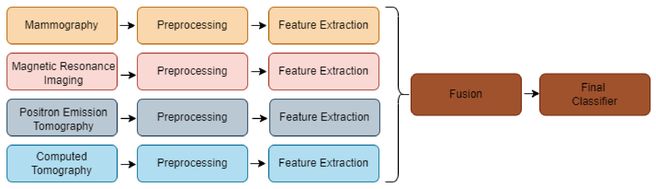

Figure 1: Fusion Approach

This research is at its proposal stage, with future work to implement and validate the described methods.

- The research proposes combining features from MG, MRI, PET, and CT to enhance diagnostic accuracy through a feature fusion framework.
- Each imaging modality will undergo specific preprocessing and augmentation methods to optimize feature extraction.
- Data preprocessing and feature extraction are done followed by the fusion framework and model training.
- A deep learning based classification model will be trained and validated on the Breast diagnosis multimodal datasets to distinguish between benign and malignant cases.
- This approach is expected to improve early detection and diagnosis of breast cancer, setting the stage for future clinical applications.

References

[1] Cruz-Ramos et al. Benign and malignant breast tumor classification in ultrasound and mammography images via fusion of deep learning and handcraft features. 2023.

[2] Kushangi et al. Atrey. Multimodal classification of breast cancer using feature level fusion of mammogram and ultrasound images in machine learning paradigm. 2024.

Future Research

Advanced feature fusion techniques, including attention mechanisms and graph-based methods, could further improve the integration and effectiveness of multimodal data.

Expanding datasets to include diverse patient populations and larger sample sizes will enhance the generalizability and robustness of the models.

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