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mHealth Lab BIOMEDICAL ENGINEERING

HISTOSCOPE: AI-Assisted Classification of Breast Cancer Histopathology Images

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Abstract

Breast cancer is a leading cause of cancer-related deaths worldwide. In this study, we developed a deep learning model to classify histopathology images using the BACH dataset, which includes 400 images in four categories: Normal, Benign, In Situ, and Invasive. Our two-step model, combining patchwise and imagewise ResNet50 classification, achieved over 93% accuracy when tested on data from 34 patients. This automated approach has the potential to enhance diagnostic precision and support pathologists in clinical decision-making.

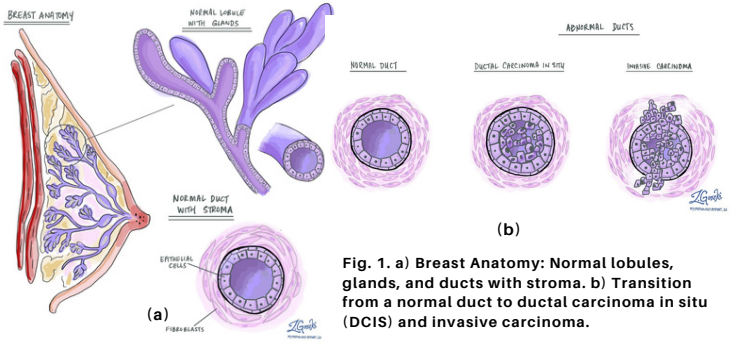


Fig. 1. a) Breast Anatomy: Normal lobules, glands, and ducts with stroma. b) Transition from a normal duct to ductal carcinoma in situ (DCIS) and invasive carcinoma.

Background

- Breast cancer is the 2nd most common cancer worldwide: 12% of all new cases, 25% in women.
- 1 in 8 women and 1 in 833 men are diagnosed with breast cancer.
- Every 3 minutes, a woman is diagnosed; every 13 minutes, a woman dies from it.
- 2.3 million women diagnosed, 670,000 deaths in 2022 worldwide
- 297,790 new invasive cases in women, 55,720 new DCIS cases were diagnosed last year
- In Bangladesh:
  - Incidence rate: 22.5 per 100,000 women.
  - Annually: Over 13,000 new cases, over 7,000 deaths.
  - 18% of female cancers are breast cancer.
  - CBE 2024: Case-based system—1.2% positive, Aggregated system—1.8% positive.

Constraints of Traditional Diagnosis:

- **Time-consuming process**
- **Lack of trained pathologists**
- **Inconsistent results**
- **Human dependence & diagnostic variability**
- **Risk of human error**

Goals

- To reduce diagnostic errors and speed up the process.
- Achieve up to 90% accuracy in breast cancer detection.
- Improve accessibility and enhance consistency
- Classify invasive (IDC) vs. non-invasive (DCIS) tumors for tailored treatment based on aggressiveness and recurrence risk.

Methodology

We developed a deep learning-based classification model using the BACH(Breast Cancer Histology) dataset, consisting of 400 breast histopathology images across four classes: Normal, Benign, In Situ, and Invasive. The dataset was split into training (70%), validation (15%), and test (15%) sets. Prior to training, the images were normalized and augmented to enhance model robustness and prevent overfitting. Our approach involved two key steps:

1. Patchwise Feature Extraction:

A ResNet50-based convolutional neural network (CNN) was trained to classify 512x512 image patches, extracting detailed local features.

2. Imagewise Classification:

The patch-level features were aggregated into 12 feature maps and input into a second ResNet50 model to classify the entire image.
The model was trained and validated on data from 34 patients, achieving over 93% accuracy on the test set. We employed cross-entropy loss, the Adam optimizer, and used early stopping and dropout layers to improve generalization and performance.

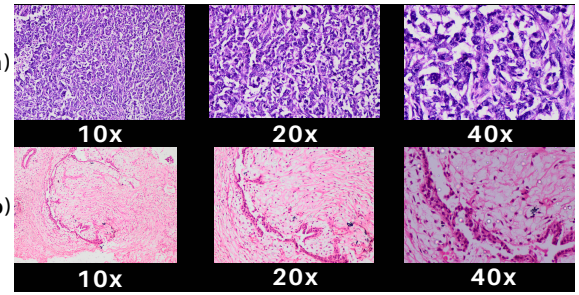


Fig. 3. a) Invasive breast cancer histopathology image
b) Benign breast tissue histopathology image
(Both NICRH patient data; H&E 10x,20x,40x magnification)

AI Heatmap vs. Histopathologist Annotations for Invasive Cancer

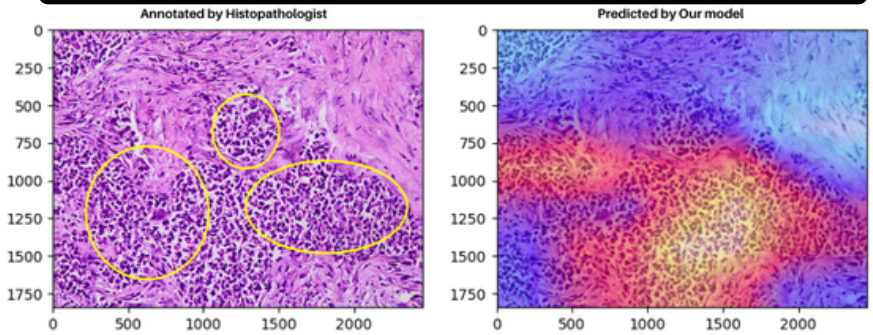
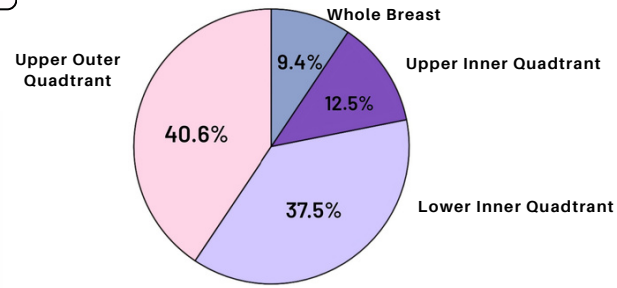


Fig. 2.(a) Histopathologist annotations of invasive malignant regions (yellow) (b) AI model heatmap, where red indicates high influence on prediction, green/yellow are moderately important, and blue represents the least important areas. (NICRH patient data)

Tumor Location Distribution



Results Analysis

The model showed strong performance, with higher accuracy at the image level (93.44%), indicating that aggregating patch-level features improves classification. Heatmaps confirmed the model's focus on key regions, highlighting its potential as a reliable tool for breast cancer diagnosis.

Performance on BACH Dataset

Model Type	Validation Accuracy	Test Accurcy
Patchwise	81.95%	83.00%
Imagewise	84.75%	93.44%

Discussion and Conclusion

- The model performed well on the BACH dataset, but its accuracy may vary when applied to data from different countries due to demographic differences.
- We are collecting more local patient data to improve model generalization across diverse populations.
- Future efforts will explore other AI architectures like GANs (Generative Adversarial Networks), RNNs (Recurrent Neural Networks), and LLMs (Large Language Models) for enhanced multilevel classification of breast cancer images.
- As this is an ongoing study, we aim to develop population-specific diagnostic tools, improving accuracy and clinical relevance for local use.

Reference