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Application of Image Segmentation Techniques to Study Abnormalities in Fundus Images

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Edge Detection, Matlab

ABSTRACT:

Findings from the fundus images of eye are very crucial in identifying various diseases of not only the eye but also the whole body. It plays a major role in finding the disease status from the fundus image. With the growing population it is not easy for the existing physicians to screen these many cases in the stipulated time. There are several software technologies in use to diagnose maximum cases in a short period of time. Considering this as a great opportunity, this work is aimed to use several techniques to apply on fundus images to identify the quality of the techniques that perform the best to segment various parts of the fundus image and identify the best technique among the applied and compared with a quantitative analysis. Matlab program has used different segmentation and edge detection techniques to the fundus images and obtained qualitative results and for further precise analysis of the medical image for efficient and effective diagnosis of the abnormality or disease status. The same technique can be used to apply other types of medical images to get the results, useful for the physician to diagnose and treat the patient in a better way.

1. Introduction

Image processing has a great importance in the evaluation of diagnostic medical images. The main purpose of image processing is to provide a high-quality visibility in the image for keen observation of abnormalities in the image for effective treatment by the physician. A range of techniques utilized in the image processing are built on the fundamental ideas of the digital image processing. By processing and analyzing diagnostic images for medical diagnosis, both qualitative and quantitative diagnosis are significantly aided. Different types of conventional methods were used for the better analysis. The methods employed produced good outcomes with greater accuracy. One of the fundamental goals of computer vision is to interpret the contents of a picture. Image segmentation is a technique for removing the backdrop of an image so that the contents can be visualized defectively [1][7][8][9][10][11][15][16][17][18][27]. A fundamental and significant aspect of an image is its edge and edge detection locates the edges of objects in pictures [7][9][16][26][30][32]. By spotting changes in brightness, edge detection is employed in the fields of image processing, computer vision, and machine vision for image segmentation and data extraction [25][29]. The edge detection plays a crucial role in medical imaging. Users can examine an image's characteristics for a substantial shift in the grayscale using edge detection. This texture serves as a visual cue, where one section of the image ends and another begins [2][3][4][5]. It decreases the quantity in an image of data while maintaining its structural characteristics features. The performance of the popular and well known edge detection techniques for the image processing is examined in this work in an effort to bring out the best analysis [7][9][16][26][30][32][34]. Since the validity, effectiveness, and potential for the completion of following stages of processing depend on edge detection, it must be effective and dependable. Edge detection satisfies the need by providing all the relevant image Information [6][7][9]. For this reason, image derivatives are computed. The problem of picture differentiation, however, is poorly posed since image derivatives are susceptible to a variety of noise sources, physical and semantic ramifications, as well as the effects of discretization and quantization [15][16][18][19][20]. The samples were analyzed with the edge detection techniques and visualized qualitatively and compared Quantitatively [22][23][24][28]. The goal of image segmentation is to divide an image into useful sections in relation to a certain application [34][9]. Various sources of noise might affect medical imaging throughout the procedure for gathering data. Edge detection facilitates the detection of irregularities in medical images by computer vision systems and human clinicians [6][9][15]. A crucial distinction between edge- and surface-based object recognition theories allows for many hypotheses on how surface information affects recognition. According to edge-based reports, object recognition might not be impacted by surface information [9][22][25]. In this work, different edge detection techniques are applied to verify for the best edge detection based on the intensity parameter [25][26][27]. The techniques like Canny, Sobel, Prewitt and Robert etc. were used and are described as follows.

2. Methods

Image segmentation is the process of partitioning an image into distinct, meaningful regions or segments. This technique enables the isolation of specific objects or structures within the image, facilitating more accurate analysis and understanding of its content in computer vision and image processing applications.

For this qualitative analysis we have used different techniques for the analysis of the fundus imaging and identifying the best technique for segmenting the fundus images.

QUALITATIVE ANALYSIS OF FUNDUS IMAGES ON APPLICATION OF VARIOUS TECHNIQUES

1. Medical Image Segmentation and Report Generation
2. Give a fundus image of eye as an input.
3. Convert Original Image to Grayscale image.
4. Apply Gaussian filter to Grayscale image.
5. Applying different image segmentation techniques to Grayscale image
6. Finding edge strength of different techniques.
7. Comparing different techniques with edge strength.
8. Finally the output gives the condition of normal or abnormal.

