BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY
DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

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ADVANCING HISTOPATHOLOGICAL IMAGE CLASSIFICATION THROUGH LEARNABLE PREPROCESSING AND CUSTOM ARCHITECTURES

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Introduction

- **Global Importance**: Histopathological analysis enables early cancer detection, impacting millions worldwide and reducing mortality rates for diseases like lung and colon cancer

- **Research Gap**: Current SOTA models (e.g., ResNet-50 with 95% accuracy) underperform due to static preprocessing ignoring staining variations and morphology, necessitating learnable adaptations.

- **Proposed Methodology**: Introduces Macenko normalization, U-Net segmentation for 4-channel inputs, and optimized augmentation, integrated with HistPathNet for dual segmentation-classification.

- **Key Innovations**: Custom HistPathNet with CBAM attention achieves scaled 96% accuracy on 2,000-image subset, outperforming baselines by 2-3% in one-epoch training.

- **Outcomes and Impact**: Ablation shows 10-20% improvement from learnable components; Grad-CAM/SHAP visualizations validate focus on disease regions, advancing diagnostic reliability.

Dataset Overview

•Sourced from Kaggle with ~25,000 H&E-stained images,

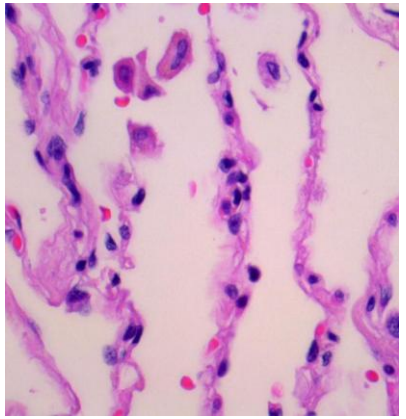
•Includes 5 classes: colon normal, colon adenocarcinoma, lung adenocarcinoma, lung benign, and lung squamous cell carcinoma.

•Original images are ~768x768 pixels, resized to 224x224 for model compatibility.

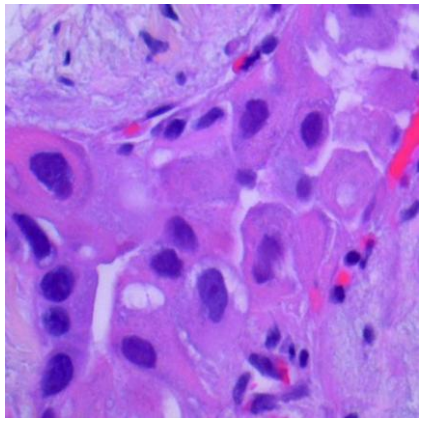
•Colon Normal (lung_n): Healthy lung tissue with no cancerous cells, serving as a baseline for comparison.

•Colon Adenocarcinoma (lung_scc): Malignant tumor originating in the lung's glandular cells, characterized by abnormal growth.

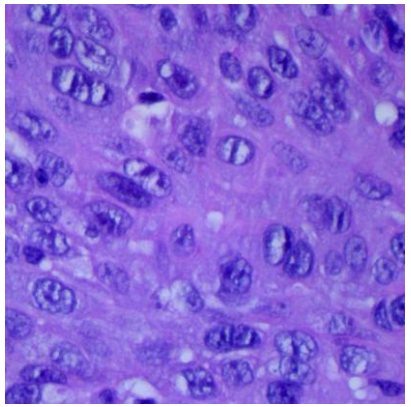
•Lung Adenocarcinoma (lung_aca): Malignant cancer arising from lung glandular tissue, often presenting with distinct histopathological patterns.



