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Transfer Learning For Automated Segmentation Of Coronary Arteries Using Swin-Unet

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Introduction. According to the World Health Organization, cardiovascular diseases remain the leading cause of death globally. Timely diagnosis and intervention significantly improve patient outcomes. Coronary artery disease (CAD) is a severe medical condition that can lead to myocardial infarction and ischemic heart disease. Accurate and reliable assessment of arterial stenosis is essential for determining the need for medical intervention and selecting the optimal treatment strategy. In recent years, deep learning has revolutionized medical image analysis, particularly in segmentation tasks [3]. One of the most promising architectures for medical image segmentation is Swin-UNET, a hybrid model that combines the strengths of Vision Transformers (ViTs) and U-Net for capturing both global and local features effectively [1,2]. The objective of this study is to explore the capability of Swin-UNET for segmenting coronary arteries in contrast-enhanced computed tomography coronary angiography (CTCA) images using transfer learning.

Main Part. This study utilizes the ASOCA dataset, which consists of CTCA scans labeled for coronary artery segmentation [4]. The dataset includes both healthy and diseased cases, providing a balanced representation for training and evaluation. To enhance model performance, transfer learning was employed using two additional datasets: BTCV (Beyond the Cranial Vault), a multi-organ segmentation dataset that provides general anatomical features useful for pretraining the model [5], and ImageCAS, which contains a large number of 3D CTCA scans, making it highly relevant to the target task before fine-tuning on ASOCA [4]. Swin-UNET, a Transformer-based segmentation model, was selected for this study. It integrates shifted window self-attention for efficient spatial information extraction, preserving long-range dependencies while maintaining computational efficiency. The training process leveraged transfer learning, where the model was pretrained on BTCV and ImageCAS before fine-tuning on ASOCA. Various optimization techniques and loss functions, including Focal Loss and AdamW optimizer, were applied to improve segmentation accuracy. The model was implemented on high-performance hardware to facilitate efficient training and inference. The segmentation was applied to contrast-enhanced CTCA images, focusing on extracting coronary arteries for further analysis. The trained model was evaluated using standard segmentation metrics such as Dice Similarity Coefficient (DSC), Hausdorff Distance 95% (HD95), and Intersection over Union (IoU). The results demonstrated that transfer learning significantly enhanced segmentation accuracy, making it a viable approach for automated coronary artery segmentation. The model demonstrated competitive performance in coronary artery segmentation, with transfer learning playing a key role in improving results.

Conclusion. The study demonstrates the feasibility of using Swin-UNET with transfer learning for coronary artery segmentation in CTCA images. The study highlights that the Transformer-based Swin-UNET model is highly effective in capturing long-range dependencies, which is crucial for accurate coronary artery segmentation. The integration of pretraining on BTCV and ImageCAS datasets played a significant role in enhancing the model's ability to identify relevant anatomical structures [5,6]. Furthermore, the use of transfer learning contributed to improved generalization and efficiency, allowing the model to achieve robust segmentation performance across different cases. Future work will focus on further optimizing the architecture, incorporating active learning for better generalization, and exploring self-supervised pretraining strategies.

References

1. Hatamizadeh, A., et al. (2022). Swin UNETR: Swin transformers for semantic segmentation of brain tumors in MRI images. arXiv preprint arXiv:2201.01266.
2. Liu, Z., et al. (2021). Swin transformer: Hierarchical vision transformer using shifted windows. Proceedings of the IEEE/CVF International Conference on Computer Vision (pp. 10012–10022).
3. MONAI Consortium. (2020). MONAI: Medical Open Network for AI. Zenodo.
4. ASOCA Challenge. (2020). Automated Segmentation of Coronary Arteries (ASOCA).
5. BTCV Challenge. (2015). Beyond the Cranial Vault (BTCV) Abdomen CT Segmentation.
6. ImageCAS Dataset. (2022). A large-scale CT coronary angiography dataset.