Parallel Canny Gradient Edge Detector

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***Abstract*— Image segmentation is the process of partitioning a digital image into multiple segments, in simpler words, it is the process of assigning a label to each and every pixel in an image such that pixels with the same label share similar characteristics. Canny Gradient Edge Detector is one of the most important and promising image segmentation model. In this paper, we propose an efficient parallel version of Canny Gradient Edge Detector. We build the parallel framework of this proposed model using C++ and OpenMP.**

Keywords*— *Canny Gradient Edge Detector, C++, OpenMP

I. Introduction

Images provide us with a lot of information, but sometimes the information that we require is specific. Image segmentation is used segment the image into different components or in other words convert the image into something more meaningful and easier to analyze. There are many applications of image segmentation which includes Diagnosing tissues for cancer, object detection, finger-print matching , autonomous driving and so on.

In image processing, interpretation of image contents is one of the objectives in computer vision. In this era, it is one of the HOT topics for research. Image segmentation is the process of partitioning a digital image into multiple segments, in simpler words, it is the process of assigning a label to each and every pixel in an image such that pixels with same label share similar characteristics. There are numerous image segmentation models have been proposed. Few of them are mentioned below.

A. Thresholding

This method is used to extract foreground from background and vice versa. It is used for grey scale image. Here we choose a threshold value T, where T is selected by plotting a histogram and finding a clear valley in it. Let f(x,y) be the pixel value of an image at any location (x,y)

$$g(x,y) = f(x) = \begin{cases} 1, & if\ f(x,y) > T \\ 0, & if\ f(x,y) \le T \end{cases}$$

The point at which f(x,y)>T is called an object point else it is called a boundary point.

B. Region based segmentation

Region Growing – See neighbouring features, if they are similar expand the region.Better than edge detection method in case of noisy image where edge detection is difficult.
Region Splitting – Start from whole image as a region divide the image into four quadrants if the condition of the region is not satisfied.
Region Merging – Opposite of region splitting, here we start with smaller regions and we do merging of the regions of similar features.

C. Watershed Technique

We assume a grey image as a topological surface where high intensity denotes peaks or hills and low intensity denote valleys. We start pouring water of different colors to different isolated valleys and as they start to merge, we put a boundary. We do it until all the peaks are submerged under the water. Sometimes, it gives over segmented image to reduce that we add markers and we start pouring water in the marked regions only.

D. Edge detection and segmentation

Edge-based segmentation methods first search edges of objects in the image and then use this edge information to reconstruct complete boundaries for the principal objects in the image. We use Gradient operator for detecting edges. The gradient of an image f(x,y) at any location (x,y) is the vector –

$$\nabla f = \begin{bmatrix} G_x \\ G_y \end{bmatrix} = \begin{bmatrix} \partial f / \partial x \\ \partial f / \partial y \end{bmatrix}$$

The Gradient vector points in the direction of maximum rate of change of f(x,y) at a given (x,y). The magnitude of the gradient vector is given by-

$$|\nabla f| = \sqrt{G_x^2 + G_y^2}$$

And also the direction of the gradient vector is given by –

$$\alpha(x,y) = \tan^{-1}\left(\frac{G_y}{G_x}\right)$$

In this paper, our aim is to study Canny Gradient Edge Detector Model which uses the concept of edge detection and segmentation.

II. Literature Survey

Image segmentation has always been the one of the HOT research topics [1]. The very first method and also the simplest method is Thresholding [2]. It converts a grey-scale image into a binary image. Nobuyuki Otsu developed an

algorithm known as Otsu's Thresholding which perform the image thresholding automatically [3].

Edge detection techniques uses gradient operators for finding the edges. Many researchers researched and came up with different gradient operators in the form of masks. Lawrence Roberts (1965) introduced Robert Edge Detector, Sobel in 1970 (Rafael C.Gonzalez (2004)) gave Sobel Operator [4], Prewitt in 1970 (Rafael C.Gonzalez) proposed Prewill Edge Detector [4], Kirsch edge detection is introduced by Kirsch (1971) [5], Laplacian of Gaussian (LoG) was proposed by Marr(1982) which was the second order gradient of an image [6].

John Canny at MIT in 1983 proposed Canny Gradient Edge Detector which turned out to be the most promising image segmentation model at that time and still it outperforms many of the newer image segmentation algorithms that have been developed. This method separates noise from the image before finding edges of the image [7, 8].

III. Serial Canny Gradient Edge Detector

Canny technique is very important method to find edges as before find edges of image we isolate noises from the image, without affecting the features of the edges in the image.
Canny Gradient Edge Detector Algorithm –

1. Convolve image f(r, c) with a Gaussian function to get smooth image f^(r, c).
   f^(r, c)=f(r, c)*G(r,c,6)
2. Apply first difference gradient operator to compute edge strength then edge magnitude and direction are obtained as before.
3. Apply non-maximal or critical suppression to the gradient magnitude.
4. Apply threshold to the non-maximal suppression image.

IV. Scope for parallelization

Canny gradient edge detector is a four-step process and in each step, operation are performed on each pixel separately. So, we can divide the pixels into groups and assign each group a thread to perform the operations. For example – the step 2 involve calculation of first order gradient of each pixel. Since, gradient of each pixel is independent of gradient of other pixel so, there is no issue of race condition also, a simple #pragma omp for can do the job. We will build a parallel framework using OpenMP.

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