Comparative Analysis of Image Segmentation using Edge-Region Based Technique and Watershed Transform

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***Abstract*--- An image segmentation is the process of partitioning a digital image into multiple segments that share similar attributes like color, to simplify the representation and making it more useful for the analysis and interpretations. Image segmentation is an important image processing step, and it is used everywhere if we want to analyze what is inside the image. Image segmentation, basically provide the meaningful objects of the image. This paper represents the various image segmentation techniques that could be used in the segmentation algorithm. Whenever we work with the image in any application, initial step is to segment the image in order to solve its complexity. The segmentation of images is the basic thing for understanding the images. It is used in the Image processing applications, Computer vision, etc. In this paper, we are emphasizing Edge and Region based segmentation and Watershed transform which further includes their respective techniques.**

***Keywords*--- Image segmentation, Edge-Based Technique, Region Based technique, Watershed transformation**

I. INTRODUCTION

The prime consideration in the field of object recognition is the presence of multiple objects in an image. It is even harder when the objects are touching or overlapping each other, as they may be identified as one object, and can produce an incorrect recognition. We need to segment it so that it would become easier for the computer to understand. Segmentation is the most important part in image processing. Segmentation may also depend on various features that are contained in the image. It may be either color or texture. Before denoising an image, it is segmented to recover the original image. The main motto of segmentation is to reduce the information for easy analysis. Segmentation is also useful in Image Analysis and Image Compression [1].

Image segmentation is the process of partitioning an image into multiple segments, so as to change the representation of an image into something that is more meaningful and easier to analyze. Segmentation technique, basically convert the complex image into the simple image as shown in the fig 1.

Fig. 1: Technique of Segmentation

The basic applications of image segmentation are: Content-based image retrieval, Medical imaging, Object detection and Recognition Tasks, Automatic traffic control systems and Video surveillance, etc. The image segmentation can be classified into two basic types: Local segmentation (concerned with specific part or region of image) and Global segmentation (concerned with segmenting the whole image, consisting of large number of pixels). The image segmentation approaches can be categorized into two types based on properties of image [2].

All image processing operations generally aim at a better recognition of objects of interest, i. e., at finding suitable local features that can be distinguished from other objects and from the background. The next step is to check each individual pixel to see whether it belongs to an object of interest or not. This operation is called segmentation and produces a binary image. A pixel has the value one if it belongs to the object; otherwise it is zero. Segmentation is the operation at the threshold between low-level image processing and image analysis. After segmentation, it is known that which pixel belongs to which object. The image is parted into regions and we know the discontinuities as the boundaries between the regions [3].

II. EDGE-BASED SEGMENTATION

Edge detection is one of the fundamental operations when we perform image processing. It helps us reduce the amount of data (pixels) to process and maintains the structural aspect of the image. We're going to look into two commonly used edge detection schemes -

A. Sobel Edge Detection

It is also known as first order derivatives i.e., the gradient based edge detector. Sobel edge detector is a gradient based method based on the first order derivatives. It calculates the first derivatives of the image separately for the X and Y axes.

The operator uses two 3X3 kernels which are convolved with the original image to calculate approximations of the derivatives - one for horizontal changes, and one for vertical.

B. Laplacian Edge Detection

It is also known as second order derivative i.e., it is extremely sensitive to noise based edge detector. Unlike the Sobel edge detector, the Laplacian edge detector uses only one kernel. It calculates second order derivatives in a single pass.

Both of them work with convolutions and achieve the same end goal.

Edge detection is an important feature for image analysis. These features are used by higher-level computer vision algorithms (e. g., recognition). Edge detection is used for object detection which serves various applications like medical image processing, biometrics etc. Edge detection is an active area of research as it facilitates higher level image analysis. There are three different types of discontinuities in the grey level like point, line and edges. Spatial masks can be used to detect all the three types of discontinuities in an image [4]. Edge detection techniques are generally used for finding discontinuities in gray level images. Edge detection is the most common approach for detecting meaningful discontinuities in the gray level. Image segmentation methods for detecting discontinuities are boundary based methods. Edge detection can be done using either of the following methods. Edges are local changes in the image intensity. Edges typically occur on the boundary between two regions.

