Texture-Unet: A Texture-Aware Network for Bone Marrow Smear Whole-slide Image Region of Interest Segmentation

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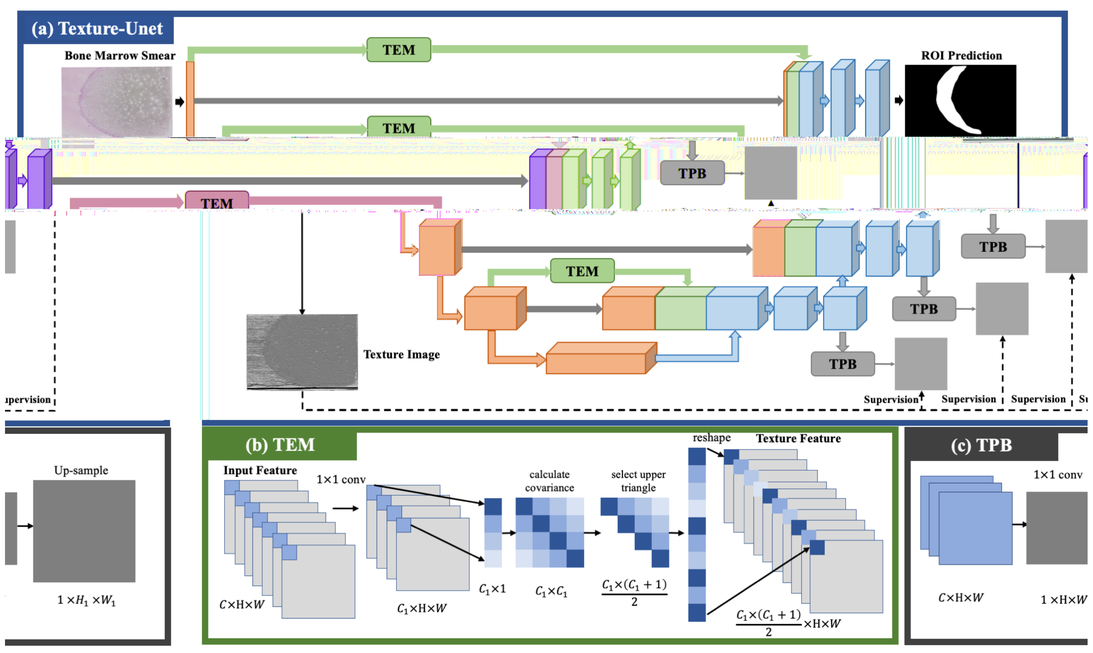
1.Introduction

- This study introduces a texture-aware segmentation network, Texture-Unet, specifically designed for the segmentation of Regions of Interest (ROI) in whole-slide images of bone marrow smears, enhancing the accuracy of segmentation by leveraging textural features.
- Through a detailed examination of ROIs and non-ROIs in the thumbnails of whole-slide images (WSI), Texture-Unet captures distinct textural characteristics at the micro-level, which arise from variations in the shape, size, and arrangement of blood and non-blood cells.
- The contributions of this research include the development of innovative structural components such as the Texture Extraction Module (TEM) and the Texture Prediction Block (TPB) within the network framework, facilitating the automatic identification and segmentation of ROI in the thumbnails of bone marrow smear WSI, thereby improving the efficiency and accuracy of bone marrow smear analysis.

2.Method

➢ *Schematic diagram of the overall structure of the model*



The Texture-Unet model features an advanced encoder-decoder structure, powered by a ResNet-based encoder for robust feature extraction, designed to efficiently process input images and facilitate multi-level texture feature extraction for accurate ROI segmentation in bone marrow smears.

➢ *Texture Extraction Module(TEM)*

We specifically designed a Texture Deep Supervision Module (TDSM) A novel module within Texture-Unet that enhances texture information extraction by calculating feature map covariances, capturing the co-occurrence of features to provide detailed textural insights, which are crucial for distinguishing ROI from non-ROI areas in bone marrow smear images.

➢ *Texture Deep Supervision Module (TDSM)*

This module employs deep supervision techniques using a texture image extracted from the raw input, focusing on refining the network's ability to extract and utilize texture features throughout the decoding process, thereby improving the segmentation accuracy of ROI in whole-slide images of bone marrow smears.