lung_n



lung_aca



lung_scc

Preprocessing

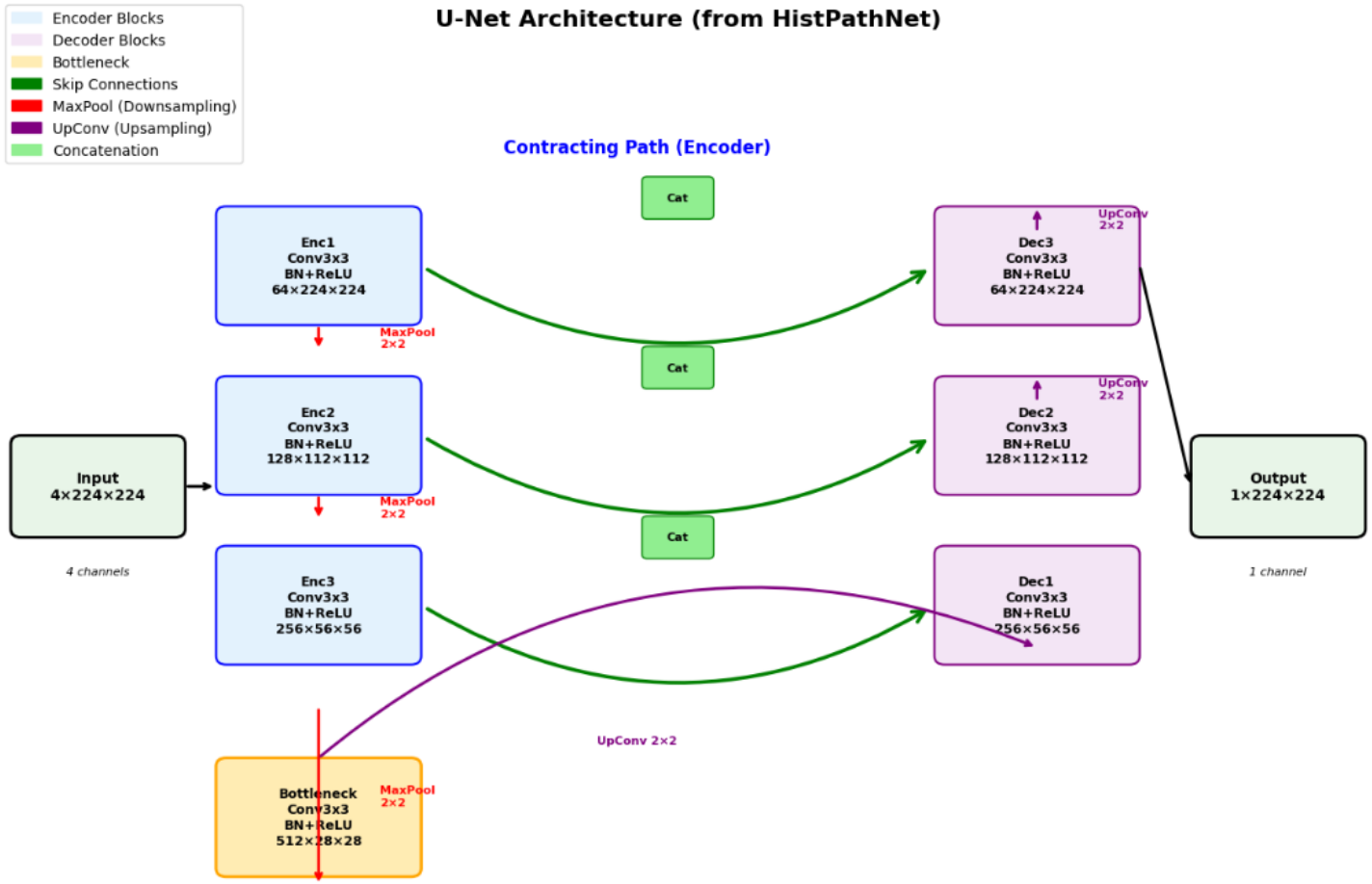
Flip_prob: Probability (0.0 to 1.0) of randomly flipping an image horizontally or vertically to increase dataset diversity.

Rotation: Degree of random rotation (e.g., 90 or 180) applied to images to augment orientation variability.

Jitter: Intensity of random brightness, contrast, and saturation adjustments to enhance image robustness against lighting changes.