TYPES OF IMAGE SEGMENTATION TECHNIQUES

Image segmentation techniques are methods used to partition an image into multiple segments or regions to simplify its representation or extract meaningful information. Image segmentation techniques are various methods used in computer vision and image processing to divide images into meaningful discrete regions. A common class of segmentation techniques is thresholding. Thresholding compares the intensity of pixels with a predefined threshold and classifies the pixels into different regions based on the threshold. Another widely used approach is edge-based segmentation. Detects boundaries by detecting sudden changes in intensity. Operators such as Sobel and Canny edge detectors are often used. Region-based segmentation uses algorithms such as K-means clustering and basin transformation to group pixels with similar features or characteristics, such as color or texture. Contour-based segmentation defines the boundaries of objects by identifying lines in the image, often using techniques such as active lines and snakes. In addition, semantic segmentation assigns a specific label to each pixel and categorizes the pixels into meaningful classes. This has been noticed with the emergence of deep learning models such as convolutional neural networks. Each type of segmentation technique has its advantages and is suitable for specific applications, from medical image processing to object detection and scene perception in autonomous systems. The choice of segmentation method depends on the characteristics of the image and the purpose of the analysis.

There are various types of image segmentation techniques, including: Some popular segmentation methods include:

a) Thresholding (e.g., global thresholding, adaptive thresholding)
b) Region-based segmentation (e.g., watershed, region-growing)
c) Edge-based segmentation (e.g., Canny edge detection)

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d) Clustering-based segmentation (e.g., K-means clustering)
e) Deep learning-based segmentation (e.g., U-Net, FCN)

A) Thresholding: Involves setting a threshold value to convert grayscale or color images into binary images, where pixels are classified as foreground or background based on intensity or color.

B) Clustering-based Methods: Techniques like K-means clustering or Gaussian Mixture Models (GMM) group pixels into clusters based on their similarity in color, intensity, or other feature spaces.

C) Region-based Segmentation: It involves grouping pixels into regions by considering criteria such as color, texture, or proximity using methods like region growing, region merging, or split-and-merge.

D) Edge Detection: Focuses on identifying edges or boundaries in an image by detecting sudden changes in pixel intensity. Techniques like the Canny edge detector or Sobel operator are commonly used.

E) Deep Learning-based Segmentation: Utilizes convolutional neural networks (CNNs) for semantic segmentation tasks. Architectures like U-Net, Mask R-CNN, and FCN (Fully Convolutional Networks) have been successful in segmenting objects in images.

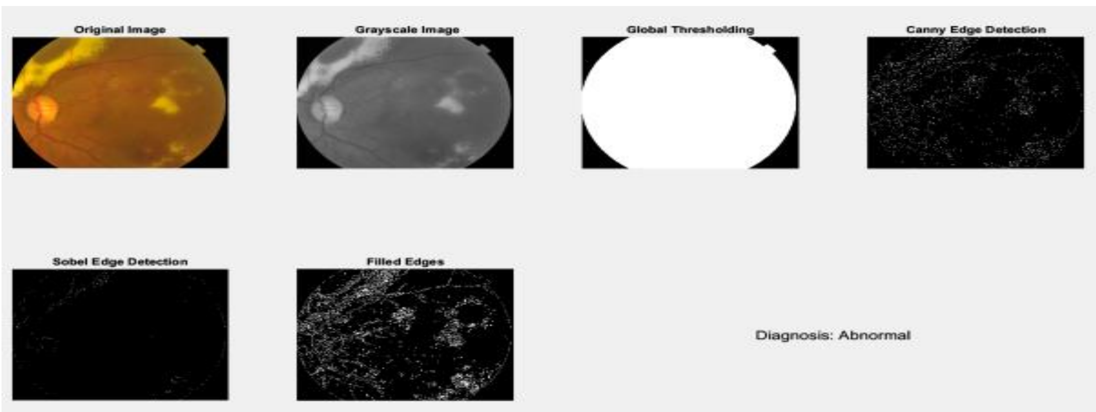
APPLYING GLOBAL THRESHOLDING TO GRAYSCALE IMAGE

Global thresholding is a fundamental technique in image processing used to separate objects or regions of interest from the background in a grayscale image. The primary idea behind global thresholding is to divide the image into two distinct classes based on the pixel intensity values: foreground (objects or regions of interest) and background. This separation is achieved by selecting a threshold value that distinguishes between the two classes. Pixels with intensities above the threshold are classified as foreground, while pixels with intensities below the threshold are considered background.

