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An Extensive Review on Image Segmentation Techniques

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Abstract*: *Image processing is the use of algorithms to perform various operations on digital images. The techniques that are explained further are image segmentation and image enhancement. Image Segmentation is a method to partition an image into multiple segments, to change the presentation of an image into something more meaningful and easier to analyze. The current image segmentation techniques include region-based segmentation and edge detection segmentation. Image Enhancement is the process of improving the quality of image. Under this section there are two broad divisions- Spatial Domain Technique and Frequency Domain Technique.

Keywords*: *Image Enhancement, Segmentation, Image Processing, thresholding, Region Based, Spatial Domain

I. INTRODUCTION

An image contains a large amount of helpful information, understanding it and extracting information from it to attain work is an important area of demand in image technology, and the first step to inspect the image is image segmentation. Image segmentation is the decision of whether a given point of light (pixel) in an image is an element of an object or that of background. It is mainly used to find the object and boundaries in a picture. It can be said that image segmentation is the process of allotting a label to each pixel which is available in such a way that pixels having the same label have the same properties. Edge detection algorithm submits to the use of different region of pixel gray or color discontinuity detection region of the edge to file image segmentation. [1]

The four basic steps of image segmentation are-

• **Smoothing -** That means to minimize as much noise as feasible from the image, without destroying the actual edges in it.

- **Enhancement** – To look for a filter to boost the quality of the edges in the image i.e. to blunt it mainly.
- **Detection** – To identify which edge pixels must be not considered as sound and which should get retained. In general, thresholding provides the criterion used for recognition.
- **Localization** – To find the actual position of an edge which means that sub-pixel resolution may be required for some purpose, i.e. to approximate the place of edge for enhanced spacing between pixels. Linking and edge tapering and are usually required in this step [2].

1.1 Image processing

Image processing is a process of turning an image into a digital form and mostly performs some method on it, to obtain a recovered image or to get some useful information.

It mainly includes below - given steps:

1. Importing the image.
2. Manipulating and analyzing the image.
3. Output (which gives a changed image or report based on analysis).

The motive of image processing is categorized into five groups:

1. Visualization
2. Restoration and Image sharpening.
3. Image extraction.
4. Image recognition.
5. Capacity of patterns.

Amidst other image processing techniques, image segmentation plays a crucial role in the analysis and extraction of information given by images. It is the sub-dividing an image into a set of pixels, according to homogeneity with value to some features such as color, texture, intensity, similarity between pixels of a region, etc. ‘

(a) Image Processing Methods:

Image Processing has the following two methods

- **Analog Image Processing:**

It is done by working on analog signals; this process includes processing on two- dimensional analog signals

In this type of processing the images are manipulated by electrical means by varying their electrical signal.

- **Digital Image Processing:**

In this image processing, a digital system has to be developed. This system is used to work on digital images.

Digital image processing has benefitted over analog image processing with the passing time because of its large use of applications.

1.2 Segmentation

The goal of image segmentation is to abridge the depiction of an image into such a thing which is more significant and easy to understand too.

The purpose of dividing the image is to further analyze each object carefully to extract some useful data. Studies till now shows that the main issues that image segmentation faces are there are many image segmentation techniques present,

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yet not even a single technique can be applied to all types of images, neither are all techniques equally appropriate for a particular type of image. There isn't any universally accepted technique to evaluate the segmented output, and also, there exists no proper literature related to color image segmentation yet. Suggestions made by researchers say that a fine approach to produce meaningful segments would be to fuse segmentation techniques together based on the input and output requirements. According to experts, most techniques developed for a certain category of an image can be easily applied extended to an additional class of images. A method has been described to combine segments recruited by using a region-growing concept, where the edges between regions are removed or altered based on gradient, contrast, and shape of the boundary.