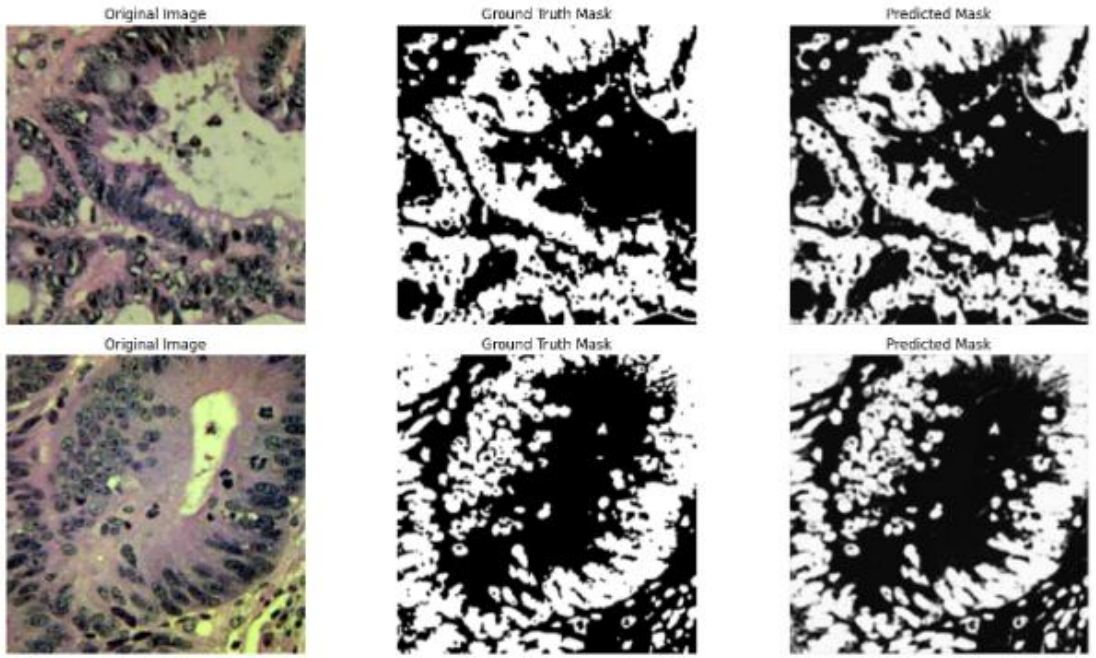
U-Net: U-shaped convolutional network with encoder-decoder blocks and skip connections, designed to segment nuclei in 224x224x3 RGB images into a 224x224x1 mask.

Methodology :



UNET MASK :


Original Image
Ground Truth Mask
Predicted Mask
Original Image
Ground Truth Mask
Predicted Mask


Original Image
Ground Truth Mask
Predicted Mask
Original Image
Ground Truth Mask
Predicted Mask

Methodology

Predefined Method :