III. CANNY EDGE DETECTOR TECHNIQUE

In that Canny edge detector has some step by step procedure for segmentation is mentioned in Fig 2, which is as follows:

Step 1: To reduce the effect of noise, the surface of the image is smoothened by using Gaussian Convolution.

Step 2: Sobel operator is applied to the image to detect the edge strength and edge directions.

Step 3: The edge directions are taken into considerations for non-maximal suppression i.e., the pixels that are not related to the edges are detected and then, they are minimized.

Step 4: Final step is removing the broken edges i.e., the threshold value of an image is calculated and then the pixel value is compared with the threshold that is obtained. If the pixel value is high than the threshold then, it is considered as an edge or else it is rejected.[5]

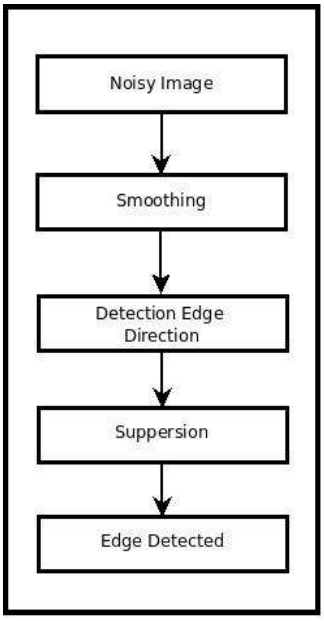


Figure 2: Canny Edge Detector procedure

The Canny Edge Detection procedure is described in the flowchart. Edges are the discontinuities in the sense of intensity, which gives us a layout of an object. All objects in the image are traced when the intensities are calculated accurately [6].

Various Edge Detectors are described.

i. The edges are detected by calculating the minimum and maximum of first derivative in gradient edge detector.
ii. Zero Crossing is found in second derivative to identify the edges in Laplacian edge detector.
iii. Sobel Edge Detector uses Convolution Kernel to detect the edges.
iv. Magnitude of the spatial gradient is calculated for edges in Robert's Edge Detector.
v. Canny Edge Detector also uses high spatial gradient but it takes more computation than Sobel.

IV. REGION BASED SEGMENTATION

The process of segmentation is one of the very first steps in the various remote sensing image analyses. Generally the image is divided into regions which represent the relevant objects in best method in the scene. Various region properties like area, shape, statistical parameters and texture can be extracted and used for additional analysis of the data.

In this technique pixels that are related to an object are grouped for segmentation [7].The thresholding technique is bound with region based segmentation. The area that is detected for segmentation should be closed. Region based segmentation is also termed as "Similarity Based

Segmentation" [4]. There won't be any gap due to missing edge pixels in this region based segmentation.[8]

A. Region Growing

Region growing is a procedure that group's pixels in whole image into sub regions or larger regions based on predefined criterion [10]. Region growing can be processed in four steps:-

i. Select a group of seed pixels in original image [9].
ii. Select a set of similarity criterion such as grey level intensity or color and set up a stopping rule.
iii. Grow regions by appending to each seed those neighboring pixels that have predefined properties similar to seed pixels.
iv. Stop region growing when no more pixels met the criterion for inclusion in that region (i. e. Size, likeness between a candidate pixel & pixel grown so far, shape of the region being grown).

B. Region Splitting and Merging

Rather than choosing seed points, user can divide an image into a set of arbitrary unconnected regions and then merge the regions [11, 12] in an attempt to satisfy the conditions of reasonable image segmentation. Region splitting and merging is usually implemented with theory based on quad tree data.

V. WATERSHED SEGMENTATION

Watershed Transformation belongs to the category of the region based similarities. Watershed model is a mathematical morphological approach and derives its analogy from a real life flood situation [13].

