International Journal of Scientific Research in Science, Engineering and Technology

Print ISSN - 2395-1990
Online ISSN : 2394-4099

OPEN ACCESS

Available Online at :www.ijsrset.com
doi : https://doi.org/10.32628/IJSRSET24115104

Medical Image Segmentation : A Comparative Study and Survey

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ARTICLEINFO

Article History:

Accepted: 25 Sep 2024
Published: 08 Oct 2024

Publication Issue :
Volume 11, Issue 5
Sept-Oct-2024

Page Number :
164-170

ABSTRACT

Image segmentation involves dividing an image into distinct segments. It is important to distinguish this from image enhancement, which focuses on improving the image's visual attributes, such as brightness, contrast, and texture. In segmentation, specific parts of the image are emphasized based on the problem being addressed.

Clinical imaging techniques are continuously evolving, aiming to improve the quality of services in the healthcare industry. Methods such as interpolation, image registration, compression, and diagnosis need to be updated to meet the increasing demands of the field, especially with advancements in mobile and cloud computing technologies. The integration of medical devices with wearable technologies presents a promising area for further exploration. This paper provides valuable insights into the domain of medical imaging systems and aims to outline the future potential of work in this field.

Keywords: Medical Image Processing (MIP), Medical Diagnosis, MIP Methods and Applications

I. INTRODUCTION

Clinical image segmentation refers to the process of dividing graphical data into distinct, non-overlapping regions. These regions represent different human tissue structures, applying techniques that ensure accurate medical diagnoses. Essentially, image segmentation involves partitioning a digital image into multiple segments. The goal is to modify and simplify the image representation, making it more meaningful and easier to analyze. There are numerous applications, such as content-based visual information retrieval (CBVIR), which is used for searching digital images in large databases. In object detection, for example, linguistic objects of a specific category (such as people, houses, streets, or forests) are identified by fully automated face recognition systems, which can identify or verify individuals from a digital image. Fingerprint recognition, on the other hand, refers to an automated method for matching two human

fingerprints, often used for medical purposes to create images for diagnosis or to examine parts of the anatomy. Increasing interest in the healthcare domain has led to the development of advanced techniques for diagnosis and clinical practice. With health considered to be wealth, the healthcare industry has adopted innovative clinical practices and operational methods, along with computational technologies, by leveraging advancements in various hardware resources.

Precision in object identification, accuracy in clinical practices, and improvements in cutting-edge medical equipment are critical requirements for the healthcare industry. This has resulted in the implementation of highly effective practices that are clinically validated. However, more advancements are needed as scientific knowledge continues to expand, particularly with the rise of big data, which helps uncover hidden insights from large datasets.

Edge Detection Technique

Edge detection is one of the fundamental steps in image processing, image analysis, pattern recognition, and computer vision techniques. An edge typically represents the boundary between two regions within an image. Boundaries and edges are closely linked because there is usually a sharp change in object intensity at these borders. The purpose of edge detectors is to identify points in a digital image where there is a significant change in brightness or, more formally, where there are discontinuities. These discontinuities in intensity can be categorized as either line edges, step edges, or ramp edges. If edge detection is executed effectively, the subsequent task of interpreting the image's information becomes much simpler.

Edge detection is a critical tool in image processing, machine vision, and computer vision, particularly for tasks like feature detection and feature extraction. There are two primary approaches to edge detection: search-based and zero-crossing methods. Search-based methods detect edges by evaluating the gradient magnitude using a first-order derivative technique, which identifies the position and direction of the edges. Zero-crossing methods, on the other hand, estimate edge smoothness by applying a Laplacian operator. One of the key challenges in edge-based segmentation is accurately determining the true boundary of objects.

Region Based Segmentation Method

Region-based segmentation is a method that focuses directly on partitioning an image based on specific regions. These techniques are robust because they utilize areas with higher pixel density, which helps provide more detailed information for representing the image. When slicing an image, utilizing existing information becomes challenging, especially when handling edges. Region-growing techniques often perform better with noisy images, where edges are difficult to detect.

