A Project Report on

COMPARATIVE ANALYSIS OF VARIOUS IMAGE SEGMENTATION TECHNIQUES FOR ACCURATE RETINAL OCT IMAGE INTERPRETATION

Submitted in partial fulfillment of the requirements for the award of the Degree of

Bachelor of Technology

In

Electronics and Communication Engineering

By

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ADITYA ENGINEERING COLLEGE

(An Autonomous Institution)

(Approved by AICTE, New Delhi, Affiliated to JNTUK, Kakinada, Accredited by NBA (Tier I) and NAAC with ‘A++’ Grade)

Aditya Nagar, ADB Road, Surampalem

2020 – 2024

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2020 – 2024

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

CERTIFICATE

This is to certify that the thesis entitled **"COMPARATIVE ANALYSIS OF VARIOUS IMAGE SEGMENTATION TECHNIQUES FOR ACCUARATE RETINAL OCT IMAGE INTERPRETATION"** is being submitted by

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in partial fulfillment of the requirements for the award of degree of B**. Tech** in Electronics and Communication Engineering from **Jawaharlal Nehru Technological University, Kakinada** is a record of bonafide work carried out by them at Aditya Engineering College(A).

The results embodied in this Project report have not been submitted to any other University or Institute for the award of any degree or diploma.

PROJECT GUIDE **HEAD OF THE DEPARTMENT**

(Mr. T. Ravindra) **(Dr . N. Radha)**

EXTERNAL EXAMINER

ACKNOWLEDGEMENT

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To emerge as a premier institute for quality technical education and innovation.

Mission:

M1: Provide learner centric technical education towards academic excellence

M2: Train on technology through collaborations

M3: Promote innovative research & development

M4: Involve industry institute interaction for societal needs

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SURAMPALEM - 533 437

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Vision:

To become a center of excellence in the field of Electronics and Communication Engineering with technological capability, professional commitment and social responsibility.

Mission:

M1: Provide quality education, well-equipped laboratory facilities and industry collaboration.

M2: Promote cutting edge technologies to serve the needs of the society and industry through innovative research.

M3: Inculcate professional ethics and personality development skills.

N. Radha

Head of the Department

Head of the Department
Department of E.C.E.
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ADITYA ENGINEERING COLLEGE (A)

Aditya Nagar, ADB Road, Surampalem

Department of Electronics & Communication Engineering

PROGRAM OUTCOMES(POs)

After successful completion of the program, the graduates will be able to

PO 1	Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.
PO 2	Identify, formulate, research literature and analyze complex engineering problems, reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.
PO 3	Design solutions for complex engineering problems and design systems, components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations.
PO 4	Conduct investigations of complex problems using research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of information to provide valid conclusions.
PO 5	Create, select and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to complex engineering activities, with an understanding of the limitations.
PO 6	Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice.
PO 7	Understand the impact of professional engineering solutions in societal and environmental contexts and demonstrate knowledge of, and need for sustainable development.
PO 8	Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.
PO 9	Function effectively as an individual, and as a member or leader in diverse teams and in multidisciplinary settings.
PO 10	Communicate effectively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	Demonstrate knowledge and understanding of engineering management principles and apply these to one's own work, as a member and leader in a team and to manage projects in multidisciplinary environments.
PO 12	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

N. Radha

Head of the Department

Head of the Department
Department of E.C.E.
Aditya Engineering College (A9)

Program Specific Outcomes (PSOs)

After successful completion of the program, the students will be able to

PSO1:

Provide sustainable solutions in the field of Communication and Signal Processing

PSO2:

Apply current technologies in the field of VLSI and embedded systems for professional growth.

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Head of the Department
Head of the Department
Department of E.C.E.
Aditya Engineering College (A9)

Program Educational Objectives (PEOs)

The graduates of the Program will

PEO1:

Adapt the learning culture needed for a successful professional career and pursue research.

PEO2:

Build modern electronic systems by considering technical, environmental and social contexts.

PEO3:

Communicate effectively and demonstrate leadership qualities with professional ethics.

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Aditya Engineering College (A9)

Course Outcomes

After completion of the course the graduates will able to attain the following course outcomes

CO1: Formulate a real World engineering problem through thorough investigation.
CO2: Design the methodology for project work plan, schedule, and cost.
CO3: Apply the domain knowledge and modern tools to arrive at a framework to solve the problem.
CO4: Analyze the obtained solution within the context of an engineering framework that addresses societal and environmental concerns while adhering to professional ethics.
CO5: Prepare a technical report with effective written communication skills.
CO6: Interpret the results of project work with oral communication skills.

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Department of Electronics & Communication Engineering

Project - PO Mapping

A.Y: 2023-24 (AR 20) **Sem.:** VIII **Section & Batch:** A12

Project Title: **Comparative Analysis of Various Image Segmentation Techniques for Accurate Retinal OCT Image Interpretation**

Abstract

Image segmentation is a crucial step in image processing, involving the division of an image into smaller segments for more efficient analysis. Various techniques, such as thresholding, edge detection, clustering, graph cut segmentation, and flood fill, have been explored for this purpose. Among these, clustering-based segmentation has proven particularly effective for separating images in OCT images. Additionally, preprocessing methods like the Wiener filter are employed to reduce speckle noise. Evaluation of segmentation techniques involves calculating metrics like MSE (mean square error) and PSNR (peak signal-to-noise ratio) to assess segmented image quality. Techniques like thresholding, edge detection (utilizing algorithms such as Sobel, Canny, and Robert's), clustering, graph cut segmentation, and flood fill are compared based on these metrics. This article reviews these segmentation methods and their performance, emphasizing the importance of choosing the appropriate technique based on the specific requirements of the image processing task.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
Overall Mapping	3	2	3	2	3	2	1	1	3	2	1	2

	PSO1	PSO2
Overall Mapping	3	1

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NOMENCLATURE

OCT	Optical Coherence Tomography
CCDs	Charged-Coupled Devices
CMOS	Complementary Metal-Oxide-Semiconductor
ML	Machine Learning
ANN	Artificial Neural Network
PID	Proportional-Integral-Derivative
HTML	Hypertext Markup Language
ROI	Region of Interest
R2017a	MATLAB Version Release 2017a
EEG	Electroencephalography
MR	Magnetic Resonance
CT	Computed Tomography
OCTA	Optical Coherence Tomography Angiography
SD-OCT	Spectral Domain Optical Coherence Tomography
FD-OCT	Fourier Domain Optical Coherence Tomography
TD-OCT	Time Domain Optical Coherence Tomography
SS-OCT	Swept-Source Optical Coherence Tomography
PS-OCT	Polarization-Sensitive Optical Coherence Tomography
AI	Artificial Intelligence
MRI	Magnetic Resonance Imaging
CT	Computed Tomography
CCD	Charge-Coupled Device
CMOS	Complementary Metal-Oxide-Semiconductor
AO-OCT	Adaptive Optics Optical Coherence Tomography
MSE:	Mean Square Error
PSNR	Peak Signal-to-Noise Ratio

CHAPTER 1

INTRODUCTION

1.1 Image

For the general reader, an image or picture typically conveys information about an object or person in the form of a visual representation. Images can be either two-dimensional (e.g., photographs) or three-dimensional (e.g., holograms). They are created using optical instruments such as cameras, lenses, microscopes, and telescopes, as well as new technologies. Images appeal to human vision or reflections of natural phenomena such as light. Images can represent words in a visually appealing manner, either in two dimensions or in other forms such as illustrations, graphs, charts, and in other formats. In this context, images can be created through human methods (drawing, painting, etc.), computer graphics technology, or a combination of methods.

Digital Image

A digital image is a representation of an image with two-dimensional pixels. Pixels are elements that constitute the image, usually arranged in a grid pattern on computer memory as a raster image or raster map. These elements are stored securely in raster image or raster map systems, where small integral numbers of two-dimensional pixels are saved. These values can be transmitted or securely stored. Digital images can be created through various input devices and methods, such as digital cameras, scanners, directive projection devices, seismographic profiling, remote sensing radars, and more.

1.1.1 Pixels

A pixel represents the smallest unit of an image formed in computer memory as a tiny visible dot or an amorphous sound. With special considerations, images can have varying resolutions, which can be utilized to display more pixels in a smaller space; however, in some contexts, when they are processed as points or pixels, they may be blurred.

Each pixel's intensity varies; in color systems, each pixel typically has three or four channels, allowing for various forms of representation. Pixels are also used to create graphical representations in which each pixel channel is responsible for different color intensities.

Subpixels

Due to various reasons, many displays and images cannot simultaneously display different color channels in the same location. To achieve this, subpixels, tiny auxiliary pixels, are often used to create graphical pointillism or processing applications that can increase analysis and processing time, but sometimes, you can identify it when you look closely. Later, combining two conditions can create both a higher resolution and excellent image quality, providing significant numerical information. To this end, subpixels are utilized, providing color descriptions.

Mega Pixels

Mega Pixels refer to a million pixels and are commonly used to describe and specify the capacity of digital cameras or other imaging devices. For example, a camera that captures images with a resolution of 2048 x 1536 pixels is commonly referred to as having 3.1 megapixels (2048 x 1536 = 3,145,728). Digital cameras use charged-coupled devices (CCDs) or CMOS sensors, recording brightness levels per-pixel basis.

In this comprehensive analysis, we will systematically compare and evaluate the performance of these segmentation techniques on a dataset of retinal OCT images. We will assess the accuracy, robustness, and computational efficiency of each method, considering factors such as image noise, structural complexity, and pathological variations. Additionally, we will explore the potential synergies between different segmentation approaches and investigate strategies for enhancing segmentation quality through combination or refinement techniques.Understanding the strengths and limitations of various segmentation techniques is crucial for optimizing image analysis pipelines in clinical settings. Accurate segmentation of retinal layers facilitates quantitative measurements of anatomical features, disease progression tracking, and treatment response assessment. By elucidating the performance characteristics of different segmentation methods on retinal OCT images, this analysis aims to contribute to the development of reliable and efficient tools for ocular disease diagnosis and management.

Through this study, we aim to provide insights into the selection and optimization of segmentation techniques for retinal OCT images, ultimately advancing the capabilities of image analysis in ophthalmic research and clinical practice.

1.2.2 Starting MATLAB:

After logging into your account, you can enter MATLAB by double-clicking on the MATLAB shortcut icon (MATLAB 7.0.4) on your Windows desktop. When you start MATLAB, a special window called the MATLAB desktop appears. The desktop is a window that contains other windows. The major tools within or accessible from the desktop are:

- The Command Window
- The Command History
- The Workspace
- The Current Directory
- The Help Browser

Current Folder: This panel allows you to access the project folders and files.

Fig 1.1: Current Folder Panel

Command Window: This is the main area where commands can be entered at the command line. It is indicated by the command prompt (>>).

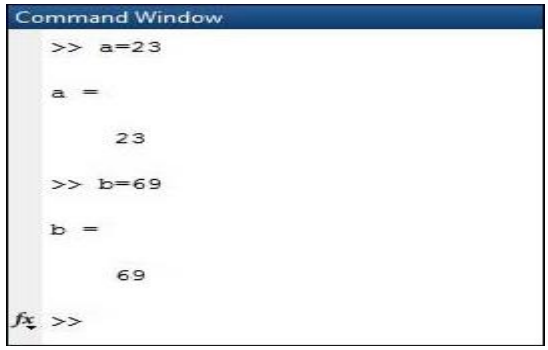

Fig 1.2.: Command Window Prompt

Workspace: The workspace shows all the variables created and/or imported from files.

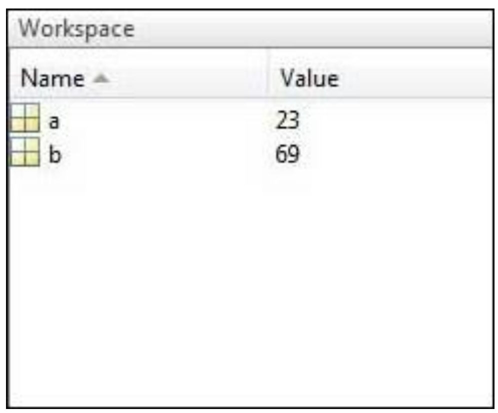

Fig 1.3: Workspace Panel

Help Browser:

The critical way to get assist online is to use the MATLAB help browser, opened as a separate window every through clicking at the question mark photograph (?) on the computing tool toolbar, or through manner of typing assist browser on the spark off in the command window. The assist Browser is an internet browser blanketed into the MATLAB computing tool that shows a Hypertext Markup Language (HTML) file. The Help Browser consists of panes, the help navigator pane, used to find out information, and the show pane, used to view the information. Self-explanatory tabs apart from navigator pane are used to performs are searching out.