Applying global thresholding to a grayscale image involves the process of segmenting the image into two distinct regions—foreground and background—based on a single threshold value. This technique aims to separate objects or areas of interest from the background by defining a threshold that distinguishes between the two classes. Initially, an optimal threshold value is determined by analyzing the histogram of the grayscale image. Various methods can be used to find this threshold, such as Otsu's method, which seeks to identify a threshold that minimizes the intra-class variance or maximizes inter-class variance. Once the threshold value is established, pixels with intensity values above the threshold are categorized as part of the foreground, while those below the threshold are considered part of the background.

3. Results

Sample 1: Following Are The Obtained Results On Application Of The Applied Techniques



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Following Parameters Developed Based On The Above Obtained Results

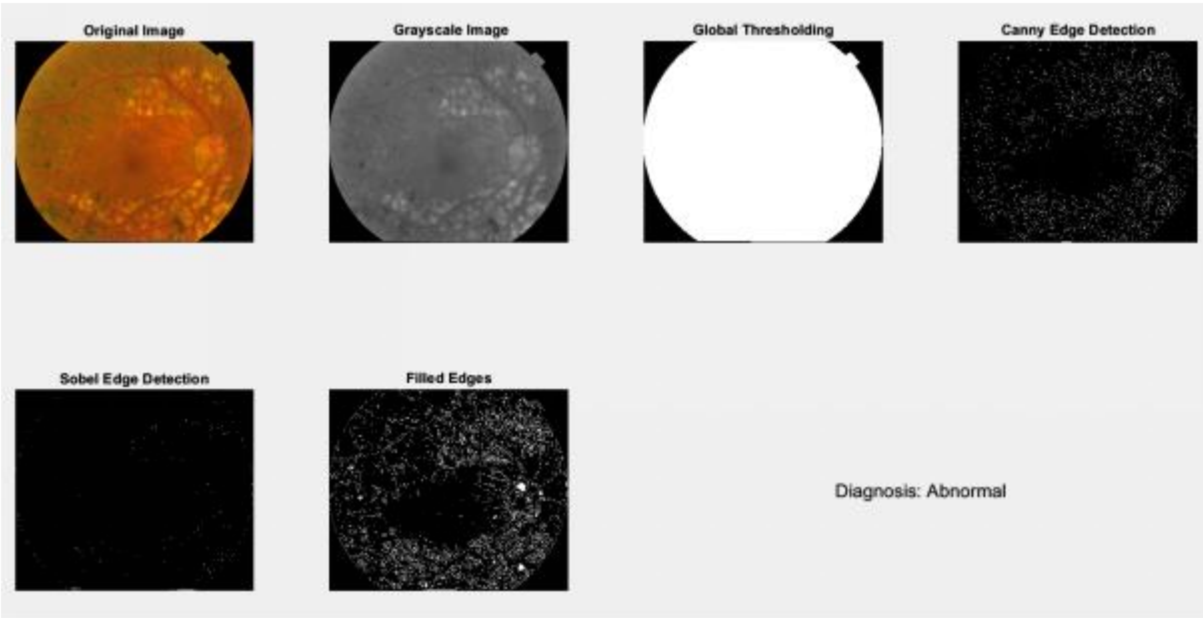
```
Edge Strength (Global Thresholding): 15.14

Edge Strength (sobel Edge Detection): 9.62

Edge Strength (Filled Edges): 8.23

Edge Strength (Canny Edge Detection): 11.98
```

Sample 2: Following Are The Obtained Results On Application Of The Applied Techniques



Following Parameters Developed Based On The Above Obtained Results

```
Edge Strength (sobel Edge Detection): 10.5

Edge Strength (Global Thresholding): 15.72

Edge Strength (Filled Edges): 8.83

Edge Strength (Canny Edge Detection): 13.55
```

SAMPLE 3: On Application Of The Applied Techniques Following Are The Obtained Results

