OVERVIEW OF EDGE DETECTION METHODS

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ABSTRACT

Image segmentation is the process of partitioning a digital image into multiple segments. Segmentation and classification tools provide an approach to extracting features from imagery based on objects. These objects are created via an image segmentation process where pixels in close proximity and having similar spectral characteristics are grouped together into a segment. Edge is a basic feature of image. The image edges include rich information that is very significant for obtaining the image characteristic by object recognition. Edge detection refers to the process of identifying and locating sharp discontinuities in an image. So, edge detection is a vital step in image analysis and it is the key of solving many complex problems. In this paper, the main aim is to study the theory of edge detection for image segmentation using various computing approaches based on different techniques

Keyword : Segmentation, Classification, Edge Detection

I. INTRODUCTION

Image segmentation is the process of partitioning a digital image into multiple segments. i.e. sets of pixels, also known as superpixels. Each of the pixels in a region are similar with respect to some characteristic or computed property, such as color, intensity, or texture.Scientifically, segmentation is a hypothetical middle-level vision task performed by neurons between low-level and high-level cortical areas.Technically, image segmentation refers to the decomposition of a scene into different components.Main challange in this area is that the content variety of images is too large, and the second one is that there is no benchmark standard to judge the performance. Segmentation techniques are categorized in 2 categories:

- **Local Segmentation:** In this type of segmentation technique segmentation is concerned with part of image. It deals with segments consisting of relatively small number of pixels[4].
- **Global Segmentation:** In this type of segmentation technique segmentation is It deals with segments consisting of relatively large number of pixels concerned with whole image[4].

Segmentation and classification tools provide an approach to extracting features from imagery based on objects. These objects are created via an image segmentation process where pixels in close proximity and having similar spectral characteristics are grouped together into a segment.Segments exhibiting certain shapes, spectral, and spatial characteristics can be further grouped into objects. The objects can then be grouped into classes that represent real-world features on the ground. Image classification can also be performed on pixel imagery. i.e. traditional unsegmented imagery. Image segmentation is an initial and vital step in a series of processes aimed at overall image understanding. Applications of image segmentation include:

- Identifying objects in a scene for object-based measurements such as size and shape
- Identifying objects in a moving scene for object-based video compression (MPEG4)
- Identifying objects which are at different distances from a sensor using depth measurements from a laser range finder enabling path planning for mobile robots[5].

II. TYPES OF SEGMENTATION

There are mainly 5 types of segmentations possible which are briefly described below:

2.1. Edge based segmentation

Segmentation can be done by using edge detection techniques. In this technique the boundary is identified to segment. Based on the detection of discontinuity, normally tries to locate points with more or less abrupt changes in gray level. Edges on the region are traced by identifying the pixel value and it is compared with the neighbouring pixels. In this edge based segmentation, there is no need for the detected edges to be closed. There are various edge detectors that are used to segment the image.[1]

2.2. Region based segmentation

In this technique pixels that are related to an object are grouped for segmentation. The area that is detected for segmentation should be closed. Region based segmentation is also termed as “Similarity Based Segmentation”. There won’t be any gap due to missing edge pixels in this region based segmentation. The boundaries are identified for segmentation. In each and every step at least one pixel is related to the region band is taken into consideration.Group Pixels into homogeneous regions. Including Region growing, Region splitting, Region merging or their combination.[1]

2.3. Thresholding method

Threshold is the easiest way of segmentation. It requires that histogram of an image has a number of peaks, each correspond to a region. The threshold values are obtained from the edge detected image. So, if the edge detections are accurate then the threshold too. Segmentation is done through adaptive threshold. The gray level points where the gradient is high, is then added to threshold surface for segmentation. Frank Jiang [3] proposed anew multilevel Threshold-based segmentation techniqueusing PSO and Wavelet mutation. [1].

2.4. Feature based clustering

Segmentation is also done through Clustering. They followed a different procedure, where most of them apply the technique directly to the image but here the image is converted into histogram and then clustering is done on it. Pixels of the colour image are clustered for segmentation using an unsupervised technique Fuzzy C. This is applied for ordinary images. If it is a noisy image, it results to fragmentation.

2.5. Model based method

Markov Random Field (MRF) based segmentation is known as Model based segmentation. An inbuilt region smoothness constraint is presented in MRF which is used for colour segmentation. Components of the colour pixel tuples are considered as independent random variables for further processing. MRF is combined with edge detection for identifying the edges accurately

