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An Analysis of Image Segmentation Methods

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Abstract. Image segmentation is a crucial stage in image processing because it allows for meaningful image analysis and information extraction. Image segmentation may be done in a variety of ways. This study examines a few of these approaches for grayscale images. MATLAB 8.1 was used to construct the paper. In order to analyze and extract information from these pictures, segmentation is essential. The segmentation of images has a promising future and has been the focus of modern study. The usual segmentation methods were addressed here: edge detection, clustering, and region growth. The problem with segmentation is that no one approach is suited for a certain type of picture, nor are all techniques applicable to all images.

Keywords: Image segmentation, clustering, edge-detection, Canny Edge Detector, region-growing, region-merging

1. Introduction

Image segmentation is the technique of determining whether a particular point of light (pixels) in an image belongs to an object or the background. It is commonly used in images to locate objects and boundaries. Image segmentation, to put it another way, is the process of giving a label to each accessible pixel so that pixels with the identical sticker have certain features. Image segmentation may be categorized based on image features such as discontinuity and similarity. In discontinuities, partitioning is done based on sudden variations in the strength levels of an image [1-2]. We primarily concentrate on identifying isolated points, lines, and edges. Partitioning, on the other hand, is based on pixel grouping based on their similarity to one another. The most crucial aspect of image processing is image segmentation [3, 4]. Dividing an image into many sections gives it more significance and makes it easier to process. These few portions, when combined, will cover the whole image [5, 6]. The process of converting an image to a digital format and process that can be done on it in order to improve the image or extract useful information from it is known as image processing. It generally consists of many steps: (i) Importing the image (ii) Analyzing and editing the image (iii) Output (this might result in a modified picture or report depending on analysis).

The goal of image processing is split into five categories: (i) Visualization (ii) Image sharpening and restoration (iii) Image retrieval (iv) Pattern measurement (v) Image recognition.

Image segmentation, among other image processing techniques, is important in the study and extraction of information from images. Image subdivision is the method of separating an image interested in a cluster of pixels based on homogeneity of certain properties such as colour, intensity, texture, similarity between pixels in a region, and so forth [7-10].

2. Literature Review

This section introduces relevant image segmentation work by a variety of authors with varying perspectives on image segmentation and associated methodologies. In [2], presented a seeded region expanding and merging method. A set of seed pixels expands into regions, which are compared to their 8-neighboring pixels and the pixels in that group that meet the homogeneity function, and their pixel value is changed to that of the seed value. The first unassigned pixel is chosen as the next seed pixel for the accompanying areas. For the subsequent group of pixels, the same procedure is followed. To avoid excessive segmentation, merging is done in two ways: (i) smaller regions are deemed noise and are eliminated by connecting them to neighboring regions, and (ii) neighboring regions that meet the homogeneity function are merged by setting a new threshold. Colour image segmentation has two critical issues: which segmentation algorithm to employ and which colour space to use [1, 2]. They advocate combining colour segmentation methods based on the image or application. A colorful picture segmentation method combines color-edge detection with seeded region growth. The centroids between color-edges are employed as the beginning seed using an isotropic edge detector and an entropic threshold approach. These seeds are then gradually replaced with the centroids of the produced homogenous picture areas, employing the extra pixels as needed. Color-edge extraction and seeded region growth findings are combined to produce homogenous areas with precise and closed boundaries [5, 6]. A new technique is presented a technique for medical image segmentation that combines the K-means algorithm with an enhanced watershed segmentation algorithm, which addresses the limitations of the traditional watershed approach when applied to medical pictures. The suggested approach is a two-stage procedure. The first phase use K-means clustering to generate a main segmentation of the input image. The second phase applies the enhanced watershed to the main segmentation to generate a final segmentation map [8, 9]. In this method, a picture is subdivided based on some sudden variations in the intensity level of pixels. They are classified into three types: point detection, line detection, and edge detection and it is evaluated all edge detectors for grayscale and colour pictures. Color pictures provide more details about objects in a scene than grayscale images [15]. For colour segmentation, there are two primary techniques. The first method is called the Monochromatic-based methodology, and it involves separating and then combining information from specific colour channels to arrive at the desired outcomes. The Vector-valued approach is the second procedure, in which colour information is supplied as color vectors [11-13].