The Watershed Segmentation works as follows:

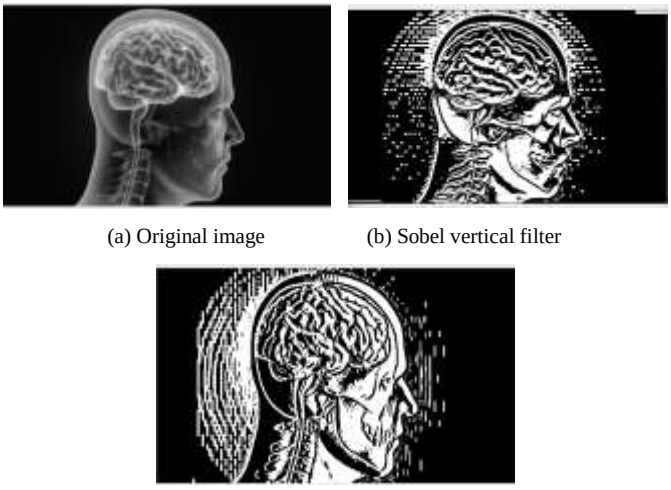
The first step is to apply preprocessing techniques that includes reducing the noise and adjust the image intensity by preserving image information in it. The noisy images lead to over segmentation and not an accurate segmented image. So, here we first remove the noise from the image and pixel values are adjusted so that they will help to obtain the well segmented image.

The second step is pre segmentation processes that includes various morphological operations such as finding out regional maxima and mark the foreground objects that help in segmentation process. Then after marking the foreground objects reconstruct the image.

In the third step we did the main task of our process that is segmentation. After reconstructing the image we superimpose it with the original image, clean the edges of the segmented image and compute background markers.

The last step is to apply watershed transformation to the distance transform of the image and then see the result that is segmented image.[14]

VI. EXPERIMENTAL RESULTS

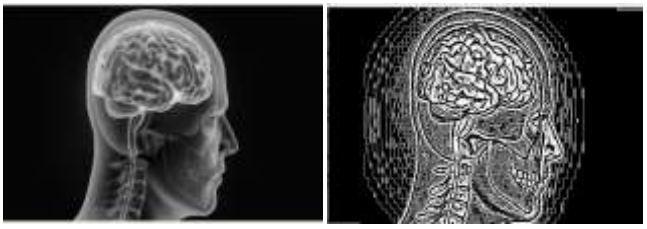


(a) Original image (b) Sobel vertical filter

(c) Sobel horizontal filter

Figure 3: Sobel filter results

As we can see, the result is not much impressive. The filters are calculating the gradient change from either horizontal or vertical side. Also, noise is still causing problems. We have denoised the image using the Gaussian blur technique. Also, We have applied a Laplacian filter to the picture. See the result as shown in figure 4.



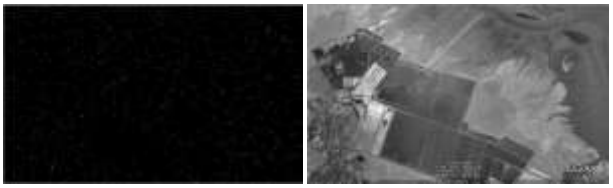
(a) Original image (b) Laplacian filter

Figure 4: Gaussian noise reduction and Laplacian filter

Note now the edges are much distinct. But there is still some noise in the output. aplacian filter applies the gradient check well on the denoised image. The Canny algorithm has a low error rate hence the accuracy is great. Also, it marks the edges in the image only once. So, noise does not result in false edges.

(a) Original image (b) Canny image

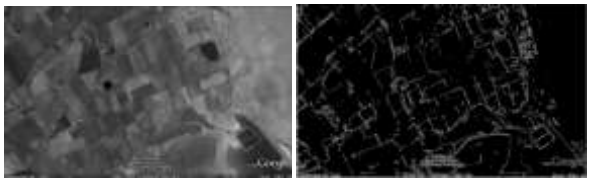
Figure 5: Canny edge detection



(a) Original image (b) Seed image

(c) Mask image (d) Segmented image

Figure 6: Region growing



(a) Original image (b) Canny edge image

(c) Segment output using watershed

VII. CONCLUSION

In this paper, we have analysed the image from a human perspective view point and also using qualitative analysis. As we have used edge detection, region growing, region split-and-merge and watershed based segmentation for segmenting the image till now. We have been analyzing image in many different ways. We conclude that Canny has the best performance analysis for segmenting image using edge detection, using region-grow make segmentation process fast compare to region split-and-merge, and lastly by using watershed segmentation it gives us an almost accurate segmented image which are typically simple, faster to compute.

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