3.Experiment

➢ *Environment*

We've collected a unique dataset from Chongqing University Cancer Hospital, comprising 80 bone marrow smear WSIs, which were annotated by a physician for ROI segmentation. Our evaluation metrics include IoU, Dice, and PA, ensuring a comprehensive assessment of model performance.

➢ *Comparison Experiments*

Our method outperforms existing segmentation methods like PSPNet, PAN, Linknet, DeepLabV3, and Unet++ in terms of IoU, Dice, and PA, demonstrating the superior performance of Texture-Unet for segmenting ROI in bone marrow smear thumbnails.

Table 1. Comparison with different segmentation methods

Methods	Encoder	IoU	Dice	PA
PSPNet[13]	ResNet34	0.411	0.582	0.93
[redacted]				

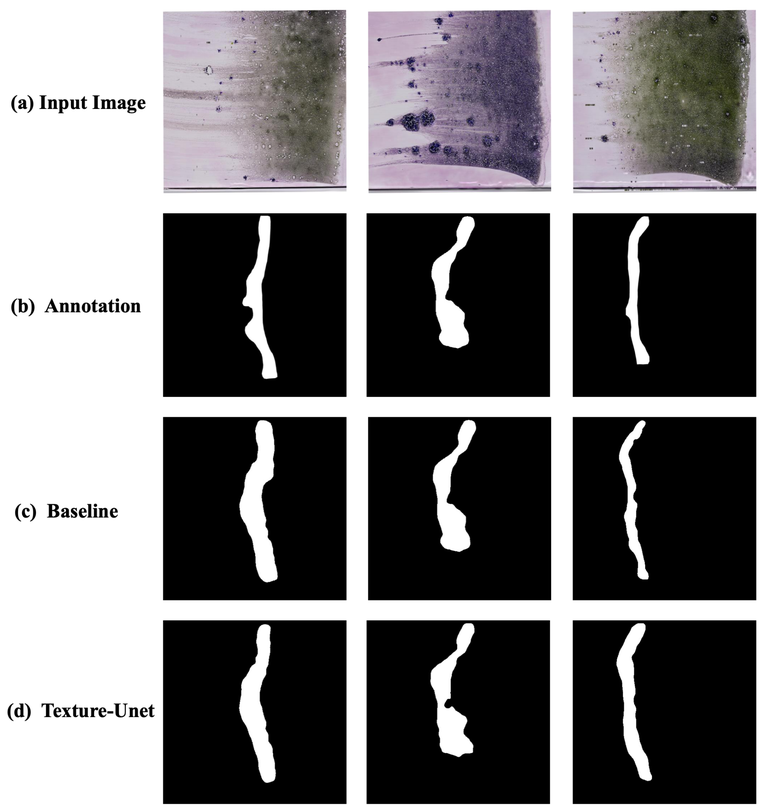
Table 2. Ablation studies for different components in our method

Encoder	TEM	TDSM	IoU	Dice	PA
ResNet34			0.453	0.624	0.942
ResNet34	✓		0.462	0.631	0.947
ResNet34		✓	0.463	0.632	0.943
ResNet34	✓	✓	**0.474**	**0.643**	**0.948**

➢ *Ablation Experiments*

By conducting ablation studies, we've validated the effectiveness of TEM and TDSM components within our model. The addition of TEM and TDSM significantly improves IoU, Dice, and PA metrics, highlighting their importance in enhancing the model's ability to extract and utilize texture information for ROI segmentation.

➢ *Visualization*



4.Conclusion

- This study introduces Texture-Unet, a novel segmentation network tailored for identifying regions of interest (ROI) in bone marrow smear whole-slide images, with a focus on leveraging the unique textural properties of these images to enhance segmentation precision and efficiency.
- We have developed a Texture Extraction Module (TEM) to bolster the network's capacity for extracting intricate texture information, and a Texture Deep Supervision Module (TDSM) that employs a texture image from the original input for deep-level feature supervision during the decoding process.
- Our custom dataset, created for evaluating the ROI segmentation in bone marrow smear images, supports our experimental findings that Texture-Unet surpasses conventional segmentation approaches in IoU, Dice, and PA metrics, highlighting the benefits of integrating texture analysis for superior model performance in bone smear image segmentation.