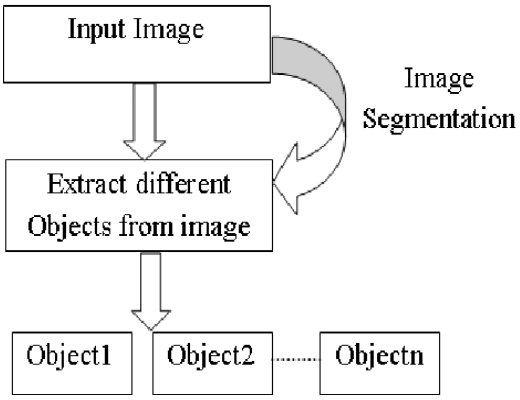

Figure 1: The process of image segmentation

II. SEGMENTATION TECHNIQUES

2.1 Region Based Segmentation:

2.1.1 Segmentation by Thresholding:

One among the easiest approaches for image segmentation is dependent on the intensity levels and is known as threshold-based. Thresholding can be implemented by global methods or local methods. Global thresholding distinguishes object and background by comparing them with their threshold value taken to segment the images. Local thresholding is sometimes known as adaptive thresholding. In this technique, the threshold varies over the image which is dependent on the local characteristics of the divided regions in the image [6]. Histogram thresholding is used for segmenting an image; there are various before dealing out and after-processing techniques that are required for threshold segmentation. Segmentation by means of Adaptive Thresholding, the original image is segmented by adaptive thresholding. Firstly the image is changed from RGB to gray. In this method, local adaptive segmentation is based on the highest and lightest of the mean method and is used to set threshold values.

Figure 2: Region based segmentation [7]

2.1.2 Regional Growth Segmentation:

Regional growth segmentation is a technique for examining a region that we want to mark directly, Instead of looking for the same at boundaries. To start the very first step in regional growth segmentation is to choose a set of the seed points, the seed points can be chosen based on gray scale range or pixels evenly spaced on a grid.

For this segmentation, some of the times one needs a rule that will elaborate the growing mechanism and a protocol to check the homogeneous points of the regions after each growth's step [10].

2.2 Segmentation of image by Edge Detection:

In an image segmentation process, the foremost step is the recognition of an edge. It separates an image into an object and its remaining areas such as the background of the image. This method distinguishes the parts of an image by examining the change in power or pixels of an image. The Gradient and another one the gray histogram are the major methods for edge detection in image segmentation.

2.2.1 Laplacian algorithm:

In Laplacian Edge detection, to locate the edge of an image we first blur the image and then smoothen it down for that purpose Gaussian is used and then the further edge detection process is carried forward and while blurring the image only important edges that need to be detected are focused in order that the necessity may be fulfilled [7]. Comparison of various image segmentations technique is shown in Table 1.1.

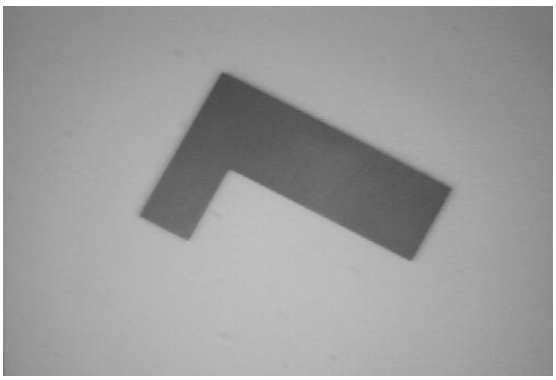

Figure 3: Image before edge detection by Laplacian method. [5]

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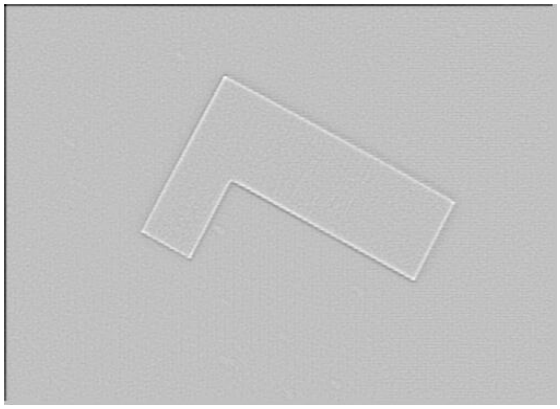

Figure 4: After Laplacian edge detection. [5]

III. IMAGE ENHANCEMENT TECHNIQUES

3.1 Introduction:

Image enhancement is the techniques that improves the quality of an image by enhancing its contrast and improving the edges and the features like its boundaries and produce a good quality digital image than it was earlier. It mainly is categorized in two-

1. Spatial domain technique
2. Frequency Domain Technique

3.1.1. Spatial Domain Technique:

Spatial Domain means aggregate of pixels composing an image. When a pixel is taken to get enhanced at some coordinate (x,y), the old image referred to as 'I' then the new image 'I1' is the result of the operations performed on the neighboring pixels of the pixel at the coordinates (x,y).Neighborhoods can exist in any shape but mostly they are rectangular in shape[14].

