Chapter 9
Medical Image Segmentation Techniques: A Review

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ABSTRACT

Medical image segmentation is a critical task in medical imaging that involves delineating structures of interest within medical images, such as organs, tissues, and abnormalities. The accuracy and efficiency of segmentation directly impact the quality of medical care, making it a pivotal component in modern healthcare. In this paper, Medical Image Segmentation Techniques are presented. Medical image processing involves a series of steps to transform raw medical image data into meaningful information for clinical decision-making. The detailed process is presented in the paper. Also, comparison of latest medical image segmentation techniques is compared based on Technique, Key features, advantages and limitation.

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INTRODUCTION

Traditional segmentation methods, such as thresholding, region growing, and edge detection, have laid the groundwork for the development of more advanced techniques (Qiao et al., 2024). However, these methods often struggle with the variability and complexity of medical images. The advent of machine learning, particularly deep learning, has revolutionized the field, offering significant improvements in segmentation performance.

Convolutional Neural Networks (CNNs) and their variants, such as U-Net and Fully Convolutional Networks (FCNs), have become the cornerstone of state-of-the-art medical image segmentation (Kattenborn et al., 2021; Shukla et al., 2020; Shukla et al., 2021; Shukla et al., 2023. These models leverage large annotated datasets to learn intricate patterns and features, enabling them to handle diverse imaging modalities, including MRI, CT, and ultrasound. Transfer learning and data augmentation techniques further enhance their robustness and generalizability.

Despite these advancements, challenges remain. Annotating medical images is labor-intensive and requires expert knowledge, limiting the availability of high-quality training data. Additionally, the heterogeneity of medical images, variations in acquisition protocols, and presence of artifacts pose significant hurdles. Addressing these issues necessitates the development of more sophisticated models, improved training strategies, and the integration of domain-specific knowledge (Luo & Yang, 2024).

Future directions in medical image segmentation include the exploration of unsupervised and semi-supervised learning approaches to reduce dependency on annotated data, the use of multi-modal imaging to provide complementary information, and the incorporation of explainability into AI models to ensure their reliability and acceptance in clinical practice. By continuing to innovate and address existing challenges, medical image segmentation holds the promise of significantly enhancing diagnostic accuracy and patient outcomes.

MEDICAL IMAGE SEGMENTATION TECHNIQUES

Medical image segmentation, which involves dividing a picture into meaningful parts that correspond to anatomical features or regions of interest, is a crucial step in the study and interpretation of medical images. This task is essential for various clinical applications, including diagnosis, treatment planning, and disease monitoring (Ramesh et al., 2021). There are several techniques used for medical image segmentation, each with its advantages and limitations. These techniques can be broadly categorized into traditional methods, machine learning approaches, and deep learning techniques (Karimi et al., 2021; Simpson et al., 2019; Wu et al., 2024).