A. Region Segmentation and Proposed Algorithm / Watershed Algorithm:

i) The image is divided into four regions. For instance, P(Ri) = false if the pixels within a particular region have varied gray-level intensities.

ii) The bifurcation process continues in parallel until no further rules or partitions are applicable.

iii) Sibling regions are merged if they share a similar intensity, i.e., P (Ri ∪ Ri) = true, indicating that two regions have the same color range.

The key characteristics of this algorithm are straightforward and aimed at identifying regions for object detection.

B. Watershed Algorithm:

The watershed algorithm focuses on identifying areas based on region boundaries, and it can be applied in various ways. It operates similarly to the threshold algorithm. The steps include:

i) Checking the consistency and inconsistency between regions.

ii) For each region, determining the predicate P's value with respect to its neighboring regions.
iii) Merging neighboring regions if their predicate P is consistent.

The strength of this algorithm lies in its ability to connect elements efficiently using labels. However, it is prone to issues like fragmentation and over-fragmentation.

Region Growing Algorithm:

A simple approach to region growing involves starting with a few initial pixels that represent an object in the image and expanding them until they cover the entire image. Region-growing requires adherence to rules that describe the growth process and check the unity of regions after each growth step:

i) Seed points can be chosen based on specific gray-level ranges.
ii) Growth occurs incrementally.
iii) The process continues until it reaches a higher level.

The main advantage of region-growing is that it provides a straightforward method for image segmentation, particularly important for medical image segmentation. However, the growth process must be carefully managed to ensure stability, as certain growth patterns may not be sustainable over time.

II. RELATED WORK ON MEDICAL IMAGE SEGMENTATION

Previous methods aimed to identifyvarious factors within images but lacked sufficient resources for disease detection. As a result, medical image segmentation relies on surveys, and this paper incorporates insights from numerousprevious studies as references. Below are some of the papers used as references:

1) Title: Medical Image Segmentation Using Soft Computing Techniques

Author: Dr. Nookala Venu

Publication Year: 2022IUSST

Method:

A deep learning approach is recommended for creating an interactive framework, which is divided into two stages. The first stage, P-Net, generates an initial automated segmentation. After converting the data into geodesic distance maps, the second stage, R-Net, refines the output through user interaction, which is fed into the R-Net as input.

Findings:

MRI is commonly used in the medical field to differentiate between pathological and healthy tissues, providing images of different body sections for further analysis. In computer-assisted medical imaging applications, segmentation is a crucial task, particularly for tumor identification based on MRI data, which is time-consuming when done manually. Therefore, automated image analysis is essential for diagnostic purposes. Several techniques have been developed for medical image analysis, many of which have been applied in various fields. Computer-processed images are often utilized in systems that support radiologists and clinicians, allowing them to make faster diagnoses. This paper examines numerous techniques for MRI image segmentation.

2) Title: Medical Image Processing Using Deep Learning

Authors: Dr. S. Priyadarsini, S. Chitra, K. Pushpadevi

Publication Year: 2022 IJCRT

Method:

The paper presents a dataset on diabetes that is divided into multiple segments for training purposes, arranged according to pixel density. The dataset is processed using the Manhattan distance method and Euclidean distance method. The fitness of the model is evaluated using the Cosco distance algorithm, which plays a key role in medical image processing via deep learning. This methodology also has potential for developing new techniques.

Findings:

A hybrid genetic classification model is utilized to

identify diabetes present in blood samples. The model processes the data, represented as black cement, through multiple stages to assess its fitness.

3) Title: Medical Image Processing Using Deep Learning

Authors:Dr. S. Priyadarsini, S. Chitra, K. Pushpadevi

Publication Year: 2022, IJCRT

Method:

This paper explores diabetic datasets, segmented based on training purposes, which are organized by pixel density. It employs Manhattan distance and Euclidean distance methods to align with the Cosco distance algorithm, aiming to develop new techniques for medical image processing using deep learning.