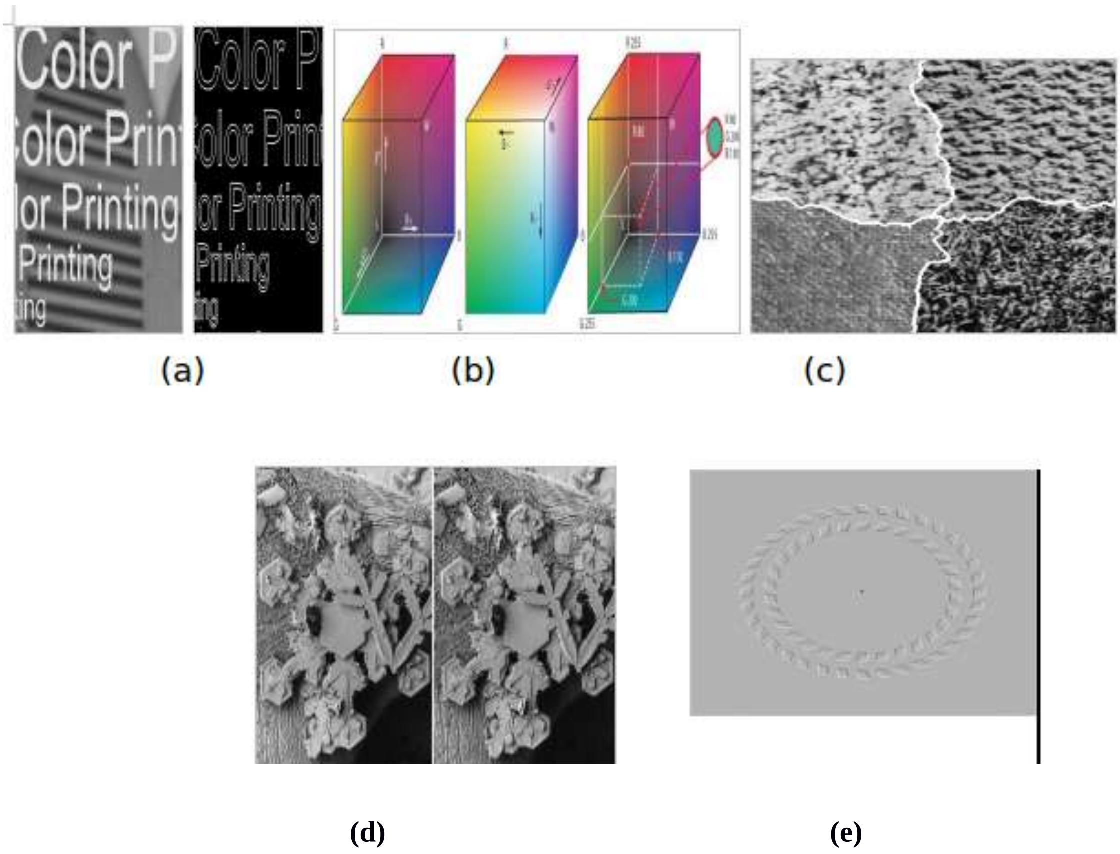

Figure 1:(a) Edge based segmentation (b) Color based segmentation (c) Texture based segmentation (d) Disparity based segmentation (e) Motion based segmentation

III. EDGE DETECTION

The separation of the image into object and background is a critical step in image interpretation. When we imitate the human visual system by using computer algorithms, quite a lot of problems can be encountered. Segmentation subdivides an image into its constituent regions or objects. The level to which the subdivision is carried depends on the problem being solved. That is, segmentation should stop when the objects of interest in an application have been isolated[6]

An Edge in an image is a significant local change in the image intensity, usually associated with a discontinuity in either the image intensity or the first derivative of the image intensity. Discontinuities in the image intensity can be either Step edge, where the image intensity abruptly changes from one value on one side of the discontinuity to a different value on the opposite side, or Line Edges, where the image intensity abruptly changes value but then returns to the starting value within some short distance. However, Step and Line edges are rare in real images. Because of low frequency components or the smoothing introduced by most sensing devices, sharp discontinuities rarely exist in real signals. Step edges become Ramp Edges and Line Edges become Roof edges, where intensity changes are not instantaneous but occur over a finite distance[7]

There are mainly 3 gradient base approach for this segmentation

IV. SOBEL EDGE DETECTION

The Sobel operator, sometimes called the Sobel–Feldman operarator or Sobel filter, is utilized as a part of image processing, especially inside edge identification calculations where it makes a image emphasising edges. It is named after Irwin Sobel and Gary Feldman.

In fact, it is a discrete separation operator, registering an estimate of the gradient of the image intensity function. At every point in the image, the consequence of the Sobel–Feldman operator is either the relating gradient vector or the norm of this vector.

As an outcome of its definition, the Sobeloperator can be executed by basic means in both equipment and programming: just eight image focuses around a point are expected to figure the relating result and just number-crunching is expected to register the angle vector estimate.

Methodology

The operator utilizes two 3×3 parts which are convolved with the original image to ascertain approximations of the subordinates - one for horizontal changes, and one for vertical. If we characterize An as the source image, and Gx and Gy are two pictures which at every point contain the horizontal and vertical subordinate approximations separately, the calculations are as per the following

$$\mathbf{G}_x = \begin{bmatrix} -1 & 0 & +1 \\ -2 & 0 & +2 \\ -1 & 0 & +1 \end{bmatrix} * \mathbf{A} \quad \text{and} \quad \mathbf{G}_y = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ +1 & +2 & +1 \end{bmatrix} * \mathbf{A} \qquad (1)$$

where * here denotes the 2-dimensional signal processing convolution operation.The *x*-coordinate is defined here as increasing in the "right"-direction, and the *y*-coordinate is defined as increasing in the "down"-direction. At each point in the image, the resulting gradient approximations can be combined to give the gradient magnitude, using-

$$\mathbf{G} = \sqrt{\mathbf{G}_x^{\,2} + \mathbf{G}_y^{\,2}} \qquad (2)$$

By this information, we can also figure out the gradient's direction:

$$\Theta = \operatorname{atan2}(\mathbf{G}_y, \mathbf{G}_x) \qquad (3)$$

where, for instance, **Θ** is 0 for a vertical edge which is lighter on the right side.