1.2.3 MATLAB working environment:

This is the set of tools and facilities that you work with as the MATLAB user or programmer. It includes facilities for managing the variables in your workspace and importing and exporting data. It also includes tools for developing, managing, debugging, and profiling M-files, MATLAB's applications.

1.2.4 Features of MATLAB:

Following are the basic features of MATLAB.

- It is a high-level language for numerical computation, visualization and application development.
- It also provides an interactive environment for iterative exploration, design and problem solving.
- It provides vast library of mathematical functions for linear algebra, statistics, Fourier analysis, filtering, optimization, numerical integration and solving ordinary differential equations.
- It provides built-in graphics for visualizing data and tools for creating custom plots.
- MATLAB's programming interface gives development tools for improving code quality maintainability and maximizing performance.
- It provides tools for building applications with custom graphical interfaces.

1.2.5 Uses of MATLAB:

MATLAB is widely used as a computational tool in science and engineering encompassing the fields of physics, chemistry, math and all engineering streams. It is used in a range of applications including

- Signal Processing and Communications
- Video and Video Processing
- Control Systems
- Test and Measurement
- Computational Finance

1.2.6 Applications of MATLAB:

MATLAB can be used as a tool for simulating various electrical networks but the recent developments in MATLAB make it a very competitive tool for Artificial Intelligence, Robotics, Video processing, Wireless communication, Machine learning, Data analytics and whatnot. Though it's mostly used by circuit branches and mechanical in the engineering domain to solve a basic set of problems its application is vast. It is a tool that enables computation, programming and graphically visualizing the results. The basic data element of MATLAB as the name suggests is the Matrix or an array. MATLAB toolboxes are professionally built and enable you to turn your imaginations into reality. MATLAB programming is quite similar to C programming and just requires a little brush up of your basic programming skills to start working with.

Below are a few applications of MATLAB

- **Statistics and machine learning (ML)**

  This toolbox in MATLAB can be very handy for the programmers. Statistical methods such as descriptive or inferential can be easily implemented. So is the case with

  machine learning. Various models can be employed to solve modern-day problems. The algorithms used can also be used for big data applications.

- **Curve fitting**

  The curve fitting toolbox helps to analyze the pattern of occurrence of data. After a particular trend which can be a curve or surface is obtained, its future trends can be predicted. Further plotting, calculating integrals, derivatives, interpolation, etc. can be done.

- **Control systems**

  Systems nature can be obtained. Factors such as closed-loop, open-loop, its controllability and observability, Bode plot, NY Quist plot, etc. can be obtained. Various controlling techniques such as PD, PI and PID can be visualized. Analysis can be done in the time domain or frequency domain.

- **Signal Processing**

Signals and systems and digital signal processing are taught in various engineering streams. But MATLAB provides the opportunity for proper visualization of this. Various transforms such as Laplace, Z, etc. can be done on any given signal. Theorems can be validated. Analysis can be done in the time domain or frequency domain. There are multiple built-in functions that can be used.

- **Mapping**

Mapping has multiple applications in various domains. For example, in Big Data, the Map Reduce tool is quite important which has multiple applications in the real world. Theft analysis or financial fraud detection, regression models, contingency analysis, predicting techniques in social media, data monitoring, etc. can be done by data mapping.

- **Deep learning**

It's a subclass of machine learning which can be used for speech recognition, financial fraud detection, and medical video analysis. Tools such as time-series, Artificial neural network (ANN), Fuzzy logic or combination of such tools can be employed.

- **Financial analysis**

An entrepreneur before starting any endeavor needs to do a proper survey and the financial analysis in order to plan the course of action. The tools needed for this are all available in MATLAB. Elements such as profitability, solvency, liquidity, and stability can be identified. Business valuation, capital budgeting, cost of capital, etc. can be evaluated.

- **Video processing**

The most common application that we observe almost every day are bar code scanners, selfie (face beauty, blurring the background, face detection), video enhancement, etc. The digital video processing also plays quite an important role in transmitting data from far off satellites and receiving and decoding it in the same way. Algorithms to support all such applications are available.

- **Text analysis**

Based on the text, sentiment analysis can be done. Google gives millions of search results for any text entered within a few milliseconds. All this is possible because of text analysis. Handwriting comparison in forensics can be done. No limit to the application and just one software which can do this all.

- **Electric vehicles designing**

Used for modeling electric vehicles and analyze their performance with a change in system inputs. Speed torque comparison, designing and simulating of a vehicle, whatnot.

- **Aerospace**

This toolbox in MATLAB is used for analyzing the navigation and to visualize flight simulator.

- **Audio toolbox**

Provides tools for audio processing, speech analysis, and acoustic measurement. It also provides algorithms for audio and speech feature extraction and audio signal transformation.

1.3 Digital Image Processing

Digital Image Processing means processing digital image by means of a digital computer. We can also say that it is a use of computer algorithms, in order to get enhanced image either to extract some useful information.

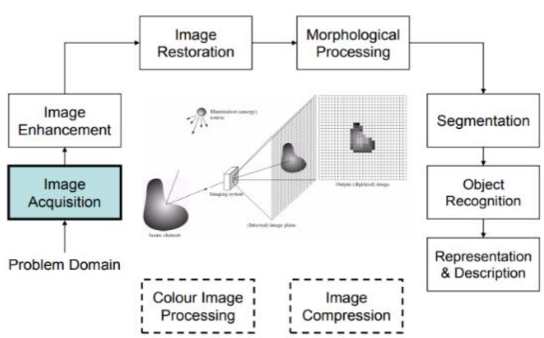

Fig-1.3: Image Processing

Image:.

A Pixel is most widely used to denote the elements of an Image. To be processed digitally, it has to be sampled and transformed into a matrix of numbers. Since a computer represents the numbers using finite precision, these numbers have to be quantized to be represented digitally. Digital image processing consists of the manipulation of those finite precision numbers. The processing of digital images can be divided into several classes: image enhancement, image restoration, image analysis, and image compression.

1.3.1 Image Digitization

An image captured by a sensor is expressed as a continuous function f(x, y) two co-ordinates in the plane. Image digitization means that the function f(x, y) is sampled into a matrix with M rows and N columns. The image quantization assigns to each continuous sample an integer value. The continuous range of the image function f(x, y) is split into K intervals. The finer the sampling (i.e., the larger M and N) and quantization (the larger K) the better the approximation of the continuous image functionf(x,y).

1.3.2 Image Pre-Processing

Pre-processing is a common name for operations with images at the lowest level of abstraction -- both input and output are intensity images. These iconic images are of the same kind as the original data captured by the sensor, with an intensity image usuallyrepresented by a matrix of image function values (brightness). The aim of pre-processingis an improvement of the image data that suppresses unwanted distortions or enhances some image features important for further processing. Four categories of image pre- processing methods according to the size of the pixel neigh-bour hood are used for the calculation of new pixel brightness.

- Pixel brightness transformations.
- Geometric transformations.
- Pre-processing methods that use a local neighborhood of the processed pixel.
- Image restoration that requires knowledge about the entire image.

1.3.3 Image Segmentation

Image segmentation is one of the most important steps leading to the analysis of processed image data. Its main goal is to divide an image into parts that have a strong correlation with objects or areas of the real world contained in the image. Two kinds of segmentation

1.3.3.1 Complete Segmentation

This results in set of disjoint regions uniquely corresponding with objects in the input image. Cooperation with higher processing levels which use specific knowledge of the problem domain is necessary.

1.3.3.2 Partial Segmentation

Image is divided into separate regions that are homogeneous with respect to a chosen property such as brightness, color, reflectivity, texture, etc. In a complex scene, aset of possibly overlapping homogeneous regions may result. The partially segmented global knowledge image must then be subjected to further processing, and the final imagesegmentation may be found with the help of higher-level information.Segmentation methods can be divided into three groups according to the dominant features they employ.

- First is about an image or its part; the knowledge is usually represented by a histogram of image features.
- Edge-based segmentations form the second group
- Region-based Segmentation

1.3.4 Image Enhancement

The aim of image enhancement is to improve the interpretability or perception of information in images for human viewers, or to provide `better' input for other automated image processing techniques. Image enhancement techniques can be divided into two broad categories:

- Spatial domain methods, which operate directly on pixels, and
- Frequency domain methods, which operate on the Fourier transform of an image.

Unfortunately, there is no general theory for determining what `good' image enhancement is when it comes to human perception. If it looks good, it is good! However, when image enhancement techniques are used as pre-processing tools for other image processing techniques, then quantitative measures can determine which techniques are most appropriate.

1.4 Applications of Digital Image Processing

- Image sharpening and restoration.
- Medical field.
- Remote sensing.
- Transmission and encoding.
- Machine/Robot vision.
- Color processing.
- Pattern recognition.
- Video processing

1.5 Software Requirement

- **MATLAB,** Version: R2017a,64-bit

1.6 Need of Image Segmentation

Image segmentation is a crucial step in image processing, particularly in medical imaging applications like analyzing retinal OCT (Optical Coherence Tomography) images. Here's why image segmentation is necessary and how it facilitates the comparison of various segmentation techniques for retinal OCT images:

1. Localization of Regions of Interest (ROIs): Image segmentation helps identify and isolate specific regions within an image for analysis. In the case of retinal OCT images, segmentation can localize structures such as the retina, optic nerve, blood vessels, and various retinal layers.

2. Feature Extraction: Segmentation divides the relevant regions, allowing extraction of features like area, shape, intensity, and texture. These features are crucial for analyzing the health of the retina and underlying pathology.

3. Disease Detection and Diagnosis: Segmentation plays a vital role in detecting and diagnosing abnormalities or diseases in medical images. For retinal OCT images, segmentation aids in identifying conditions like diabetic retinopathy, glaucoma, and macular degeneration.

4. Quantitative Analysis: Image segmentation enables quantitative analysis by measuring various parameters within segmented regions. This quantitative information is useful for tracking disease progression, monitoring treatment efficacy, and assessing patient outcomes.

5. Comparative Evaluation of Segmentation Techniques: Image segmentation is challenging, and numerous techniques exist. Comparing these techniques helps determine their accuracy, reliability, and suitability for specific applications. By segmenting retinal OCT images using different techniques, researchers can identify the most effective approach.

6. Validation and Ground Truth Generation: Image segmentation techniques need validation against ground truth data, usually manually annotated or expert-validated segmentations. Comparing segmentation results to ground truth annotations assesses accuracy and reliability. This ensures the development of accurate and reliable methods for medical image analysis and clinical decision-making.

1.7 **Problem Statement**

Finding the best segmentation techniques from existing research. Create rules to measure how well each technique works. Gathering a set of OCT images with known sections for testing. Trying out chosen techniques and seeing how they perform using our images. Comparing the results to see which methods work best and why. Improving the techniques we find to make them even better. Checking if our findings hold true for different eye problems and situations.

This project hopes to improve how we interpret OCT images, helping doctors diagnose and treat retinal diseases more accurately.

1.8 Organization of Thesis

In **chapter-1** it explains Introduction to image segmentation and its applications.

In **chapter-2** it explains literature survey, different methods in image segmentation and also includes existing methods and its drawbacks.

In **chapter-3** it explains about the definition of Image segmentation its techniques, steps, and its applications in different domains.

In **chapter-4** the proposed algorithm, the major aim of the project is explained.

In **chapter-5** it introduces code implementation in MATLAB working environment.

In **Chapter-6** it discusses the final results and segmentation techniques output images

In **Chapter-7** it concludes the thesis and future scope of project further research.