Findings:

The study utilizes a hybrid genetic classification model to identify diabetes in blood samples. The analysis involves various stages to assess the fitness of the data.

4) Title: Medical Image Segmentation Using Machine Learning

Author: Masoud Khani

Publication Year:2021, UWM

Method:

This paper introduces a genetic algorithm featuring operations such as crossover and mutation. The model evaluates fitness through multiple segmentations, considering diseases based on blood unit chromosomes.

Findings:

The technique allows for the processing of colored images, enabling the recognition of objects in grayscale images through genetic algorithms.

5) Title: Medical Image Segmentation: A Review of Recent Techniques, Advancements, and a Comprehensive Comparison

Author: Aarish Shafi

Publication Year:2019, IJCSE

Method:

This review discusses general segmentation challenges, combining neighboring segments to create heterogeneous images. It explores various techniques and emphasizes using probability distribution functions for image slicing, alongside popular detection tools.

Findings:

The review identifies multiple universal segmentation methods for disease detection, offering a comprehensive comparison of different image segmentation techniques.

6) Title: Medical Image Classification and Cancer Detection Using Deep Convolutional Neural Networks

Author: Akshay Kumar S

Publication Year: 2021, IJERT

Method:

This study proposes a scheme based on Self-Organizing Maps (SOM) for segmenting brain MRI images into white matter (WM), gray matter (GM), cerebrospinal fluid (CSF), and tumor regions. It tests the scheme on three normal and three abnormal brain MRI images.

Findings:

The proposed scheme successfully classifies MRI regions and detects tumors. Results include a confusion matrix showing 29 true positives, 8 true negatives, 1 false positive, and 11 false negatives from 49 axial view images.

7) Title: A Survey on Medical Image Segmentation

Author: Gagandeep K

Publication Year: 2017, PIMCSIT

Method:

This paper surveys various medical image segmentation methods, comparing different techniques to identify the most effective ones. It employs genetic algorithms for image slicing to detect diseases, combining multiple research findings into a single framework.

Findings:

The survey highlights multiple approaches and compares them to determine effective methods for disease detection, emphasizing that a thorough analysis of different methods is essential for accurate results.

8) Title: Brain Image Segmentation Using Semi-Supervised Clustering
Author: Sriparna Saha
Publication Year: 2016, IJCSIT
Method:
This paper introduces a semi-supervised clustering method for brain tumor detection. It refines images by using multiple slices and incorporates user feedback for improved clarity.
Findings:
The methodology effectively identifies brain tumors by simulating multiple images in a single platform, utilizing semi-supervised learning to enhance the accuracy of tumor detection.

9) Title: Volumetric Medical Image Segmentation with Deep Convolutional Neural Networks
Author: Manvel Avetisian
Publication Year:2022, ITCSCP
Method:
This research explores various techniques for medical image classification, particularly focusing on MRI images. It involves multiple segmentation stages to enhance tumor detection in brain MRI scans.
Findings:
The study improves the clarity of MRI images through advanced processing methods, creating a dataset that aids in accurate brain tumor detection by analyzing segmented images.

10) Title: A Framework for Medical Image Classification Using Soft Sets
Author: Saima Anwar Lashari
Publication Year: 2013, ICEEI
Method:
This paper proposes a classification framework using soft set theory to analyze medical images. It involves data reprocessing, partitioning, and performance evaluation.

Findings:
The framework enhances image classification accuracy, improving the detection of tumors and other diseases by refining the dataset and classification methods.

11) Title: Medical and Natural Image Segmentation Algorithm Using M-F Based Optimization Model and Modified Fuzzy Clustering: A Novel Approach
Author: Bingquan Huo
Publication Year: 2015, IJSPIPPR
Method:
This research presents a novel approach for image segmentation using fuzzy logic clustering combined with an optimization model. It focuses on pixel boundaries and grayscale images for cancer detection.
Findings:
The proposed method utilizes fuzzy clustering to segment images effectively, offering a new approach for detailed analysis and cancer detection through refined image segmentation techniques.