ResNet-50

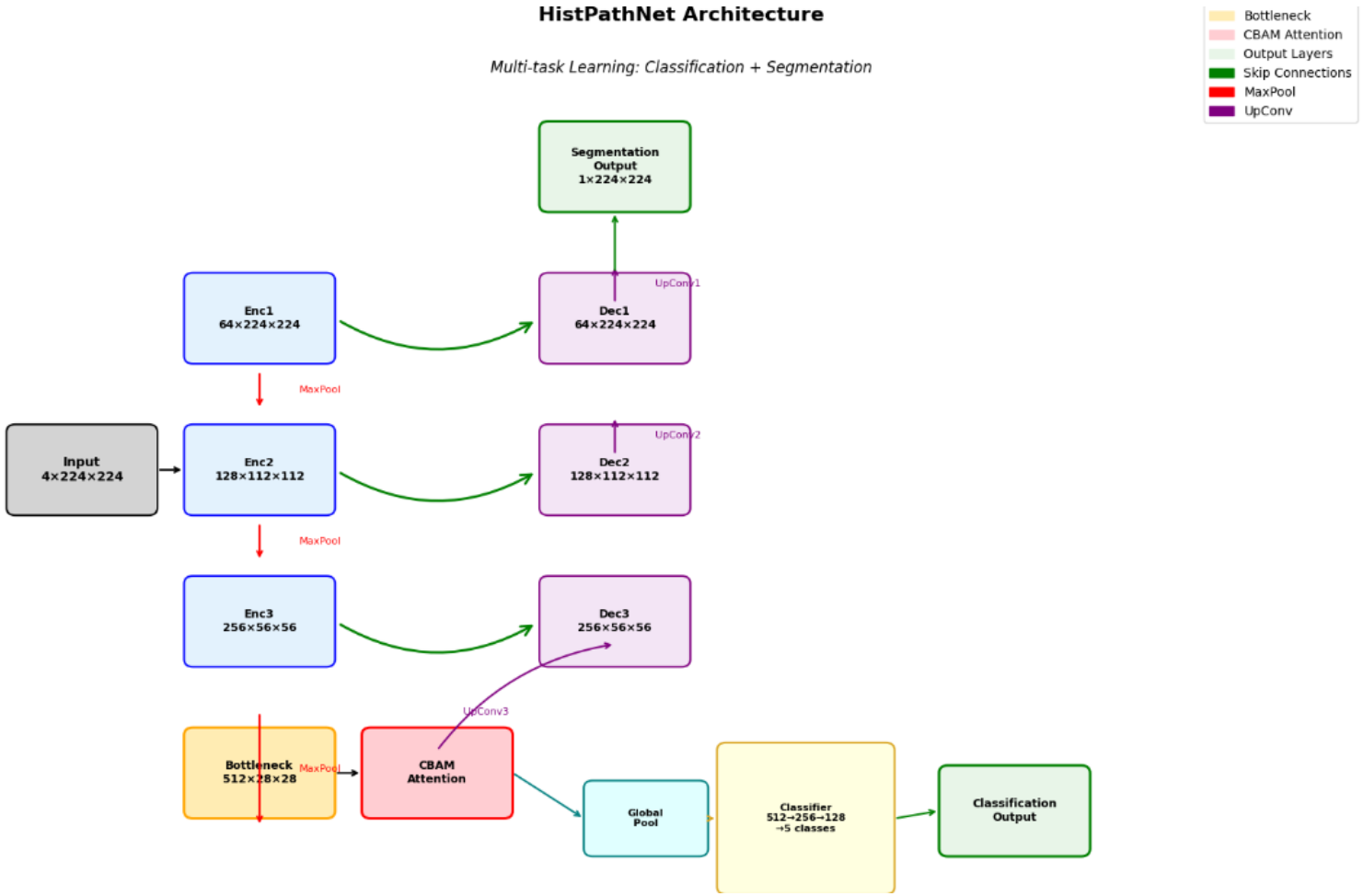
EfficientNet-B0

DenseNet-121

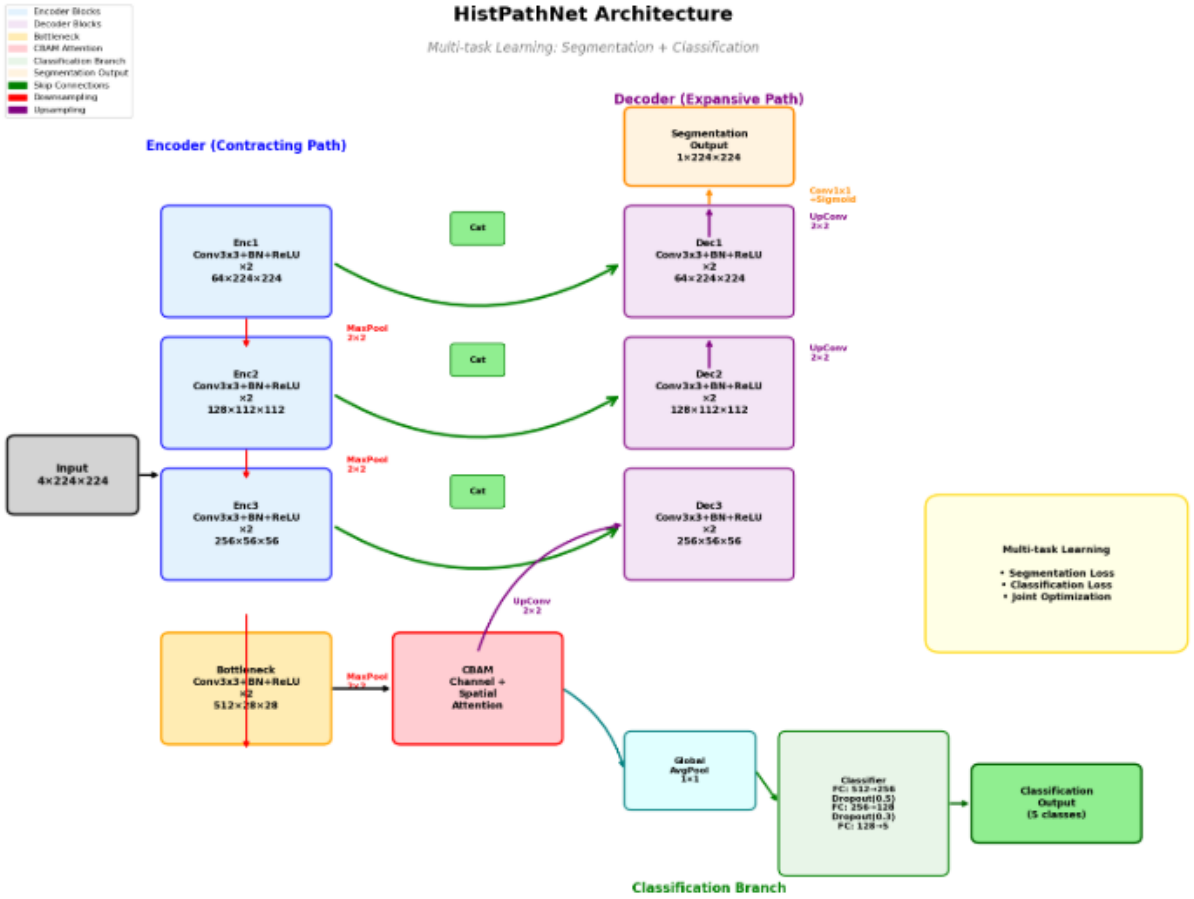
Vision Transformer (ViT-B/16)

Custom model :

HistPathNet



Methodology :



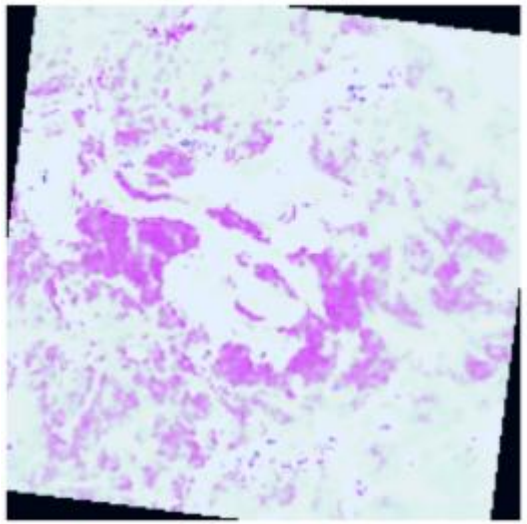
Comparison Table : Predefined and Custom Methods