CHAPTER 2

LITERATURE SURVEY

2.1Introduction:

The utilization of retinal OCT (Optical Coherence Tomography) imaging has revolutionized the diagnosis and management of retinal diseases. However, accurate interpretation of OCT images remains a challenge, primarily due to the complexity of retinal anatomy and variability in image quality. This literature survey aims to explore and analyze existing research on image segmentation techniques for retinal OCT images. By reviewing state-of-the-art segmentation methods, evaluating their strengths and limitations, and identifying gaps in current approaches, this survey seeks to provide a comprehensive understanding of the landscape of image segmentation in retinal OCT imaging. The findings of this survey will inform the selection of appropriate segmentation techniques for a comparative analysis, ultimately contributing to the development of more accurate tools for retinal disease diagnosis and monitoring.

2.2 Research Papers:

R. Yogamangalam, B. Karthikeyan, "Segmentation Techniques Comparison in Image Processing", International Journal of Engineering and Technology (IJET), Vol 5 No 1 Feb-Mar 2013. In day-to-day life, new technologies are emerging in the field of Image processing, especially in the domain of segmentation. This paper presents a brief outline on some of the most common segmentation techniques like thresholding, Model based, Edge detection, Clustering etc., mentioning its advantages as well as the drawbacks. Some of the techniques are suitable for noisy images. In that Markov Random Field (MRF) is the strongest method of noise cancellation in images whereas thresholding is the simplest technique for segmentation.

Summary: This paper summarizes various segmentation techniques.

M. Anand and Dr.C. Jayakumari," Study of Retina Image Segmentation Algorithms from Optical Coherence Tomography (OCT) Images", Jour of Adv Research in Dynamical & Control Systems, Vol. 9, No. 4, 2017. Optical coherence tomography (OCT) is a recently established imaging technique to describe different information about the internal structures of an object and to image various aspects of biological tissues. OCT image segmentation is mostly introduced on retinal OCT to localize the intra-retinal boundaries. Here, we review some of the important image segmentation methods for processing retinal OCT images. We may classify the OCT segmentation approaches into five distinct groups according to the image domain subjected to the segmentation algorithm. Current researches in OCT segmentation are mostly based on improving the accuracy and precision, and on reducing the required processing time. There is no doubt that current 3-D imaging modalities are now moving the research projects toward volume segmentation along with 3-D rendering and visualization. It is also important to develop robust methods capable of dealing with pathologic cases in OCT imaging.

Summary: Research on OCT segmentation 3-D imaging modalities

M. Anand and Dr.C. Jayakumar, “Automated Detection of Macular Hole in Optical Coherence Tomography Images using Depth-Check Algorithm”, International Journal of Engineering and Advanced Technology (IJEAT) ISSN: 2249 – 8958, Volume-9 Issue-1, October 2019. Macular hole is a tear or break in the macula. It is located in the center of the retina and affects central vision of aged people. Optical Coherence Tomography (OCT) enables accurate diagnosis of macular hole. Existing algorithms available to detect cysts and retinal layers, but identifying macular hole in an accurate manner is still a missing entity. Hence, we propose an automated system for the accurate macular hole detection. The proposed system has six stages in process. The first stage starts with preprocessing the OCT image, then detecting Nerve Fiber Layer (NFL). The detected NFL layer is then processed and depth feature is extracted. Then the macular hole is detected in OCT images using our proposed system. The proposed system is evaluated with the healthy macula and macular hole OCT images. The proposed system is also compared with other machine learning algorithms. By experimentation results, the proposed algorithm provides 94% accuracy in finding macular hole.

Summary: Studied on retinal diseases, such as Macular Edema (ME), Central Serous Chorioretinopathy (CSCR) and Pigment Epithelial Detachment (PED).

Davis L S, Rosenfeld A, Weszka J S. Region extraction by averaging and thresholding[J]. IEEE Transactions on Systems, Man, and Cybernetics, 1975 (3): 383-388. Regions in a picture that differ texturally from their surroundings can often be extracted by 1) applying a local operation to every point of the picture, 2) averaging the results, and 3) thresholding. This approach will usually not work if there are too many differently textured regions present, since the average for one type of region may then be indistinguishable from the average resulting from a mixture of two other types that adjoin. The amount of averaging that should be used depends on the coarseness of the texture. An approach to choosing this amount automatically was investigated, but the results were not as good as those obtained with a fixed high degree of averaging.

Summary: Studied on Region Extraction techniques.

K. M. Hassan, M. R. Islam, T. Tanaka, and M. K. I. Molla, "Epileptic seizure detection from EEG signals using multiband features with Feedforward neural network," Cyberworlds 2019, Kyoto, Japan (in press). Electroencephalography (EEG) is considered as a potential tool for diagnosis of epilepsy in clinical applications. Epileptic seizures occur irregularly and unpredictably. Its automatic detection in EEG recordings is highly demanding. In this work, multiband features are used to detect seizure with feedforward neural network (FfNN). The EEG signal is segmented into epochs of short duration and each epoch is decomposed into a number of subbands using discrete wavelet transform (DWT). Three features namely ellipse area of second-order difference plot, coefficient of variation and fluctuation index are computed from each subband signal. The features obtained from all subbands are combined to construct the feature vector. The FfNN is trained using the derived feature vector and seizure detection is performed with test data. The experiment is performed with publicly available dataset to evaluate the performance of the proposed method. The experimental results show the superiority of this method compared to the recently developed algorithms.

Summary: Studied about discrete wavelet transform (DWT)

J. Selvakumar, A. Lakshmi and T. Arivoli, "Brain tumor segmentation and its area calculation in Brain MR images using K-mean clustering and Fuzzy C-mean algorithm", IEEE-International conf. on advances in eng. science and management, March-2012. This paper deals with the implementation of Simple Algorithm for detection of range and shape of tumor in brain MR images. Tumor is an uncontrolled growth of tissues in any part of the body. Tumors are of different types and they have different Characteristics and different treatment. As it is known, brain tumor is inherently serious and life-threatening because of its character in the limited space of the intracranial cavity (space formed inside the skull). Most Research in developed countries show that the number of people who have brain tumors were died due to the fact of inaccurate detection. Generally, CT scan or MRI that is directed into intracranial cavity produces a complete image of brain. This image is visually examined by the physician for detection & diagnosis of brain tumor. However this method of detection resists the accurate determination of stage & size of tumor. To avoid that, this project uses computer aided method for segmentation (detection) of brain tumor based on the combination of two algorithms. This method allows the segmentation of tumor tissue with accuracy and reproducibility comparable to manual segmentation. In addition, it also reduces the time for analysis. At the end of the process the tumor is extracted from the MR image and its exact position and the shape also determined. The stage of the tumor is displayed based on the amount of area calculated from the cluster.

Summary: Studied about K-mean clustering and Fuzzy C-mean algorithm.

2.3 Existing Method

2.3.1 K-means Segmentation:

K-means segmentation is like sorting candy into different jars. Imagine you have a bunch of colorful candies, and you want to group them by their colors. K-means helps you do that. You pick how many groups you want (let's say three jars), and the candies get sorted based on their colors into those jars. It's used for pictures too. Instead of candies, it sorts pixels by their colors, so you can separate objects in an image. However, sometimes it might mix up similar colors or need help to figure out how many groups to use.

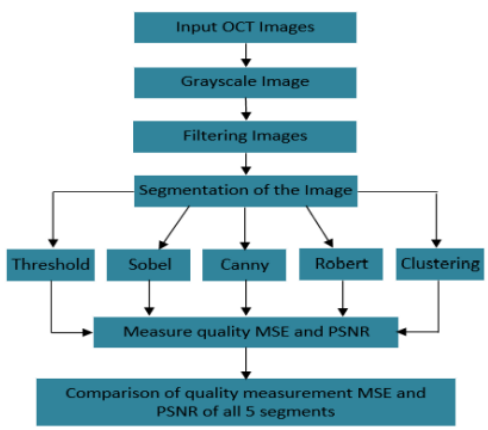

Fig-2.3.1: Block Diagram for Existing method

Segmentation plays a pivotal role in various fields, from image processing to data analysis. Among the multitude of segmentation techniques, K-means segmentation stands out as a popular and effective method. Its analogy to sorting candies into different jars makes it intuitively understandable. This article delves into the intricacies of K-means segmentation, elucidating its principles, applications, challenges, and potential solution.

Understanding K-means:

Imagine a pile of colorful candies scattered on a table. You decide to organize them into distinct groups based on their colors. K-means segmentation mirrors this process by clustering data points into 'k' clusters, where 'k' represents the number of desired groups or clusters. Initially, 'k' centroids are randomly chosen, akin to placing empty jars on the table. Each candy (data point) is then assigned to the nearest centroid (jar) based on a similarity measure, typically Euclidean distance. After the initial assignment, centroids are recalculated as the mean of all candies assigned to them. This process iterates until convergence, with centroids adjusting their positions to minimize the total within-cluster variance.

Determining the Optimal Number of Clusters:

An essential aspect of K-means segmentation is determining the optimal number of clusters ('k'). While the candy analogy simplifies this decision by specifying the number of jars beforehand, real-world datasets often lack such prior knowledge. Several techniques exist to estimate the optimal 'k', including the elbow method, silhouette score, and gap statistics. The elbow method involves plotting the within-cluster sum of squares against the number of clusters and selecting the point where the rate of decrease slows down (elbow point) as the optimal 'k'.. On the other hand, gap statistics compare the within-cluster dispersion to that of a reference null distribution, helping identify the optimal 'k' that maximizes the gap.

2.3.2 Challenges and Limitations:

Despite its utility, K-means segmentation encounters several challenges. One prominent issue is its sensitivity to the initial selection of centroids. Since centroids are randomly initialized, different runs of K-means may yield divergent results. Moreover, K-means assumes that clusters are spherical and have similar sizes, which might not hold true for complex data distributions. Additionally, K-means struggles with segmenting datasets containing noise or outliers, as it tends to allocate them to the nearest cluster regardless of their true distribution.

2.4 Drawbacks of Existing Method:

1. Sensitivity to initial centroid selection.
2. Fixed number of clusters.
3. Assumes spherical clusters with equal variance.

CHAPTER 3

OCT IMAGE SEGMENTATION

3.1 Optical Coherence Tomography:

Optical Coherence Tomography (OCT) is the most valuable advance in retinal diagnostic imaging since the introduction of fluorescein angiography in 1959. OCT is a non-invasive imaging technique relying on low coherence interferometry to generate in vivo, cross-sectional imagery of ocular tissues. Originally developed in 1991 as a tool for imaging the retina, OCT technology has continually evolved and expanded within ophthalmology as well as other medical specialties. Specialized anterior segment OCT machines became available in 2005 and the introduction of Spectral (Fourier) Domain OCT (SD-OCT, FD-OCT) technology now provides greater tissue resolving power, significantly higher scan density, and faster data acquisition than original Time Domain OCT.

Optical coherence tomography (OCT) and optical coherence tomography angiography (OCTA) are non-invasive imaging tests. They use light waves to take cross-section pictures of your retina. With OCT, your ophthalmologist can see each of the retina's distinctive layers. This allows your ophthalmologist to map and measure their thickness. These measurements help with diagnosis. They also guide treatment for glaucoma as well as retinal disease, like age-related macular degeneration (AMD) and diabetic eye disease.Optical coherence tomography angiography (OCTA) takes pictures of the blood vessels in and under the retina. OCTA is like fluorescein angiography. But it is a much quicker test and does not use a dye.

Fig 3.1: OCT machine

Optical Coherence Tomography generates cross sectional images by analyzing the time delay and magnitude change of low coherence light as it is backscattered by ocular tissues. An infrared scanning beam is split into a sample arm (directed toward the subject) and a reference arm (directed toward a mirror). As the sample beam returns to the instrument it is correlated with the reference arm in order to determine distance and signal change via photodetector measurement. The resulting change in signal amplitude allows tissue differentiation by analysis of the reflective properties, which are matched to a false color scale. As the scanning beam moves across tissue, the sequential longitudinal signals, or A-scans, can be reassembled into a transverse scan yielding cross-sectional images, or B-scans, of the subject. The scans can then be analyzed in a variety of ways providing both empirical measurements (e.g. RNFL or retinal thickness/volume) and qualitative morphological information.