3. Methodology and results discussions

3.1. Edge Detection

Edges are high intensity contrast regions in digital images. An edge separates two regions of varying intensity. Edge detection is crucial in image processing. When an edge is found, it reduces data and eliminates redundant information. Edge detection methods are classified as gradient-based (using the maximum and minimum values of the first derivative of a picture) or pixel-based (using pixels). Laplacian-based Edge Detection uses the image's second derivative to find edges [1]. Many edge detection algorithms were developed using these two detection methods.

3.2. Sobel Edge detector

Sobel edge detection is based on a gradient-based edge detector, which finds the greatest and lowest gradients in a picture by using the first derivative.

General Syntax: [g,t]=edge(I,'sobel',T,dir)

Here, I is the input picture, T denotes the threshold, and dir denotes the direction of the identified edge. A 33 mask is used to compute the gradient from an interpolated point between pixels.

The algorithm is followed as: A representative input picture is captured. Masking is used on the input. The gradient and direction of each pixel are determined [2]. The sample image is subjected to mask modification. In the end, an output image is produced that corresponds to the input image.

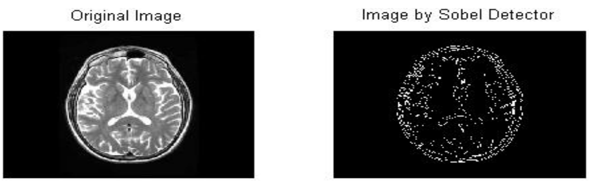

Figure 1. Sobel Edge Detection Results

3.3. Robert Edge Detection

The Roberts edge detector is built on a gradient-based detector as well, although it is more noise-sensitive [5].

General Syntax: [g,t]=edge(I,'roberts',T,dir)

Here, I stand for the input picture, T for the threshold, and dir for the detected edge's direction.

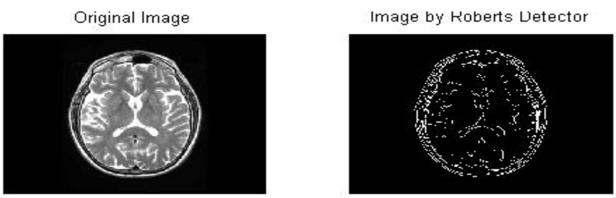

Figure 2. Robert Edge Detection Results

3.4. Prewitt Edge Detection

The prewet edge detector is another gradient-based edge detector. It produces a more noisy output [6].

General Syntax: [g,t]=edge(I,'prewitt',T,dir)

Here, I denote the input image, T denotes the threshold, and dir denotes the direction of the detected edge.

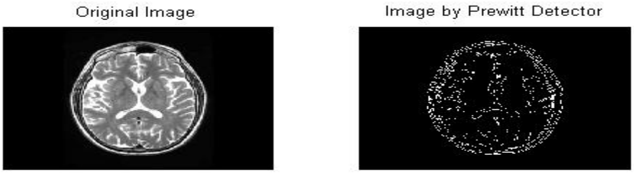

Figure 3. Prewitt Edge Detection Results

3.5. Laplacian of Gaussian

LoG uses Laplacian-based detectors, which are also known as Marr-Hildreth detectors. It's generally used on pictures that have been smoothed with a Gaussian filter to remove noise [8].

General Syntax: [g,t]=edge(I, 'log', T, dir)

Here, I is the input image, T is the threshold specified and dir shows the direction of detected edge. Algorithm: A Gaussian filter is used to smooth the input image. A Laplacian operator is used to enhance the edges. Determine the sub-pixel position of edge using linear interpolation.