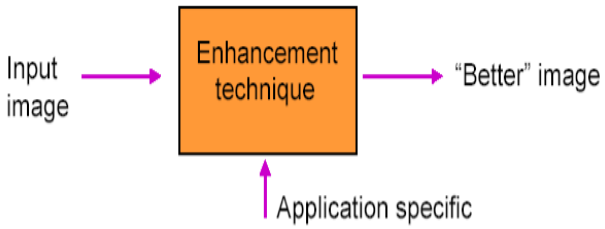

Figure 5: Image Enhancement basics

Here we manipulate the intensity of the pixels in the image directly.

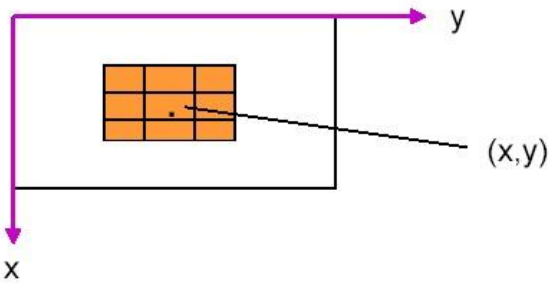

Figure 6: Spatial Domain Technique

The general formula that spatial domain follows is:

g(x,y)=T[f(x,y)]

In the above image the (x,y) coordinate exists in the central block itself. g(x,y) is the processed image. T is an operator on f defined over some coordinate (x,y)[14].

3.1.2. Frequency Domain Technique:

In this technique the image is first transferred into the frequency domain, meaning, first the Fourier transformation of the image is computed and then the enhancement operations are performed on the Fourier transform of the image and at last the inverse Fourier transformation is performed to get the final product i.e. the enhanced image. All the transformations that take place in this technique are performed in order to modify the image brightness, contrast or the distribution of the grey levels in the image. The final image is the consequence of transformation function applied on the input image provided. [15]

Here an image 'F' is converted to 'G' using 'T'. The values of pixels in images F and G are represented by 'r' and's'. Pixel values are related by the expression:

s=T(r).

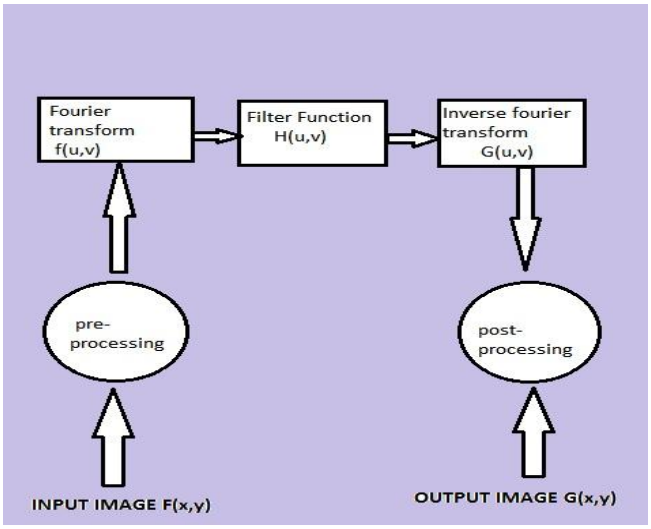

Figure 7: Frequency Domain Technique

The frequency domain methods under image enhancement work according to the convolution theorem [2].

$$g(x, y) = h(x, y) * f(x, y)$$

where,

g(x, y) = Resultant image
h(x, y) = Position invariant operator
f(x, y)= Input image

The Fourier transform representation of equation above is,

$$G(u, v) = H(u, v)\, F(u, v)$$

There are various frequency domain methods which can be listed as:
1. Contrast stretching.
2. Clipping and thresholding
3. Digital negative
4. Intensity level slicing, and
5. Bit extraction.

- **Contrast Stretching**: Contrast stretching, also known as normalization is a undemanding image enhancement technique to facilitate the enhancement in the contrast of an image through `stretching' the array of intensity standards it contains to length a preferred range of values, e.g. the occupied range of pixel values that the image type concerned allows.