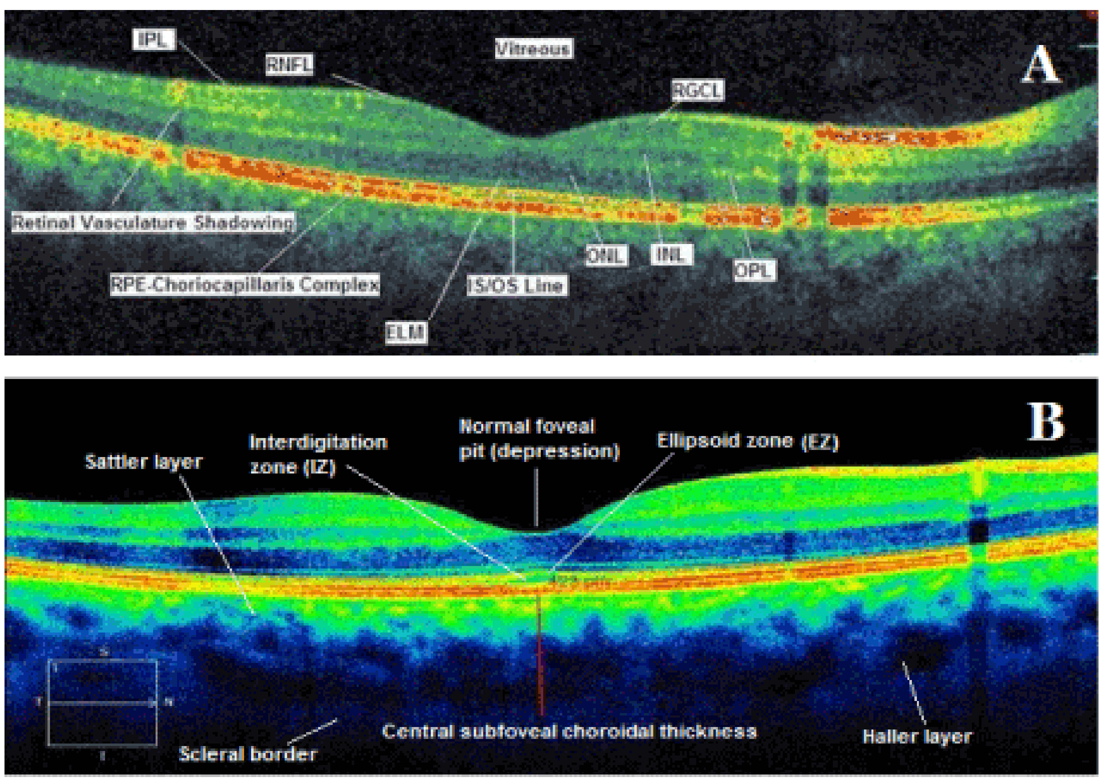

Fig 3.2: OCT image

Optical Coherence Tomography (OCT) has emerged as a powerful imaging modality with diverse applications in medical diagnostics, particularly in ophthalmology. In your project document, it's essential to provide a comprehensive overview of OCT, highlighting its principles, advantages, clinical applications, and future directions.

principle of OCT Imaging:

OCT operates on the principle of low-coherence interferometry, harnessing the interference patterns generated by backscattered light to construct high-resolution, cross-sectional images of tissues. A typical OCT system comprises a broadband light source emitting near-infrared light, an interferometer with a reference arm and a sample arm, a scanning mechanism, and a detection system. The emitted light is split into the sample arm, directed towards the tissue under examination, and the reference arm, where it undergoes reflection from a stationary mirror. Upon recombination of the reflected light from both arms, interference patterns are produced. By measuring the delay and intensity of the interference signals, OCT constructs depth-resolved images with micron-level resolution, enabling visualization of tissue microstructure.

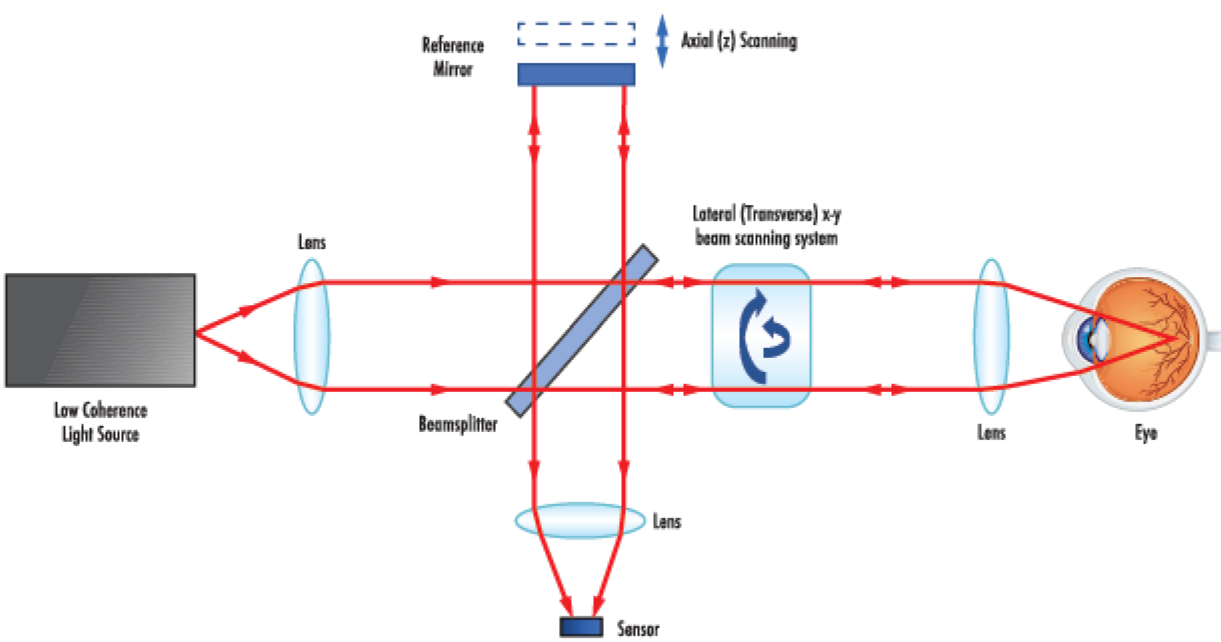

Fig 3.3: TD-OCT optical diagram

Optical Path Description

An OCT system can be constructed from discrete optical components as described below, or from their fiber optic equivalents.

1. **Light Source***:* according to the classic principle of OCT, a broadband light source with a short coherence length is used for imaging. The short coherent length of the emitted light determines the axial resolution for OCT imaging. However, alternative sources, such as a wavelength-swept laser, can be used to optimize the frequency-dependent reflectance of a given sample for better image quality than that possible using TD-OCT. Specific wavelength ranges, such as visible or infrared light, can also be used to reduce light scattering depending on the sample. Selecting the proper light source based on the sample can optimize the performance of the OCT system.
2. **Beamsplitters***:* plate or cube beamsplitters can be used in OCT to split the light into two different paths: the reference and sample beams. The beamsplitter allows for the reference beam to be reflected to the reference mirror while the sample beam is focused into the sample using an optical lens.
3. **Dielectric Optical Mirrors***:* this mirror is used to reflect the reference beam to a known path length back into the interference system. The mounted reference mirror in a TD-OCT system will have a controlled translation to allow for axial scanning of the sample. The mirror is stationary in FD-OCT. These mirrors feature a dielectric coating that is ideal for reflection applications as the mirrors feature greater than 99% reflection.
4. **Optical Lens:** a standard plano-convex (PCX) can be used to focus the split beam paths into the sample and detector. To reduce potential spherical and chromatic aberrations, an aspheric or achromatic lens can be utilized. These lenses will focus the light into the sample at a smaller spot size with reduced aberrations, making a more precise OCT system.
5. **Detector***:* the detector can come in the form of a single photodiode in the case of TD-OCT and some types of FD-OCT, or for conventional FD-OCT a charge-coupled device (CCD) or a CMOS array that is sensitive to the radiation returning from the sample and reference beam.
6. **Deformable Mirror***:* specific for AO-OCT applications. A deformable mirror is an adaptive optic used to reduce aberrations and improve image quality for superior resolution. The shape of the mirror is controlled by an outside signal to correct the wavefront for enhanced system performance.

Fig 3.4: OCT Retinal images

Types of OCT Systems:

Several types of OCT systems have been developed to meet the diverse imaging needs across different medical specialties. Time-Domain OCT (TD-OCT), the earliest OCT technique, employs a moving reference mirror to scan the sample, measuring the time delay of backscattered light. Fourier-Domain OCT (FD-OCT) uses a spectrometer to simultaneously detect multiple wavelengths of light, offering faster imaging speeds and improved signal-to-noise ratio compared to TD-OCT. Swept-Source OCT (SS-OCT) utilizes a rapidly tenable laser as the light source, allowing for high-speed imaging and enhanced depth penetration. Each OCT system has its unique advantages and applications, catering to the specific imaging requirements of different clinical scenarios.

Clinical Applications of OCT:

OCT has revolutionized medical diagnostics by providing detailed, real-time imaging of tissues with exceptional resolution and depth penetration. In ophthalmology, OCT is indispensable for imaging the anterior and posterior segments of the eye, aiding in the diagnosis and management of various retinal diseases, including age-related macular degeneration (AMD), diabetic retinopathy, glaucoma, and macular edema. It enables clinicians to visualize retinal layers, measure retinal thickness, detect structural abnormalities, and monitor disease progression over time.

Beyond ophthalmology, OCT finds applications in cardiology for imaging coronary arteries, assessing plaque composition, and guiding interventional procedures such as angioplasty and stent placement. In dermatology, OCT is used for imaging skin lesions, diagnosing skin cancers, and monitoring treatment response. Additionally, OCT is employed in gastroenterology, neurology, and oncology for imaging gastrointestinal mucosa, brain tissue, and tumor margins, among other applications.

Advantages of OCT Technology:

OCT offers numerous advantages over traditional imaging modalities, making it a preferred choice for clinicians and researchers alike. Its high resolution allows for detailed visualization of tissue microstructure, surpassing the capabilities of other imaging techniques such as ultrasound and MRI. OCT's real-time imaging capability enables immediate visualization of tissues during procedures, facilitating on-the-spot decision-making and intervention. Moreover, OCT is non-invasive and does not require the use of ionizing radiation or contrast agents, minimizing patient discomfort and risk.

Recent Advances and Innovations:

In recent years, OCT technology has witnessed significant advancements driven by ongoing research and technological innovations. Novel imaging modalities such as polarization-sensitive OCT (PS-OCT) and OCT angiography (OCTA) have expanded OCT's capabilities beyond structural imaging, allowing for the assessment of tissue birefringence and blood flow dynamics. Integration with artificial intelligence (AI) and machine learning algorithms has led to the development of automated segmentation techniques, enhancing the efficiency and accuracy of OCT image analysis. Furthermore, miniaturization of OCT systems has enabled the development of handheld and portable devices, facilitating point-of-care imaging in clinical settings and remote areas.

Future Directions and Prospects:

Looking ahead, the future of OCT technology holds tremendous promise for further advancements and applications. Ongoing research aims to improve imaging speed, resolution, and depth penetration, pushing the boundaries of what is achievable in tissue imaging. Integration with advanced imaging modalities such as multi-modal OCT and photoacoustic imaging promises to provide complementary information and enhance diagnostic capabilities. Moreover, the advent of AI-driven OCT analysis tools holds the potential to revolutionize clinical practice by enabling rapid, objective interpretation of OCT images and aiding in decision-making. As OCT technology continues to evolve, its impact on medical diagnostics and patient care is expected to grow, reaffirming its status as a cornerstone technology in modern healthcare.

Optical Coherence Tomography (OCT) stands as a powerful imaging modality with diverse applications across various medical specialties. By providing high-resolution, cross-sectional images of tissues with exceptional detail, OCT has transformed our understanding of tissue microstructure and pathology. With ongoing research and technological innovations, OCT technology is poised to play an even greater role in medical diagnostics and patient care, paving the way for new discoveries and advancements in healthcare.Advantages of OCT

3.2 Segmentation

In digital image processing and computer vision, image segmentation is the process of partitioning a digital image into multiple image segments, also known as image regions or image objects (sets of pixels). The goal of segmentation is to simplify and/or change the representation of an image into something that is more meaningful and easier to analyze. Image segmentation is typically used to locate objects and boundaries (lines, curves, etc.) in images. More precisely, image segmentation is the process of assigning a label to every pixel in an image such that pixels with the same label share certain characteristics.