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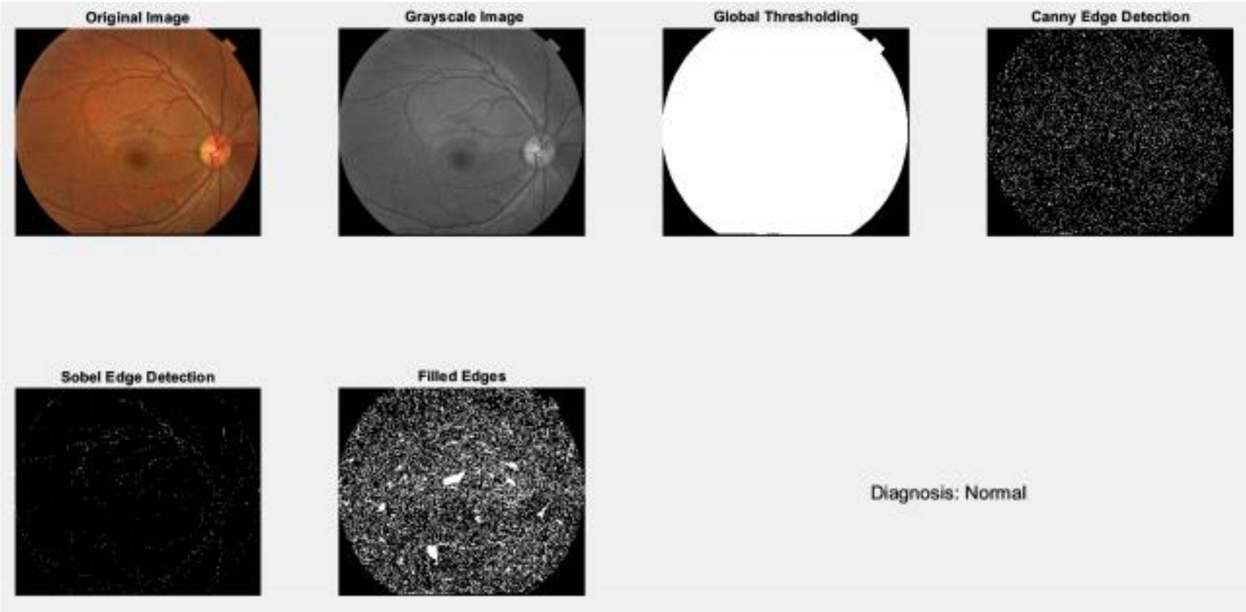


Following Parameters Developed Based On The Above Obtained Results

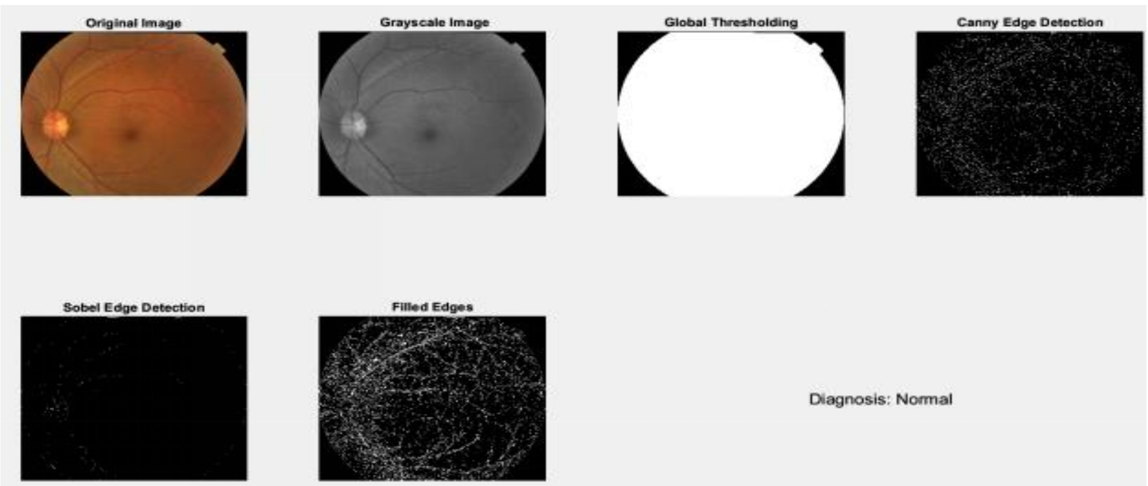
Edge Strength (Global Thresholding): 15.72

Edge Strength (sobel Edge Detection): 11.66

Edge Strength (Filled Edges): 8.85

Edge Strength (Canny Edge Detection): 13.87

Sample 4 : Following Are The Obtained Results On Application Of The Applied Techniques