Segmentation Technique	Method Description	Advantages	Disadvantages
Thresholding Method	This one tells that the histogram of an image has a significant peak, every peak corresponding to a region.	1) It does not need previous details of the image. 2) For a broad class of images satisfying the requirement, this way it works very well with low complexity	1) It does not work well with an unobstructed top or flat broad valley. 2) It does not take into consideration the details of the space and, therefore, it cannot be assured that segmental regions are contagious.
Region Based Approach	Group the pixels into homogeneous regions. Including growing region, region division, region merger or combination thereof.	It works on the right point. They are also more insensitive to noise than the edge detection technique.	1) Are inherently sequential and quite expensive in terms of computing time and memory. 2) It depends on the selection of the seed region and the order in which the pixels and regions are examined.
Edge Detection Approach	Based on the recognition of discontinuity, normally attempts to locate points with more or less abrupt changes in gray level. Generally classified into 2 categories: 1. Sequential And 2. Parallel	This detection is the way humans perceive the object and is suitable for images with good contrast between regions. It gives better results with images with fine features such as images of flowers, rivers and satellites.	1) Does not work well with images that have poorly defined outlines or too many outlines. 2) Creating a closed curve or limit is not an easy task to do.

ble 1.1: Comparison of Image Segmentation Methods

- **Clipping and thresholding:** Clipping is a special case of contrast stretching where a = g = 0.

$$f(u) = \begin{cases} 0 & 0 \le u < a \\ \alpha u & a \le u \le b \\ L & u \ge b \end{cases}$$

The slopes ‘a’, ‘b’, ‘g’ determines the relative contrast stretch. This is useful for binary or other images that have bimodal distribution of gray levels. The ‘a’ and ‘b’ define the valley between the peaks of the histogram. For a = b = t, this is called Thresholding (The output becomes binary).[17]

- **Digital negative**: The digital negative of an image is achieved by reverse scaling of its grey levels to the transformation. They are much essential in displaying of medical images.[18]

- **Intensity Level Slicing**: The images which consist of grey levels in between intensity at background and other objects require reducing the intensity of the object. This process of changing intensity level is done with the help of intensity level slicing. [18]

- **Bit Extraction:** Also known as Bit plane slicing is the translation of image into multilevel binary image. These binary images are compressed using special algorithm, where each pixel is the sequence of digital bits from these digital bits binary images is to be extracted.

3.2 The difference between frequency domain and spatial domain techniques:

The spatial domain technique is based on the modification of the pixels in the image whereas the frequency domain technique is based on modifying the Fourier Transform of a digital image.

Processing in spatial domain is done by directly processing the input image's pixel array, and in frequency domain the image is first transformed to its frequency representation and then it is processed and at last, computed [16].

IV. CONCLUSION

Image segmentation is going to be really useful and wanted in near future as it is the segmentation algorithm that has become the focus of current studies. As an outcome, image segmentation is affected by many things, such as image homogeneity, spatial characteristics of image stability, texture, and image content. -The problem of edge-based segmentation is that its results are affected by the performance of the underlying edge detector, i.e. edge detectors are low at angles. -The solution could be to introduce the results of a corner detector to compensate for this weakness.

By observing these methods of edge detecting algorithm we know that it gives better results with images with fine features such as images of flowers, rivers and satellites. Although the thresholding technique is preferable with images that have minimal features such as the fruits and images of faces, in the kind of pictures that are full of noises, regional techniques are better than the other. The contour-based method may be preferable because they are generally less complex. Edges are quite the necessary features in an image to separate regions. The edge of a region can often be difficult to find because of noise or occlusions. The combination of results can most of the times be a fine plan.

In the image enhancement techniques, we studied two types, first was spatial domain technique and the second frequency domain.

- Spatial domain deals with image plane itself whereas Frequency domain deals with the rate of pixel change.
- Spatial domain can be easier to understand whereas Frequency domain can be less easy to understand.
- Spatial domain is cheaper whereas Frequency domain is not cheaper.

Spatial domain takes less time to computer whereas Frequency domain takes more time to compute.

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Dr. Kamlesh Sharma, is currently working as a Associate Professor, MRIIRS, Faridabad, India (more than 14 years teaching experience). MCA, M. Tech from MDU University and Ph. D. in Computer Science and Engineering from Lingaya`s Vidyapeeth, India, is currently Supervising five Ph. D. scholars. She has also supervised and guided research projects of M. Tech, B.Tech and application based projects for different competitions. She is also associated with four Govt. research projects in filed of health recommender system, IOT, Machine Learning, AI and NLP. She has published more than 45 research papers in field of NLP, IOT, Bigdata, Green Computing and Data Miningin reputed Journal (Web of Science, Scopus, UGC, Elsevier) and Conferences (ACM, IEEE). Her research area "Natural Language Processing" is based on innovative idea of reducing the mechanized efforts and adapting the software to Hindi dialect.

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