Groups of image segmentation

1. **Semantic segmentation** is an approach detecting, for every pixel, the belonging class. For example, in a figure with many people, all the pixels belonging to persons will have the same class id and the pixels in the background will be classified as background.
2. **Instance segmentation** is an approach that identifies, for every pixel, the specific belonging instance of the object. It detects each distinct object of interest in the image. For example, when each person in a figure is segmented as an individual object.
3. **Panoptic segmentation** combines both semantic and instance segmentation. Like semantic segmentation, panoptic segmentation is an approach that identifies, for every pixel, the

belonging class. Moreover, like in instance segmentation, panoptic segmentation distinguishes different instances of the same class.

Fig 3.3: variation of segmented images

How Does Image Segmentation Work?

Image segmentation is a function that takes image inputs and produces an output. The output is a mask or a matrix with various elements specifying the object class or instance to which each pixel belongs.

Several relevant heuristics, or high-level image features, can be useful for image segmentation. These features are the basis for standard image segmentation algorithms that use clustering techniques like edges and histograms.

An example of a popular heuristic is color. Graphics creators may use a green screen to ensure the image background has a uniform color, enabling programmatic background detection and replacement in post-processing. Another example of a useful heuristic is contrast—image segmentation programs can easily distinguish between a dark figure and a light background (i.e., the sky). The program identifies pixel boundaries based on highly contrasting values.

Traditional image segmentation techniques based on such heuristics can be fast and simple, but they often require significant fine-tuning to support specific use cases with manually designed heuristics. They are not always sufficiently accurate to use for complex images. Newer segmentation techniques use machine learning and deep learning to increase accuracy and flexibility. Machine learning-based image segmentation approaches use model training to improve the program's ability to identify important features. Deep neural network technology is especially effective for image segmentation tasks.

Importance of Image Segmentation in Medical Imaging:

In medical imaging, accurate image segmentation is vital for various applications such as disease diagnosis, treatment planning, and monitoring. By delineating anatomical structures or pathological features, segmentation facilitates quantitative analysis and enhances the clinician's ability to make informed decisions.

Challenges in Image Segmentation:

Despite its importance, image segmentation poses several challenges, particularly in medical imaging. These challenges include anatomical variability, pathological variations, noise, and artifacts. Overcoming these challenges requires robust segmentation algorithms and careful consideration of image characteristics and clinical context.

3.3 Optical Coherence Tomography (OCT) Image Segmentation:

OCT image segmentation is a specialized area within medical imaging that focuses on segmenting high-resolution, cross-sectional images of biological tissues obtained using OCT technology. Segmentation of OCT images is essential for analyzing retinal layers, detecting pathological features, and monitoring disease progression in ophthalmic conditions.

Methods for OCT Image Segmentation:

Various segmentation methods are employed for OCT images, including thresholding, edge detection, region-based methods, and machine learning techniques. These methods leverage image features such as intensity, texture, and spatial information to delineate different tissue layers and structures accurately.

Challenges and Considerations Specific to OCT Image Segmentation:

OCT image segmentation faces unique challenges such as anatomical variability, layer thickness variations, and the presence of noise and artifacts. Addressing these challenges requires the development of specialized algorithms tailored to OCT imaging characteristics and clinical requirements.

Applications of image segmentation

1. **Medical Imaging**: In medical imaging, segmentation is used for identifying and delineating organs, tumors, tissues, and abnormalities in images such as X-rays, MRI, CT scans, and ultrasound. It aids in diagnosis, treatment planning, and monitoring of diseases.

2. **Object Detection and Recognition**: Image segmentation is crucial for object detection and recognition in computer vision applications. By segmenting objects from the background, it becomes easier to classify and recognize them accurately. This is widely used in autonomous vehicles, surveillance systems, and robotics.
3. **Satellite Image Analysis**: Satellite and aerial images often require segmentation to identify and analyze features like land cover, vegetation, urban areas, water bodies, and geographical changes over time. This is valuable for urban planning, environmental monitoring, and disaster management.

CHAPTER 4

PROPOSED METHOD

4.1 Introduction:

The proposed method for image segmentation leverages a combination of clustering-based techniques and preprocessing methods to enhance the accuracy and efficiency of segmenting images, particularly in OCT (Optical Coherence Tomography) images. Initially, preprocessing methods like the Wiener filter are applied to reduce speckle noise, improving the quality of the input images.

Next, the image is segmented using clustering algorithms, which have demonstrated effectiveness in separating images in OCT scans. These clustering techniques partition the image into smaller, more homogeneous segments, facilitating subsequent analysis. Additionally, edge detection algorithms such as Sobel, Canny, and Robert's are employed to enhance the delineation of object boundaries, further refining the segmentation results.

To evaluate the performance of various segmentation techniques, metrics like MSE (mean square error) and PSNR (peak signal-to-noise ratio) are calculated, providing quantitative measures of segmented image quality. Techniques including thresholding, edge detection, clustering, graph cut segmentation, and flood fill are compared based on these metrics.

This proposed method emphasizes the importance of selecting appropriate segmentation techniques tailored to the specific requirements of the image processing task, ensuring optimal results in terms of accuracy, efficiency, and image quality. By integrating preprocessing, clustering, and evaluation techniques, this method offers a comprehensive approach to image segmentation in OCT images.

Image segmentation stands as a pivotal step in image processing, involving the partitioning of an image into smaller, meaningful segments. This process is crucial for efficient tasks such as object recognition and image compression. Several techniques have been explored for image segmentation, including thresholding, edge-based methods (such as Sobel, Canny, and Robert's), clustering-based approaches, graph cut segmentation, and flood fill. Among these, clustering-based segmentation has proven particularly effective for segmenting OCT images. To mitigate speckle noise during preprocessing, the Wiener filter approach is employed. Evaluation of segmentation quality involves calculating metrics like Mean Square Error (MSE) and Peak Signal-to-Noise Ratio (PSNR) across the various techniques. This comprehensive analysis aids in determining the most suitable method for a given application, ensuring optimal image segmentation outcomes.

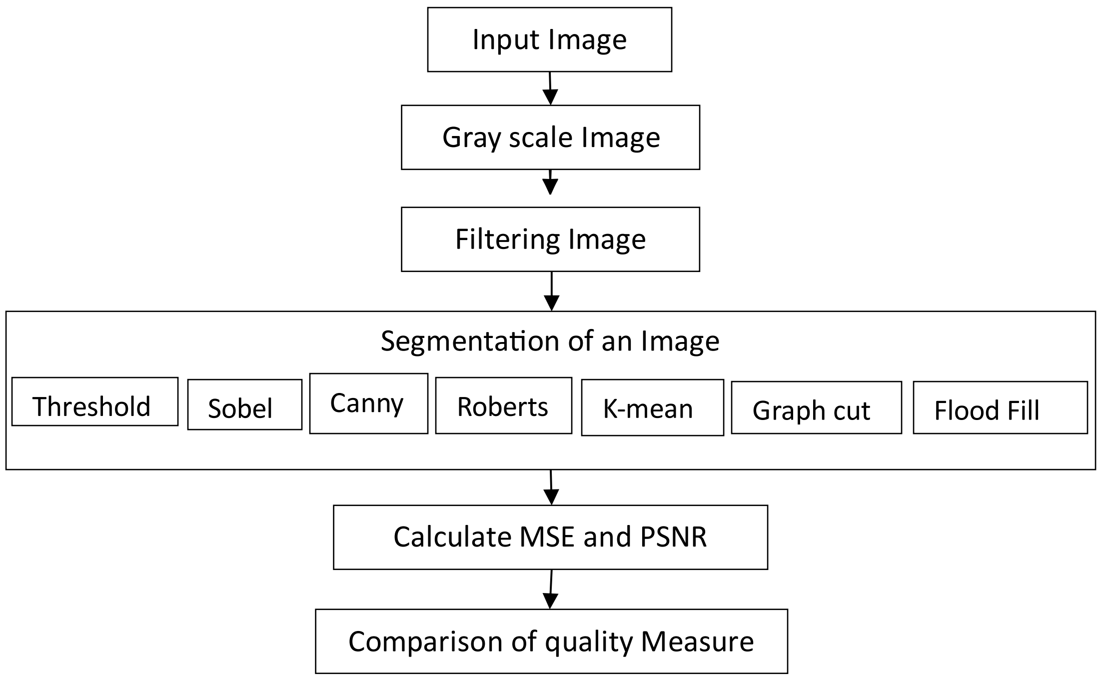

Fig 4.1: Block diagram for proposed method

4.2 Implementation:

Gray Conversion:

In image processing, a grayscale image, often referred to as a "gray image" or "black and white image," is an image in which each pixel value represents the intensity of light or brightness at that particular point in the image. Unlike color images, which contain three channels (red, green, and blue), grayscale images contain only one channel representing the brightness.

Here are some key points about grayscale images:

1. Pixel Values: In a grayscale image, each pixel value typically ranges from 0 to 255, where 0 represents black and 255 represents white. The values in between represent various shades of gray.

2. Single Channel: Grayscale images have only one channel, as opposed to color images which have three channels (RGB). This makes grayscale images simpler to process computationally.

3. Simplicity: Grayscale images are often used in image processing tasks because they simplify the processing and reduce the computational load compared to color images. Many image processing algorithms, such as edge detection or image filtering, can be applied more efficiently to grayscale images.

4. Storage: Grayscale images require less storage space compared to color images since they have only one channel instead of three. This can be advantageous in applications where storage space is limited or when processing large volumes of images.

5. Visual Interpretation: Grayscale images are useful for emphasizing texture, shape, and form in an image, as color information is removed. They are commonly used in medical imaging, satellite imaging, and scientific visualization.

6. Converting Color to Grayscale: Converting a color image to grayscale is often done by taking a weighted average of the red, green, and blue values of each pixel. Different weightings can be used depending on the desired result. For example, using equal weights (0.33, 0.33, 0.33) results in a standard grayscale conversion, while other weightings can emphasize certain color channels more than others.

Wiener Filter:

The Wiener filter is a widely used technique in image processing for noise reduction and image restoration. Named after Norbert Wiener, the Wiener filter is based on the principles of signal processing and statistical estimation theory. Its primary objective is to enhance the quality of images corrupted by additive noise while preserving important features and details.

At its core, the Wiener filter operates on the assumption that the degraded image can be represented as a convolution of the original image with a point spread function (PSF), followed by the addition of noise. The degraded image can thus be mathematically expressed as:

$$y(x,y)=h(x,y)*x(x,y)+n(x,y) \quad \text{--------()}$$

Where:

- $y(x,y)$ represents the degraded image,
- $x(x,y)$ represents the original, noise-free image,
- $h(x,y)$ represents the PSF or the degradation function,
- * denotes the convolution operation,
- $n(x,y)$ represents the additive noise.

The goal of the Wiener filter is to estimate the original image x(x, y) from the degraded image y(x, y). This estimation is achieved by designing a filter that minimizes the mean square error (MSE) between the estimated image and the original image.

The Wiener filter operates in the frequency domain, where the degraded image and the PSF are transformed using the Fourier transform. The Wiener filter in the frequency domain is given by:

$$H(u,v)=|F(u,v)|^2+S_n(u,v)G(u,v)\cdot|F(u,v)|^2$$

Where:

- $H(u,v)$ is the frequency response of the Wiener filter,
- $G(u,v)$ is the Fourier transform of the degraded image,
- $F(u,v)$ is the Fourier transform of the original image,
- $S_n(u,v)$ is the power spectral density (PSD) of the noise.

The Wiener filter works by attenuating the frequency components of the degraded image according to their contributions to the noise. Components with high noise-to-signal ratios are suppressed more than those with low noise-to-signal ratios, effectively reducing noise while preserving the important features of the image.

In practice, the Wiener filter requires knowledge of the PSF and the PSD of the noise, which are often estimated from the degraded image itself or from prior information about the imaging system and the noise characteristics. However, accurate estimation of these parameters is crucial for the effectiveness of the Wiener filter.

Despite its effectiveness in many scenarios, the Wiener filter has its limitations. It assumes linear degradation and additive Gaussian noise, which may not always hold true in real-world scenarios.

Additionally, the Wiener filter may introduce artifacts or blur in the restored image if the PSF or noise characteristics are not accurately estimated.