It is less susceptible to noise. But it produces thicker edges. So edge localization is poor.

V. PREWITT EDGE DETECTION

The Prewitt operator is used in image processing, particularly within edge detection algorithms.Actually, it is a discrete separation operator, processing a guess of the gradient of the image intensity function. At every point in the image, the aftereffect of the Prewitt operator is either the comparing gradient vector or the norm of this vector.

In basic terms, the operator figures the gradient of the image intensity at every point, giving the heading of the biggest conceivable increment from light to dark and the rate of alter in that direction. The outcome in this way indicates how "suddenly" or "easily" the image changes by then, and in this way how likely it is that part of the image represents to an edge, and in addition how that edge is liable to be oriented.

Methodology

The operator utilizes two 3×3 parts which are convolved with the original image to ascertain approximations of the subordinates - one for horizontal changes, and one for vertical. If we characterize An as the source image, and Gx and Gy are two pictures which at every point contain the horizontal and vertical subordinate approximations separately, the calculations are as per the following

$$\mathbf{G_x} = \begin{bmatrix} -1 & 0 & +1 \\ -1 & 0 & +1 \\ -1 & 0 & +1 \end{bmatrix} * \mathbf{A} \quad \text{and} \quad \mathbf{G_y} = \begin{bmatrix} -1 & -1 & -1 \\ 0 & 0 & 0 \\ +1 & +1 & +1 \end{bmatrix} * \mathbf{A} \qquad (4)$$

Where * here denotes the 2-dimensional signal processing convolution operation.

The *x*-coordinate is defined here as increasing in the "right"-direction, and the *y*-coordinate is defined as increasing in the "down"-direction. At each point in the image, the resulting gradient approximations can be combined to give the gradient magnitude, using:

$$\mathbf{G} = \sqrt{\mathbf{G}_x{}^2 + \mathbf{G}_y{}^2} \qquad (5)$$

By this information, we can also figure out the gradient's direction

$$\mathbf{\Theta} = \operatorname{atan2}(\mathbf{G}_y, \mathbf{G}_x) \qquad (6)$$

where, for instance, **Θ** is 0 for a vertical edge which is lighter on the right side.

VI. ROBERTS EDGE DETECTION

The Roberts cross operator is utilized as a part of image preparing and computer vision for edge detection. It was one of the primary edge detectors and was at first proposed by Lawrence Roberts in 1963.

As a differential operator, the thought behind the Roberts cross operarator is to approximate the gradient of a image through discrete separation which is accomplished by processing the whole of the squares of the contrasts between diagonally nearby pixels. As per Roberts, an edge detector ought to have the accompanying properties: the delivered edges ought to be all around characterized, the background ought to contribute as little noise as could be expected under the circumstances, and the intensity of edges ought to compare as close as possible to what a human would perceive.

Methodology

$$y_{i,j} = \sqrt{x_{i,j}} \qquad (7)$$

$$z_{i,j} = \sqrt{(y_{i,j} - y_{i+1,j+1})^2 + (y_{i+1,j} - y_{i,j+1})^2} \qquad (8)$$

Where x is the initial value in the image, z is the processed derivative and i , j indicate the area in the image. Keeping in mind the end goal to perform edge identification with the Roberts operator we first convolve the original image, with the accompanying two kernels:

$$\begin{bmatrix} +1 & 0 \\ 0 & -1 \end{bmatrix} \quad \text{and} \quad \begin{bmatrix} 0 & +1 \\ -1 & 0 \end{bmatrix} . \qquad (9)$$

Let I(x,y) a chance to be a point in the original image and Gx(x,y) be a point in a image framed by convolving with the first kernel and Gy(x,y) be a point in a image shaped by convolving with the second kernel.Using this information we can easily obtain gradient's magnitude.

$$\mathbf{G} = \sqrt{\mathbf{G}_x{}^2 + \mathbf{G}_y{}^2} \qquad (10)$$

By this information, we can also figure out the gradient's direction

$$\Theta = \operatorname{atan2}(\mathbf{G}_y, \mathbf{G}_x) \qquad (11)$$

Where, for instance, **Θ** is 0 for a vertical edge which is lighter on the right side.

This method is simple to implement below figure shows comaprision of various edge detection techniques[8].

(a) (b) (c)

Figure 2: Comparision of edge detection methods (a) using Prewitt Method (b) using Roberts Method (c) using Sobel Method

VII. CONCLUSION

The purpose of this paper is to present a survey of various approaches for image segmentation based on edge detection techniques.Image segmentation is very useful for partitioning image into different parts which all have same characteristics. Image segmentation and classification is also became helpful in obtaining same group of objects from the given image. Image segmentation have many application in various fields.

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