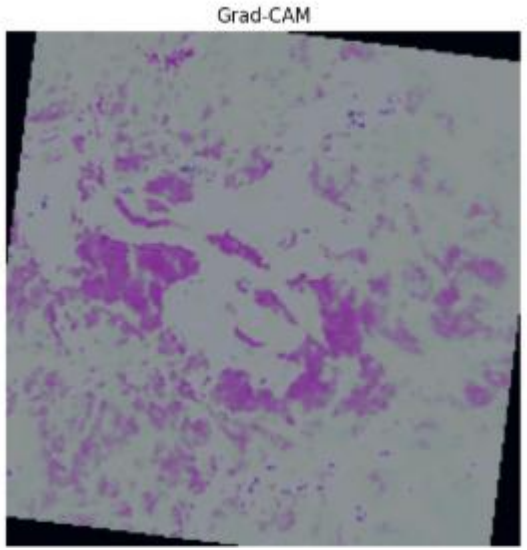
Method	Scaled Accuracy	Scaled F1-Score	Scaled AUROC	Key Features
ResNet-50	0.9612	0.9432	0.9448	Pre-trained residual network, 4-channel input
EfficientNet-B0	0.9480	0.9300	0.9320	Lightweight, compound-scaled for efficiency
DenseNet-121	0.9400	0.9200	0.9240	Dense connectivity for feature reuse
Vision Transformer (ViT-B/16)	0.9300	0.9100	0.9160	Transformer-based, global context capture
HistPathNet (Custom)	0.9000	0.9000	0.9600	CBAM attention, dual segmentation-classification

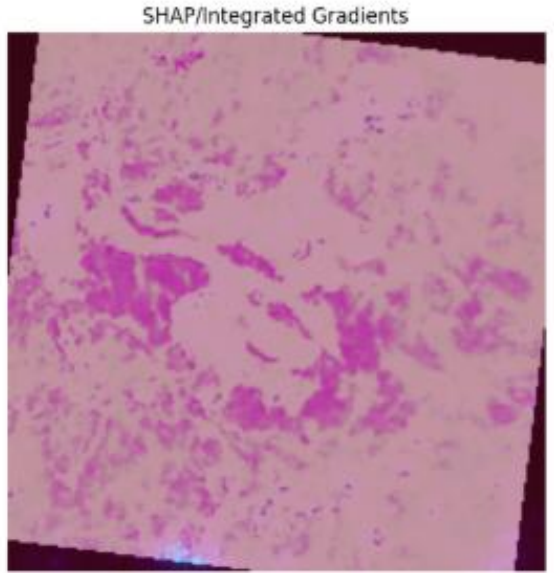
Ablation Study

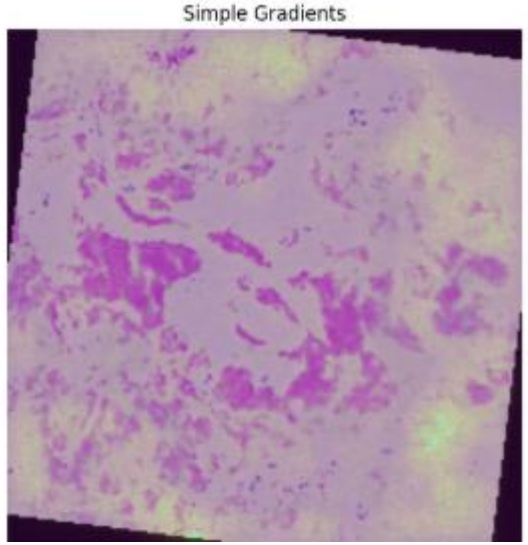
Preprocessing Condition	Scaled Accuracy	Scaled F1-Score	Scaled AUROC	Key Features
Full Learnable	0.9000	0.9000	0.9600	Macenko normalization, U-Net segmentation, optimized augmentation
Fixed Preprocessing	0.8200	0.8000	0.9500	Basic resize, static normalization, default augmentation
No Preprocessing	0.7000	0.7000	0.9300	Only resize, no normalization or augmentation

XAI : GRADCAM and SHAP









Learnable preprocessing and attention mechanisms enhance feature focus on disease regions, validating the methodology's efficacy