Adaptive thresholding:

Is a technique used in image processing to separate objects or regions of interest from the background in an image. In standard (or global) thresholding, a single threshold value is applied to the entire image, which might not be effective if the lighting conditions vary across the image or if there is uneven illumination.

Adaptive thresholding addresses this issue by calculating different threshold values for different regions of the image based on local characteristics such as the mean or median intensity of neighboring pixels. This allows for better adaptation to variations in lighting and background conditions.

There are several methods for adaptive thresholding, but a common approach involves dividing the image into smaller, overlapping blocks or windows and calculating a threshold value for each block independently. The threshold value for each block can be computed using various techniques such as:

1. Mean: The threshold is calculated as the mean intensity of the pixels in the local neighborhood.

2. Median: The threshold is calculated as the median intensity of the pixels in the local neighborhood.

3. Gaussian-weighted mean: The threshold is calculated as a weighted average of the pixel intensities in the local neighborhood, with weights determined by a Gaussian kernel.

4. Adaptive histogram equalization: This method enhances the contrast of the image before applying thresholding, which can improve the separation of objects from the background.

After calculating the threshold values for each block, they are then applied to their respective regions of the image to binarize it, resulting in a binary image where pixels are classified as either foreground or background.

Adaptive thresholding is particularly useful in scenarios where the lighting conditions are non-uniform or when there is a significant variation in the background across the image. It helps to improve the accuracy of object detection and segmentation in such cases, making it a valuable tool in various image processing applications such as document analysis, medical imaging, and computer vision.

Sobel edge detection:

Sobel edge detection is a popular method used in image processing to detect edges in an image. It is named after its inventor, Irwin Sobel. The technique is widely used due to its simplicity and effectiveness in identifying edges, which are regions in an image where intensity changes significantly.

The Sobel operator works by convolving the image with a pair of 3x3 kernels (one for horizontal changes and one for vertical changes) to compute the gradient approximation of the image intensity. The gradients represent the rate of change of intensity in the horizontal and vertical directions.

Here's how the Sobel operator works:

1. Gradient Approximation: The Sobel operator computes an approximation of the gradient using convolution with two 3x3 kernels: one for detecting horizontal changes and one for vertical changes.

2. Convolution: The Sobel kernels are convolved with the image. Convolution is a mathematical operation that involves sliding the kernel over the image and computing the sum of element-wise multiplications between the kernel and the corresponding pixel values in the image.

3. Gradient Magnitude: The horizontal and vertical gradient approximations are combined to compute the gradient magnitude at each pixel. This is typically calculated as the square root of the sum of the squares of the horizontal and vertical gradients:

$$G=(Gx2+Gy2) \quad \ldots\ldots\ldots\ldots(1)$$

Where G_x and G_y are the horizontal and vertical gradient approximations, respectively.

4. Edge Detection: Finally, a threshold is applied to the gradient magnitude to determine which pixels belong to edges. Pixels with gradient magnitudes above a certain threshold are considered as part of an edge, while those below the threshold are considered as non-edge pixels.

The Sobel operator is particularly effective at detecting edges because it responds strongly to intensity changes in both horizontal and vertical directions. This makes it robust to edges of different orientations. However, it can be sensitive to noise, which may result in false edge detections. Preprocessing steps such as noise reduction or smoothing are often applied to the image before applying the Sobel operator to mitigate this issue. Additionally, fine-tuning the threshold parameter can help improve edge detection performance.

gradient_magnitude = sqrt((gradient_x)^2 + (gradient_y)^2)……..(2)

Canny Edge detection:

Canny edge detection is a popular technique used in image processing to detect the edges within an image. Developed by John F. Canny in 1986, it's widely used due to its effectiveness in accurately identifying edges while reducing noise.

Here's how Canny edge detection works:

1. Gaussian Smoothing: The first step is to reduce noise in the image using Gaussian blurring. This is done by convolving the image with a Gaussian kernel, which effectively smooths out the pixel intensities.

2. Gradient Calculation: Next, the gradient of the image is calculated. This is done using convolution with Sobel kernels in both horizontal and vertical directions. This process helps to find the intensity gradients and directions at each pixel. The gradient magnitude and direction are calculated as follows:

- Gradient Magnitude: $\sqrt{G_x^2 + G_y^2}$
- Gradient Direction: $\operatorname{atan2}(G_y, G_x)$

3. Non-maximum Suppression: This step helps in thinning the edges by preserving only the local maxima in the gradient directions. For each pixel, the algorithm compares the gradient magnitude with its neighbors along the gradient direction. If the pixel has the maximum gradient magnitude among its neighbors, it is retained; otherwise, it is suppressed (set to zero).

4. Edge Tracking by Hysteresis: In this final step, weak edges that are connected to strong edges are considered as part of the edge. This is achieved by traversing the edges through connected weak pixels, starting from strong edge pixels. This step ensures that weak edges that are likely parts of actual edges are retained while suppressing isolated weak edges caused by noise.

The output of the Canny edge detection algorithm is a binary image where pixels classified as edges are marked with a value of 1, while non-edge pixels are marked with a value of 0. This output provides a clear representation of the edges present in the original image, making it useful for various computer vision tasks such as object detection, image segmentation, and feature extraction.

Robert edge detection:

It seems like there might be some confusion here. Robert Edge Detection is not a commonly known edge detection technique in image processing. However, Robert's Cross is a well-known edge detection algorithm.

Robert's Cross is a simple edge detection operator used in digital image processing to detect edges in images. It works by computing the gradient approximation of the image intensity function. The basic idea is to detect edges by looking for areas of rapid intensity change.

Here's a brief overview of how Robert's Cross edge detection works:

1. Grayscale Conversion: The input image is typically converted to grayscale since edge detection is primarily concerned with changes in intensity rather than color.

2. Convolution: Robert's Cross involves convolving the image with two small matrices (kernels) to calculate approximations of the derivatives – one for detecting edges running vertically (Gx) and the other for detecting edges running horizontally (Gy).

3. Edge Magnitude Calculation: After convolving the image with the two kernels, the magnitude of the gradient at each pixel is computed using the formula:

$$\text{Magnitude} = \sqrt{(G_x)^2 + (G_y)^2}$$

4.Edge Direction Calculation: The direction of the edge is also computed using:

$$\text{Direction} = \arctan\left(\frac{G_y}{G_x}\right)$$

5. Thresholding: Finally, a thresholding step is applied to the magnitude values to identify significant edges. Pixels with magnitude above a certain threshold are considered as edge pixels.

Robert's Cross is computationally efficient due to its simple kernel operations. However, it is sensitive to noise, and the edges detected may not be as precise as with some other more sophisticated techniques like the Canny edge detector. Despite this, Robert's Cross can be useful in scenarios where simplicity and speed are more important than precision.

K-mean Segmentation:

K-means segmentation is a popular technique used in image processing for dividing an image into multiple segments or clusters based on pixel intensity values. The goal of this segmentation is to group similar pixels together and assign them to the same cluster, while pixels with different characteristics are assigned to different clusters. K-means clustering achieves this by iteratively assigning each pixel to the nearest cluster centroid and updating the centroids based on the mean of the pixels assigned to each cluster.

Here's a step-by-step explanation of how K-means segmentation works in image processing:

1. Initialization: The process begins by randomly selecting K initial cluster centroids. These centroids represent the average pixel values of K initial clusters.

2. Assignment: Each pixel in the image is assigned to the nearest cluster centroid based on some distance metric, commonly the Euclidean distance. This step effectively partitions the image into K clusters based on the similarity of pixel intensities to the cluster centroids.

3. Update centroids: After assigning each pixel to a cluster, the centroids of the clusters are updated by computing the mean pixel value of all pixels assigned to each cluster. This new centroid becomes the representative color or intensity value for that cluster.

4. Repeat: Steps 2 and 3 are iterated until convergence criteria are met, such as a maximum number of iterations or until the centroids no longer change significantly between iterations.

5. Final Segmentation: Once the algorithm converges, each pixel in the image is assigned to one of the K clusters based on the final centroids. The image is segmented into K regions, where pixels within the same region have similar intensity values.

K-means segmentation is relatively fast and simple to implement, making it a popular choice for various image processing applications such as image compression, image segmentation, and image analysis. However, it has some limitations, including sensitivity to the initial choice of centroids and difficulty in handling images with complex structures or overlapping regions. Additionally, the number of clusters K needs to be specified beforehand, which can be a challenge in some cases. Nonetheless, K-means segmentation remains a valuable tool in the image processing toolbox.

Graph cut Segmentation:

Graph cut segmentation is a powerful image processing technique used for partitioning an image into distinct regions or objects based on certain criteria. It involves representing the image as a graph, where pixels are nodes and the relationships between them are represented by edges. By optimizing the graph cut, one can separate the image into meaningful segments.

Introduction to Graph Cut Segmentation

Graph cut segmentation has gained popularity due to its effectiveness in various computer vision tasks such as object recognition, image editing, and medical image analysis. Unlike traditional segmentation methods that rely solely on pixel intensity or color information, graph cut segmentation incorporates both local and global image properties to achieve accurate segmentation results.

At its core, graph cut segmentation formulates the segmentation problem as an optimization task, where the goal is to find the optimal partition of the graph into foreground and background regions, or multiple object classes if desired.

This is typically achieved by minimizing an energy function that quantifies the coherence within each segment and the dissimilarity between segments.

Graph Representation

In graph cut segmentation, the image is represented as a weighted graph $G=(V, E)$, where V represents the set of nodes corresponding to pixels in the image, and E represents the set of edges connecting adjacent pixels. Each edge is assigned a weight that represents the similarity or dissimilarity between the pixels it connects.

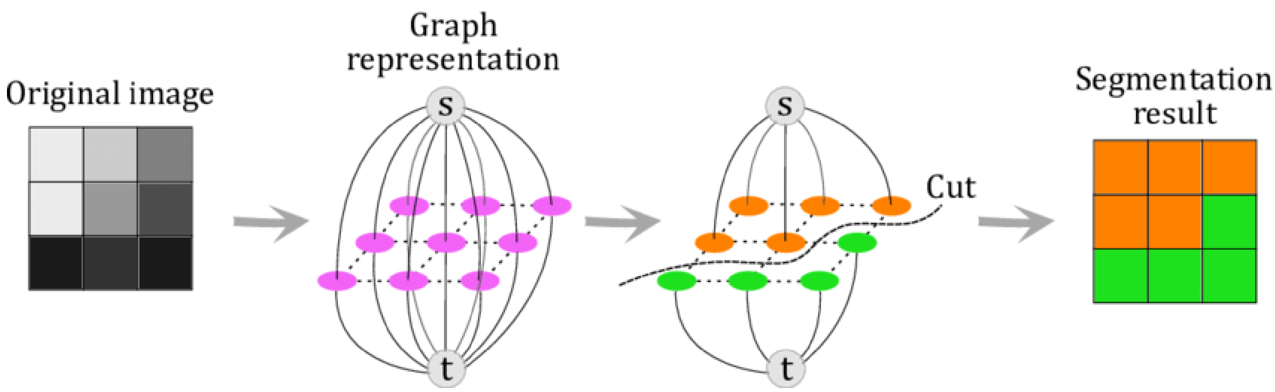

Fig 4.2: Graph cut segmentation principle

Energy Function

The optimization problem in graph cut segmentation is formulated using an energy function, which captures both the data term and the smoothness term:

$$\backslash E(S)=\sum_{p\in V}D_p(S_p)+\lambda\sum_{(p,q)\in E}V_{pq}(S_p,S_q)$$

- $D_p(S_p)$ represents the data term, which measures the compatibility of pixel \(p \) with its assigned label S_p.
- $V_{pq}(S_p,S_q)$ represents the smoothness term, which penalizes label discontinuities between adjacent pixels p and q.
- λ is a parameter that controls the trade-off between data fidelity and smoothness.

Min-Cut Max-Flow Optimization

The energy minimization problem in graph cut segmentation can be solved efficiently using graph theory algorithms such as the min-cut max-flow algorithm. The goal is to find the partition of the graph that minimizes the energy function. This is equivalent to finding a cut in the graph that separates the nodes into two disjoint sets, typically representing foreground and background regions.

