Multi-Scale Knowledge Transfer Convolutional Transformer: A Novel Deep Learning Framework for 3D Brain Vessel Segmentation

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Recent studies show that small cerebrovascular abnormalities are the cause of many brain disorders. Early diagnosis and monitoring of the abnormalities in vivo at the micro-level facilitates improved understanding of the etiology of diseases and better treatment. Existing methods fall short in extracting complex 3D brain vessels from in-vivo Magnetic Resonance Imaging due to the lack of synergy in coordinated local and global pattern exploration, and their performance decreases significantly when handling lower-resolution images. Therefore, I propose a novel Multi-scale Knowledge Transfer Convolutional Transformer for 3D vessel segmentation. It uniquely integrates convolutional operation with Transformer in a U-net architecture, which responds to local receptive fields with convolution layers and global contexts with transformer encoders in a multi-scale fashion. It intrinsically enhances the synergy between local and global vessel feature extractions in the joint convolutional transformer embedding space, leading to a more accurate and reliable segmentation. Furthermore, to enable using relatively low-resolution images to segment fine-scale vessels, a novel knowledge transfer mechanism is designed to explore data interdependencies and automatically transfer knowledge gained from high-resolution data to the low-resolution handling network through multi-level loss functions to improve its fine vessel segmentation capability. Extensive experiments on benchmark image datasets have demonstrated that my proposed method outperforms all other state-of-the-art deep learning methods, and the integrated 3D brain vessel segmentation and visualization software allows accurate quantification of brain vessels for computer-aided diagnosis of brain diseases and scientific discoveries.