Enhancing Medical Image Segmentation Via Heat Conduction Equation

Rong Wu
Department of Epidemiology and Biostatistics, University of California, San Francisco, CA, USA
Yim-Sang Yu
Department of Epidemiology and Biostatistics, University of California, San Francisco, CA, USA

Abstract

Medical image segmentation has been significantly advanced by deep learning architectures, notably U-Net variants. However, existing models struggle to achieve efficient global context modeling and long-range dependency reasoning under practical computational budgets simultaneously. In this work, we propose a novel hybrid architecture utilizing UMamba with Heat Conduction Equation. Our model combines Mamba-based state-space modules for efficient longrange reasoning with Heat Conduction Operators (HCOs) in the bottleneck layers, simulating frequency-domain thermal diffusion for enhanced semantic abstraction. Experimental results on multimodal abdominal CT and MRI datasets demonstrate that the proposed model consistently outperforms strong baselines, validating its effectiveness and generalizability. It suggest that blending state-space dynamics with heat-based global diffusion offers a scalable and interpretable solution for medical segmentation tasks.

Index Terms

Medical Image Segmentation, U-Net, Heat Conduction, State Space Model