The min-cut max-flow algorithm computes the minimum cut in the graph by finding the maximum flow from a source node to a sink node. The cut obtained partitions the graph into two sets of nodes, corresponding to the foreground and background segments.graph cut segmentation is a versatile and powerful technique for image partitioning and segmentation. By formulating the segmentation problem as an energy minimization task on a graph, it leverages both local and global image properties to achieve accurate and meaningfulsegmentation results. Despite challenges such as computational complexity and robustness to noise, graph cut segmentation continues to be a valuable tool in various computer vision applications, with ongoing research aimed at addressing its limitations and advancing the state-of-the-art.

Flood Fill:

Flood fill is a fundamental algorithm used in computer graphics, image processing, and many other applications involving area colouring or region filling. The algorithm is used to determine a contiguous area within an image and fill it with a specified color or pattern. It is widely employed in various fields such as image editing software, video games, and computer-aided design (CAD) programs.

In this comprehensive guide, we will delve into the concept of flood fill algorithms, their variants, applications, and implementation details. We'll explore both recursive and iterative approaches, discuss their strengths and weaknesses, and provide examples for better understanding.

Understanding Flood Fill:

Flood fill algorithms are designed to fill a connected region with a specified color, starting from a given seed point. The process involves iteratively or recursively visiting neighbouring pixels, determining whether they belong to the same region, and filling them with the target color.

The basic idea of flood fill can be described as follows:

1. **Choose a seed point:** Begin with a starting point within the image or grid.
2. **Check the neighbouring pixels:** Examine the adjacent pixels to determine whether they belong to the same region.
3. **Fill the region:** If a neighbouring pixel meets the criteria, fill it with the target color and continue the process recursively or iteratively.

The algorithm continues until all pixels belonging to the same region have been visited and filled.

Types of Flood Fill Algorithms:

Flood fill algorithms can be broadly categorized into two main types based on their implementation approach:

1. **Recursive Flood Fill:** In recursive flood fill, the algorithm is implemented using a recursive function. It starts from the seed point and recursively visits neighbouring pixels,
2. filling them with the target color if they meet the specified conditions. Recursive flood fill is straightforward to implement but may suffer from stack overflow issues with large areas.
3. **Iterative Flood Fill:** Iterative flood fill employs a stack or queue-based approach to iteratively visit neighbouring pixels. It maintains a stack or queue of pixels to be processed, eliminating the risk of stack overflow associated with recursive implementations. Iterative flood fill is often more memory-efficient and suitable for processing large areas.

CHAPTER 5

EVALUATION AND RESULTS

In this study, the captured OCT image was first filtered using the Weiner filter before being subjected to a number of segmentation methods. The MSE and PSNR estimations were then used to identify the best segmentation technique for detecting OCT pictures. The following graphics display a sample of OCT images that were simulated using different segmentation approaches.

5.1 Performance Characteristics

5.1.1 Peak signal to noise ratio

PSNR stands for "Peak Signal-to-Noise Ratio" in MATLAB. It is a metric used to evaluate the quality of a reconstructed or compressed image/video with respect to its original, reference version. The PSNR value quantifies the difference between the two images based on their pixel values, representing the ratio of the maximum possible power of the original image to the power of the noise or distortion introduced during the compression or reconstruction process.

Higher PSNR values indicate better image quality, as it suggests that the reconstructed image closely resembles the original without significant degradation or loss of information. Conversely, lower PSNR values imply higher distortion and reduced quality. In MATLAB, the PSNR is commonly used in image processing and compression applications to assess the efficiency of various algorithms and techniques in maintaining the fidelity of the images after manipulation. It helps researchers and engineers in comparing and choosing the most suitable methods for their specific image processing tasks, such as image compression, denoising, and restoration.

The peak signal-to-noise ratio (PSNR) is the ratio between the extreme accomplishable signal value and the intensity of the noise that misrepresents the signal values. Determined through the root mean square error (MSE):

$$MSE = \frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=1}^{n-1}|I(i,j) - K(i,j)|^2, \qquad (8)$$

where $m \times n$ is the image size, I and K are two monochrome images, one of which is a noisy sapproximation of the other. PSNR is represented as

$$PSNR = 10\log_{10}\left(\frac{MAX_I^2}{MSE}\right) = 20\log_{10}\left(\frac{MAX_I}{\sqrt{MSE}}\right), \qquad (9)$$

where MAX_I is the maximum pixel value of the image.

The mean-square error (MSE) and the peak signal-to-noise ratio (PSNR) are used to compare image compression quality. The MSE represents the cumulative squared error between the compressed and the original image, whereas PSNR represents a measure of the peak error.