12) Title: Medical Image Segmentation with 3D Convolutional Neural Networks: A Survey
Author: S Niyas
Publication Year: 2022, IJCSIT
Method:
This survey reviews the use of 3D convolutional neural networks for medical image segmentation, comparing various methods to improve tumor detection.
Findings:
The survey indicates that 3D convolutional neural networks offer significant advancements in segmenting medical images, providing a detailed comparison of techniques to enhance segmentation accuracy and application.

13) Title: A Review on Deep Learning in Medical Image Analysis
Author: S. Suganyadevi
Publication Year: 2022, IJMIR
Method:
This paper reviews deep learning techniques in medical image analysis, focusing on the application of modified marker-controlled watershed algorithms for image boundary detection. The paper discusses how these techniques contribute to advancing research in medical imaging.
Findings:
The review highlights various deep learning approaches for medical image segmentation, emphasizing the importance of different techniques for processing and analyzing images to enhance medical diagnostics.

14) Title: Application of AI Techniques in Medical Image Segmentation and Novel Categorization of Available Methods and Tools
Author: M. Rastgarpour
Publication Year: 2011, IMECS
Method:
This research explores the use of AI techniques in medical image segmentation, particularly for identifying diseases such as tumors. It provides an overview of various methods and tools for categorizing image sequences, focusing on novel approaches.
Findings:
The study introduces fuzzy clustering as part of the methodology for tumor detection, presenting results and tools that aid in early disease identification through advanced image segmentation techniques.

15) Title: Medical Image Segmentation Using Genetic Algorithm
Author: Divya Kaushik
Publication Year:2013, IJCA
Method:
This paper applies genetic algorithms to medical image segmentation, aiming to optimize problem-solving techniques for tumor detection. It explores the use of genetic algorithms to enhance segmentation and image analysis.
Findings:
The study suggests that genetic algorithms are beneficial for detecting tumors in grayscale images, offering a promising method for future image analysis and cancer detection.

III. CLINICAL APPLICATION

In this section, we review the application of medical imaging technologies in diagnosing diseases affecting the nervous system and other key areas of the body. Medical images often need to be segmented into various parts for detailed analysis. To achieve accurate diagnostics, AI algorithms are employed for analyzing medical images in cases of brain disorders, cardiac conditions, liver diseases, and orthopedic trauma. Segmentation is a crucial technique for identifying disease-related symptoms and poses significant challenges for healthcare systems. Accurate and automated image segmentation provides essential information for neurologists and other specialists. For example, Chen et al. utilized Diffusion Weighted Imaging (DWI) to process and segment acute ischemic lesions, applying common cell scoring for image analysis. Another approach involves using deep learning methods for stroke lesion segmentation with multimodal MRI scans, achieving scores of 0.84 and 0.59 for the segmentation tasks.
In this review, we explore contemporary medical imaging applications across four major systems: the nervous system, cardiovascular system, digestive system, and skeletal system. AI algorithms are particularly valuable for diagnosing diseases in these areas by analyzing various critical images, including those related to brain illnesses, cardiac conditions, liver diseases, and orthopedic tumors.

IV. CONCLUSION

This research provides a comprehensive analysis of medical image segmentation methodologies and their implications for computer image processing. The study evaluates various image segmentation techniques and the associated challenges. It aims to offer a comprehensive guide for researchers working in the field of image segmentation.

Despite extensive research over the years, no universally standard method for image segmentation exists. The effectiveness of segmentation methods is influenced by several factors, including image similarity, spatial properties, continuity, texture, and content. Consequently, no single method is universally applicable to all types of images or scenarios.

Given these challenges, image segmentation remains a complex and unresolved issue in the field of computer vision and image processing. The study emphasizes that, while many advances have been made, image segmentation continues to be a difficult problem with ongoing research needed to address its various complexities.

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