Following Parameters Developed Based On The Above Obtained Results

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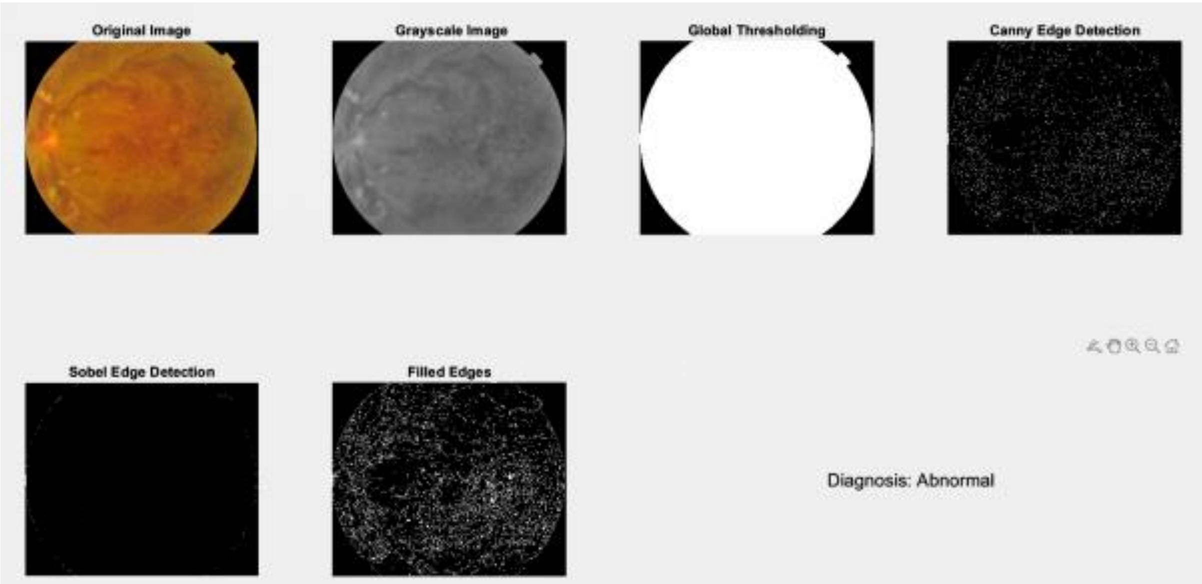
Edge Strength (Global Thresholding): 15.72

Edge Strength (Filled Edges): 8.87

Edge Strength (sobel Edge Detection): 10.93

Edge Strength (Canny Edge Detection): 13.95

Sample 5 : Following Are The Obtained Results On Application Of The Applied Techniques



Following Parameters Developed Based On the Above Obtained Results

Edge Strength (Global Thresholding): 15.14

Edge Strength (sobel Edge Detection): 8.45

Edge Strength (Filled Edges): 8.32

Edge Strength (Canny Edge Detection): 12.39

Table 1 Comparison of edge strength for the applied techniques to fundus images

TECHNIQUE NAME: SAMPLE NO:	GLOBAL THRESHOLDING	SOBEL EDGE DETECTION	FILLED EDGE DETECTION	CANNY EDGE DETECTION
1	**15.14**	**9.69**	**8.23**	**11.98**

2	**15.72**	**10.5**	**8.83**	**13.55**
3	**15.11**	**10.7**	**9.57**	**13.14**
4	**15.14**	**9.22**	**8.46**	**12.45**
5	**15.14**	**8.45**	**8.32**	**12.39**
6	**15.72**	**10.08**	**8.35**	**12.54**
7	**15.53**	**8.94**	**8.27**	**12.48**
8	**15.14**	**9.67**	**8.25**	**12.6**
9	**15.72**	**11.14**	**8.86**	**14.06**
10	**15.14**	**11.75**	**9.66**	**13.8**

4. Conclusion

The numerous technological strategies that have been used to suggest that conventional methods are required for the data analysis. When compared to other intricate processes, the Canny technique has shown good results in terms of image intensity changes out of all the strategies used in this work. Edge Strength also plays a major role in identifying the thick edges along with the suitable information of the image for the effective diagnosis. The Global Thresholding proves the efficient results for the given images. Future utilization of more image data and effective machine learning techniques will be extremely beneficial to this effort.

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