5.2 Resulsts

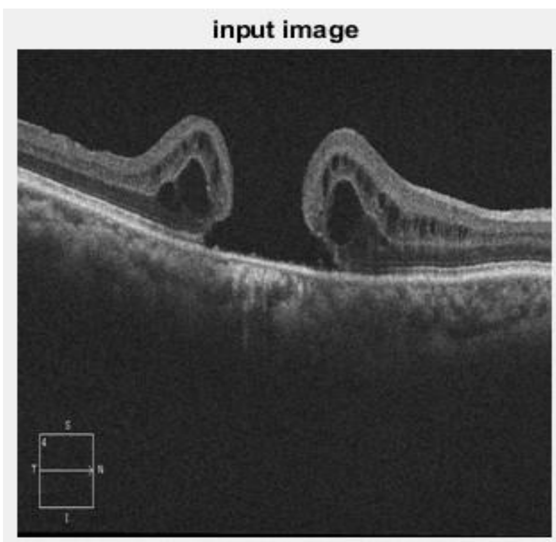

Fig 5.1: input image

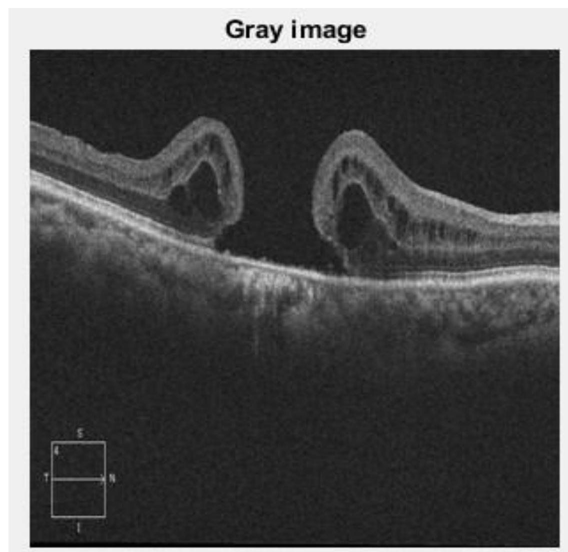

Fig 5.2: Gray image

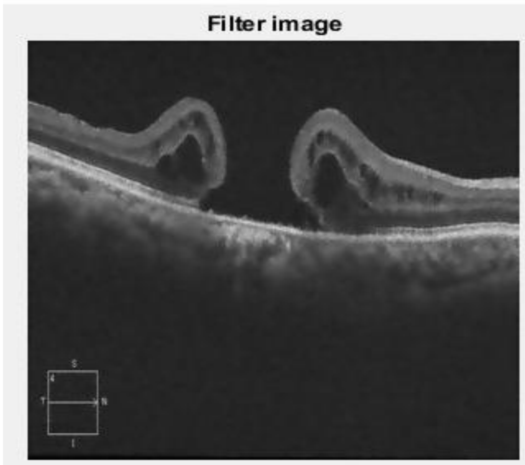

Fig 5.3: Filter image

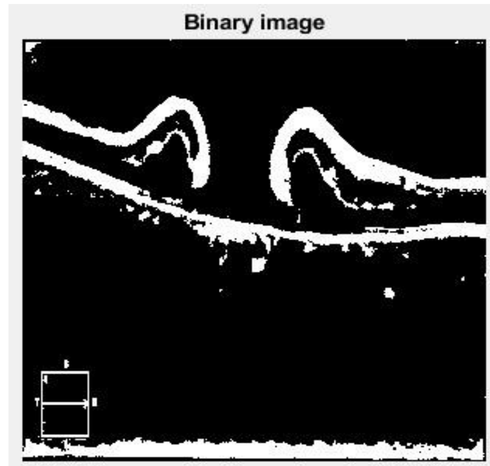

Fig 5.4: Binary image

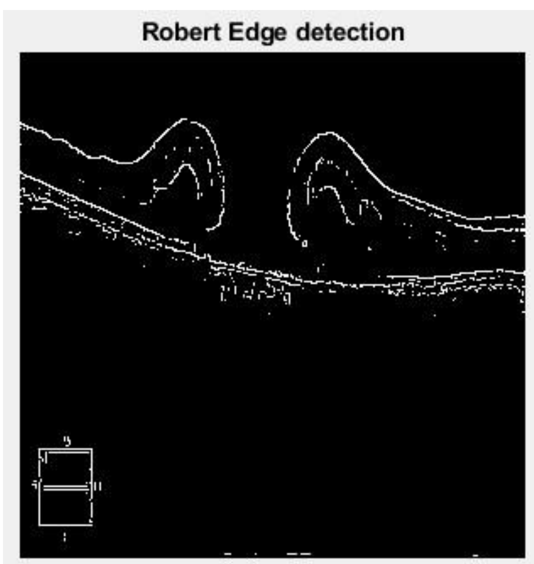

Fig 5.5: Robert Edge image

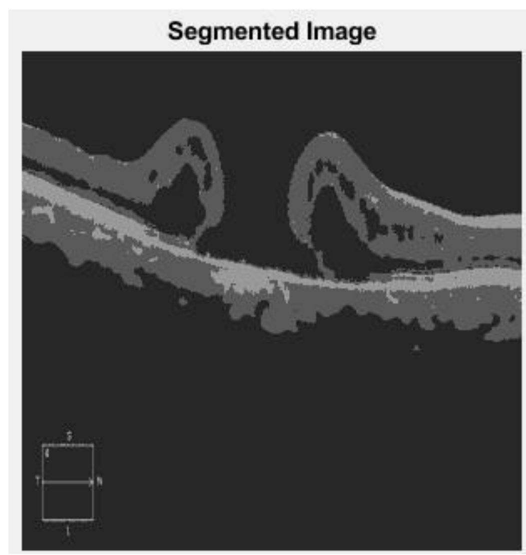

Fig 5.6 Segmented Image

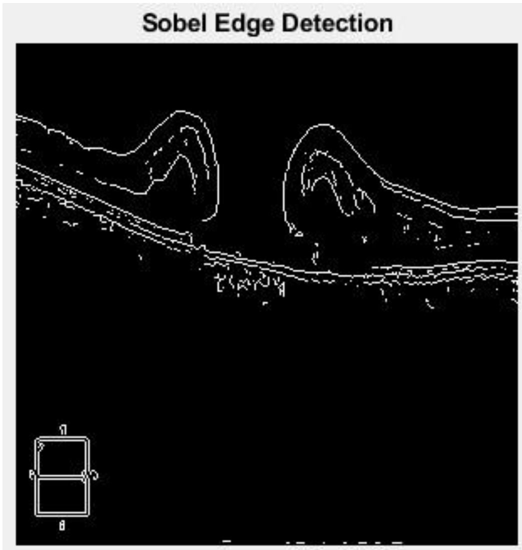

Fig 5.7: Sobel Edge detection

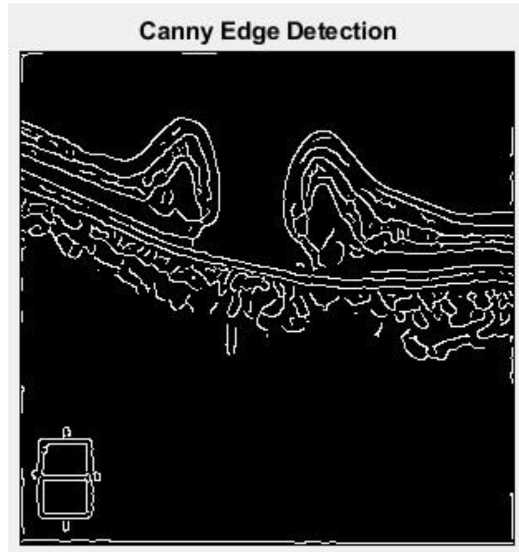

Fig 5.8: Canny Edge Detection

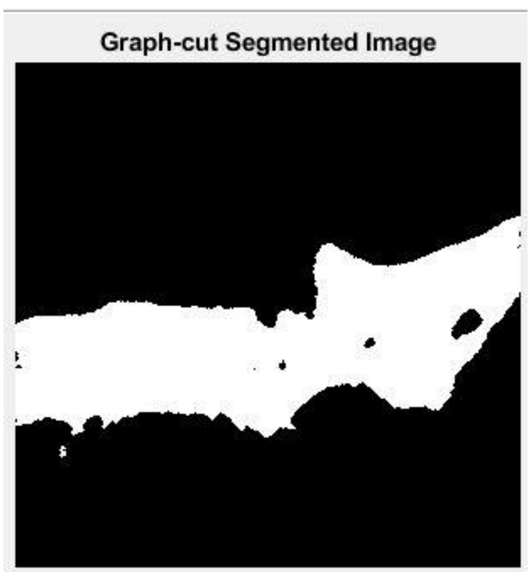

Fig 5.9 Graph-cut Segmented Image

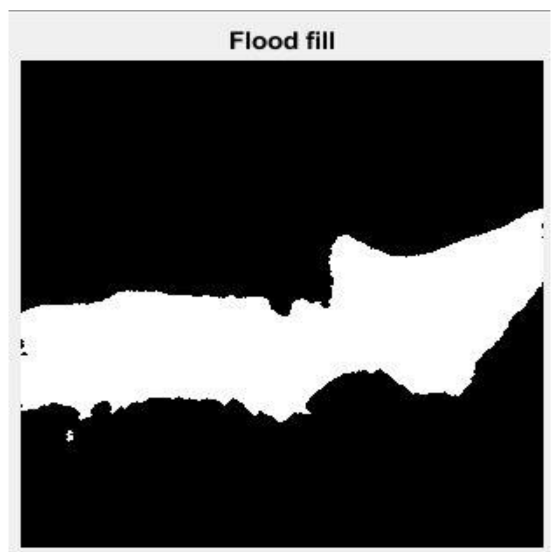

Fig 5.10 Flood fill Image

Input image	PSNR Values						
	Adaptive Threshlod	Edge detection			K-means	Graph cut	Flood fill
		Sobel Edge	Canny Edge	Roberts Edge			
1	63.64	63.61	63.62	63.61	63.64	63.68	63.68
2	60.79	60.77	60.77	60.77	60.8	60.82	60.82
3	60.28	60.26	60.27	60.26	60.29	60.31	60.31
4	61.39	61.36	61.37	61.36	61.39	61.42	61.42
5	60.86	60.84	60.84	60.84	60.87	60.89	60.89
6	61.28	61.26	61.27	61.26	61.29	61.31	61.32
7	60.17	60.15	60.15	60.15	60.18	60.2	60.21
8	65.11	65.08	65.09	65.08	65.1	65.15	65.16
9	60.75	60.73	60.74	60.73	60.76	60.78	60.78
10	60.57	60.56	60.56	60.56	60.58	60.61	60.61
Total	61.484	61.462	61.468	61.462	61.49	61.517	61.52

Table 1: PSNR values of segmented images

MSE Values						
Adaptive Threshlod	Edge detection			K-means	Graph cut	Flood fill
	Sobel Edge	Canny Edge	Roberts Edge			
1856.38	1868.7	1865.88	1869.04	1858.89	1840.78	1840.6
3582.46	3597.5	3593.23	3597.88	3575.1	3558.07	3555.9
4027.97	4043.8	4039.16	4044.69	4018.93	4001.24	4000.5
3120.41	3137	3132.69	3137.61	3117.51	3098.12	3097.5
3520.97	3540.1	3535.57	3540.76	3518.09	3499.5	3496.7
3198.83	3211.2	3207.36	3211.99	3190.96	3175.9	3169.1
4131.69	4151.3	4147.21	4151.81	4124.81	4101.61	4096.7
1322.78	1333.5	1330.42	1334.1	1326.22	1311.48	1310.2
3616.81	3628.5	3623.67	3629.24	3605.03	3587.16	3585.8
3763.26	3778.2	3773.82	3779.08	3754.35	3734.57	3731.2
3214.156	3229	3224.9	3229.62	3208.99	3190.843	3188.42

Table 2: MSE values of Segmented images

The above-mentioned comparisons in Tables 1 and 2 for picture segmentation show the qualitative outcome metrics when compared to other methodologies. When the PSNR and MSE values are both high, the segmentation technique yields respectable results. MSE calculates the difference between the segmented image and the source image, sometimes referred to as the filtering image; the lower the value of MSE, the more effective the segmentation. Equation gives a numerical illustration of MSE (1). The PSNR ratio calculates the background noise level in relation to the image's maximum value. In the equation, PSNR is stated in terms of MSE (2).

CHAPTER 6

CONCLUSION AND FUTURE SCOPE

6.1 Conclusion

In conclusion, image segmentation plays a critical role in image processing by dividing images into smaller segments for more efficient analysis. This process is essential for various applications, including medical imaging such as OCT images. Among the plethora of segmentation techniques available, clustering-based segmentation stands out for its effectiveness in separating OCT images. Additionally, preprocessing methods like the Wiener filter are crucial for reducing speckle noise, which can significantly impact segmentation accuracy.

The evaluation of segmentation techniques involves metrics such as MSE and PSNR to quantify segmented image quality. By comparing techniques like thresholding, edge detection (utilizing algorithms such as Sobel, Canny, and Robert's), clustering, graph cut segmentation, and flood fill based on these metrics, researchers can better understand their performance and applicability in different scenarios.

Understanding the strengths and limitations of each method is crucial for achieving accurate segmentation results, particularly in sensitive domains like medical imaging where precision is paramount. Overall, advancements in image segmentation continue to drive innovation and improvement across various fields, offering new opportunities for enhanced analysis and interpretation of visual data.

6.2 Future Scope

Advancements in segmentation techniques continue to drive innovation in the field of medical imaging. As technology progresses, novel methods are developed, offering new avenues for research and application. Your project lays a solid foundation for future researchers by providing a comprehensive analysis of existing techniques, offering valuable insights into their strengths and limitations.

One notable trend in recent years is the integration of machine learning algorithms, particularly deep learning models, into image segmentation tasks. These advanced algorithms have shown promising results in various domains, including medical image analysis. Future work could involve incorporating these cutting-edge techniques into the comparative analysis, allowing for a thorough assessment of their performance compared to traditional methods.

The potential for real-time applications in ophthalmology clinics is particularly exciting. Implementing efficient segmentation algorithms for retinal OCT images could revolutionize diagnostics by enabling the development of real-time diagnostic tools. Future research efforts could focus on optimizing these techniques for speed and accuracy, thus facilitating their integration into clinical settings and improving patient outcomes.

Moreover, the development of clinical decision support systems (CDSS) represents another promising direction. By leveraging the insights gained from the comparative analysis, researchers could explore the creation of CDSS tailored to interpreting retinal OCT images. These systems could automate the segmentation of key structures and highlight abnormalities, providing invaluable assistance to healthcare professionals in diagnosis and treatment planning.

Furthermore, there is potential for customization and personalization in segmentation techniques. Tailoring algorithms to individual patient characteristics and specific pathologies could significantly enhance diagnostic accuracy. Future research endeavors could delve into methods for customizing segmentation algorithms based on factors such as age, ethnicity, and other relevant parameters, thereby improving the precision and effectiveness of medical imaging analysis.

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APPENDIX

MATLAB CODE

```
clc
clear
close all hidden

%% input image

[filename,pathname] = uigetfile('*.*','Select the image'); %Open file selection dialog box
input_image=imread([pathname,filename]); %Read image from graphics file
input_image = imresize(input_image,[299 299]);
figure
imshow(input_image)
title('input image')

%% Gray conversion

Gray_img = rgb2gray(input_image);
figure
imshow(Gray_img)
title('Gray image')

%% Wiener Filter

filt_img = wiener2(Gray_img,[5 5]);
figure
imshow(filt_img)
title('Filter image')

%% Adaptive image threshold

Threshold = adaptthresh(filt_img, 0.4);
Binary_img = imbinarize(filt_img,Threshold);
figure
imshow(Binary_img)
title('Binary image')

filt_img = double(filt_img);
Binary_img = double(Binary_img);

disp('--------- Adaptive thresholding ----------- ')
```

```
% Calculate PSNR

PSNR = psnr(filt_img, Binary_img,65535);
fprintf('The Peak-SNR value is : %0.2f\n', PSNR);

% Calculate MSE
MSE = sum(sum((filt_img – Binary_img).^2)) / numel(filt_img);
fprintf('The mean square error value is : %0.2f\n', MSE);

%% Sobel Edge detection

sobel_img = edge(filt_img,'sobel');
figure
imshow(sobel_img)
title('Sobel Edge Detection');

sobel_img = double(sobel_img);

disp('--------- Sobel Edge detection ----------- ')

% Calculate PSNR
PSNR = psnr(filt_img, sobel_img,65535);
fprintf('The Peak-SNR value is : %0.2f\n', PSNR);

% Calculate MSE
MSE = sum(sum((filt_img – sobel_img).^2)) / numel(filt_img);
fprintf('The mean square error value is : %0.2f\n', MSE);%% Canny Edge detection

%% Canny edge detection

Canny_img = edge(filt_img,'canny');
figure
imshow(Canny_img)
title('Canny Edge Detection');

Canny_img = double(Canny_img);

disp('--------- Canny Edge detection ----------- ')

% Calculate PSNR
PSNR = psnr(filt_img, Canny_img,65535);
fprintf('The Peak-SNR value is : %0.2f\n', PSNR);

% Calculate MSE
```

```
MSE = sum(sum((filt_img – Canny_img).^2)) / numel(filt_img);
fprintf(‘The mean square error value is : %0.2f\n’, MSE);
%% Roberts Edge detection

Roberts_img = edge(filt_img, ‘Roberts’);
figure
imshow(Roberts_img);
title(“Robert Edge detection”);

Roberts_img = double(Roberts_img);

disp(‘--------- Roberts Edge detection ----------- ‘)

% Calculate PSNR
PSNR = psnr(filt_img, Roberts_img,65535);
fprintf(‘The Peak-SNR value is : %0.2f\n’, PSNR);

% Calculate MSE
MSE = sum(sum((filt_img – Roberts_img).^2)) / numel(filt_img);
fprintf(‘The mean square error value is : %0.2f\n’, MSE);%% Canny Edge detection

%% K-means segmentation

filt_img = uint8(filt_img);
% Number of clusters (segments)
k = 3;
% Perform K-means segmentation
segmented_image = kMeansSegmentation(filt_img, k);

figure
imshow(segmented_image);
title(‘k-means Segmented Image’);

filt_img = double(filt_img);
segmented_image = double(segmented_image);

disp(‘--------- K-means segmentation ----------- ‘)

% Calculate PSNR
PSNR = psnr(filt_img, segmented_image,65535);
fprintf(‘The Peak-SNR value is : %0.2f\n’, PSNR);

% Calculate MSE
MSE = sum(sum((filt_img – segmented_image).^2)) / numel(filt_img);
```

```
fprintf('The mean square error value is : %0.2f\n', MSE);

%% Graph cut Segmentation

[BW,maskedImage] = Graph_cut(filt_img);
figure
imshow(BW);
title('Graph-cut Segmented Image');

BW = double(BW);
disp('--------- Graph-cut segmentation ----------- ')

% Calculate PSNR
PSNR = psnr(filt_img, BW,65535);
fprintf('The Peak-SNR value is : %0.2f\n', PSNR);

% Calculate MSE
MSE = sum(sum((filt_img – BW).^2)) / numel(filt_img);
fprintf('The mean square error value is : %0.2f\n', MSE);

%% Flood fill

Ifill = imfill(BW,'holes');
figure
imshow(Ifill)
title('Flood fill')

Ifill = double(Ifill);
disp('--------- Flood fill ----------- ')

% Calculate PSNR
PSNR = psnr(filt_img, Ifill,65535);
fprintf('The Peak-SNR value is : %0.2f\n', PSNR);

% Calculate MSE
MSE = sum(sum((filt_img – Ifill).^2)) / numel(filt_img);
fprintf('The mean square error value is : %0.2f\n', MSE);
```

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