CapsNet-SA: A Hybrid Deep Learning Model for Enhanced Liver Tumor Segmentation Using Capsule Networks and Self-Attention

Dr. Poonkodi S

Department of Computing Technologies, SRM Institue of Science and Technology, Kattankulathur, Tamilnadu, India

Rohinth K

Department of Computing Technologies, SRM Institue of Science and Technology, Kattankulathur, Tamilnadu, India

Jai Harriesh M

Department of Computing Technologies, SRM Institue of Science and Technology, Kattankulathur, Tamilnadu, India

Abstract

This Liver cancer remains one of the most challenging diseases to diagnose and treat due to its complex tumour structures and variations in imaging quality. Traditional deep learning models, such as CNNs, often struggle with preserving spatial hierarchies, leading to inaccurate tumour segmentation. This study introduces CapsNet-SA (Capsule Network with Self-Attention)—a hybrid deep learning model designed to improve liver tumour detection by maintaining spatial relationships and enhancing feature representation. By integrating Capsule Networks, which capture part-whole relationships, with Self-Attention mechanisms, which help the model focus on critical tumour regions, Caps Net-SA significantly enhances segmentation accuracy. Trained on CT and MRI scans from the PLCO Liver dataset, the model outperforms traditional architectures like U-Net and ResNet, achieving a Dice score of 0.92, IoU of 0.89, and 95% accuracy. The results demonstrate that CapsNet-SA is a promising step toward AI-powered liver cancer detection, offering higher accuracy, faster inference, and better explainability. Future improvements will focus on multi-modal data fusion (CT+MRI), real-time clinical deployment, and expanding the model's capabilities to other cancers. By combining cutting-edge AI with medical expertise, this study aims to contribute to early diagnosis, improved treatment planning, and ultimately, better patient outcome.

Keywords

Liver Cancer Detection, Capsule Networks (CapsNet), Self-Attention, Tumor Segmentation, Deep Learning.