Figure 4. LoG Edge Detection Results

3.6. Zero Crossing

The second derivate of the picture is used in Zero Crossing [9].

General Syntax: [g,t]=edge(I, 'zerocross', T, dir)

Here, I is the input image, T is the threshold specified and dir shows the direction of detected edge.

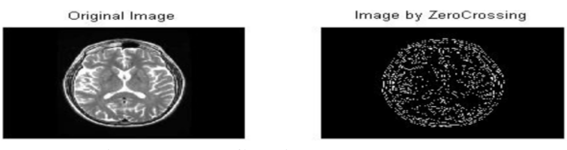

Figure 5. Zero-Crossing Result

3.7. Canny Edge Detection

Problems were found using the aforementioned detecting methods. To identify and find the appropriate edge at the right spot, and receive one response for each edge, there are three key requirements for edge detection. To remove noise and undesirable texture features, the input picture is smoothed with the assistance of an appropriate Gaussian filter. The value of sigma (Ω) is decided in the first stage [9]. A low sigma value results in a clear transition from an edge to a non-edge picture pixel. The gradient of the picture is used to determine the edge strength in the second phase. Finally, we compute the edge direction. The thin edges are subjected to Non-Maximum Suppression in the third phase. It is used to trace along the edge direction, suppressing and setting to zero any pixel value that is not deemed an edge. The current pixel's edge strength is compared to the pixel's edge strength in the positive and negative gradient directions [11]. To remove streaking, hysteresis is employed (edge contours are broken up as a result of operator output oscillating above and below the threshold.) T_1 and T_2 are the two threshold values used. Any pixel with a value greater than T_1 is considered an edge. The pixels that are linked to this pixel and have a threshold value larger than T are also chosen. This process is repeated until a gradient value less than T_1 is obtained [12, 13].

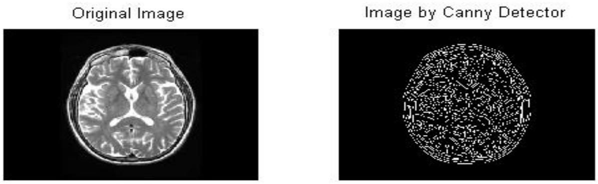

Figure 6. Canny Edge Detection Result

When the results of the edge detectors are compared across a grayscale image, the Canny edge detector produces the best results, whereas the other techniques produce more discontinuous and weaker edges [11-13, 15].

Table1: Comparison between the Edge Detection Operators

Operator	Advantages	Disadvantages
Sobel	• Simple and time efficient. • Suitable for simple objects.	• Sensitive to noise. • Inaccurate.
Roberts	• Simple.	• Sensitive to noise. • Inaccurate.
Prewitt	• Simple.	• Sensitive to noise. • Inaccurate.
LoG (Marr-Hildreth)	• Identifying the proper locations for the edges. • A wider region around the pixel is being tested.	• Problem in detecting junctions and corners. • Difficult in finding edge orientation.
Zero Crossing	• The detection and orientation of edges. • Have consistent features in all directions.	• Sensitive to noise. • Multiple responses to single edge sometimes.
Canny	• High signal to noise ratio. • Improved localization an edge detection. • Single response to an edge.	• Complex and time consuming. • Problem with junctions and corners.

4. Conclusion

In today's environment, picture segmentation has become a crucial element of comprehending images. With the growth of picture collection, there is an enormous amount of data that cannot be accessible directly. In order to analyze and extract information from these pictures, segmentation is essential. The segmentation of images has a promising future and has been the focus of modern study. The usual segmentation methods were addressed here: edge detection, clustering, and region growth. The problem with segmentation is that no one approach is suited for a certain type of picture, nor are all techniques applicable to all images. Despite years of research, no widely recognized approach exists, and the literature on colour picture segmentation is relatively sparse. We also went through various hybrid segmentation and colour image segmentation approaches. The hybrid techniques simply demonstrate that by combining the techniques, better segmentation results are obtained.

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