Image Segmentation Using Canny Edge Detection Technique

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Abstract

Interpretation of image contents is one of the main objectives in computer vision. The purpose of image segmentation is to partition the image into meaningful regions. Image segmentation is a method of separating the image from the background and read the contents. Edge is a basic and important feature of an image. Edge can be defined as boundary between two different regions in an image. Edge detection refers to the process of identifying and locating sharp discontinuities in an image. In this paper, we are presenting an efficient and effective method of edge detection commonly called as canny edge detection that results in significantly reduced memory requirements, decreased latency and increased throughput with no loss in edge detection performance. Detection of edges for an image may help for image segmentation, data compression and also help for well identical, such as image modernization and so on.

Keywords: Image segmentation, Image enhancement, Edge detection, Canny edge detection algorithm

Introduction

Segmentation is a process of distinguishing objects from the background. Image segmentation is defined as the process of separating the image from its background. The four main approaches used for image segmentation are: - Threshold Techniques, Edge Detection Techniques, Region-based techniques and Connectivity-preserving Relaxation Methods. Most widely and important amongst these four techniques is “Edge Detection”. Edge Detection is a technique in which the points where image brightness changes sharply or formally are identified. These points where the brightness of the image changes sharply are organized under line segments called edges. Some important features can be extracted from an edge of any image (e.g.-corners, lines, curves).

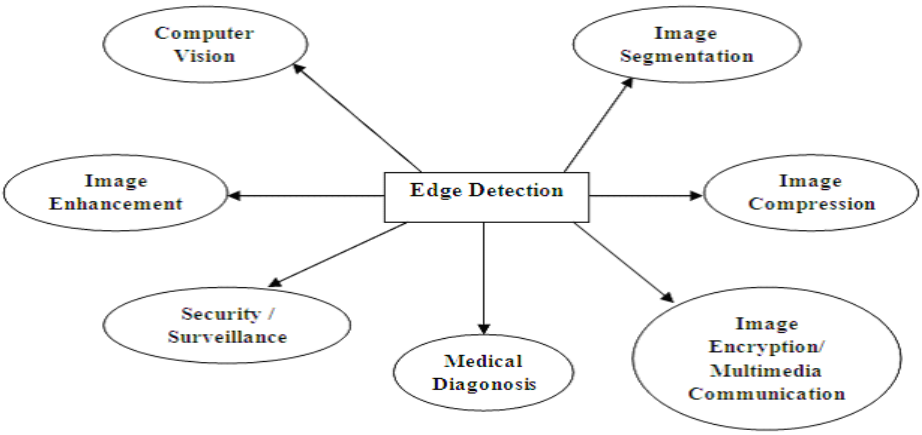
The main aim of our study about various edge detection techniques and analyzing their performance is because of some problems like false edge detection, images with noise, lost edges etc. Among the edge detection methods proposed so far, the canny edge detector is the most rigorously defined operator and is widely used. The canny edge detector is so popular because it is the most optimal method of finding edges with good detection, good localization and single response to an edge. Canny determined edges by an optimization process and proposed an approximation to the optimal detector as the maxima of gradient magnitude of a Gaussian-smoothed image.

Steps in Edge Detection

Step-I Filtration: - Every image is associated with some intensity values, random change in these values can result in noise. Some common noise is: salt and pepper noise, impulse noise etc. noise can be responsible for non-effective edge detection; hence image has to be filtered in order to reduce the noise content that leads to loss of edge strength. It is also termed as smoothening.

Step-II Enhancement: - Improving the quality of image is termed as enhancement. It aims to produce an image which is better and more suitable than original image. A filter is applied in order to enhance the quality of edge in image.

Step-III Detection: - Several methods are adopted to determine which points are edge points and which edge pixels should be discarded as noise.



Applications of Edge Detection System

Working of Canny Edge Algorithm

The edge detection in this technique is optimized with regard to the following criteria: -

- **Good Detection (Maximizing the signal-to-noise ratio of the gradient).** There should be a low probability of failing to mark true edge points, and low probability of falsely marking non-edge points. The signal-to-noise ratio should be as high as possible.
- **Good Localization (Edge localization for ensuring the accuracy of edge).** The points marked as edge points by the operator should approximate to the center of the real edge as much as possible.
- **Low Spurious Response (Minimizing multiple responses to a single edge).** Single edge produces fewer multiple responses, and false boundary responses are suppressed to the maximum.

The Canny Edge Detection method used for detecting the edges works in five separate steps: -

Step-I Smoothing: - The first step for edge detection by using canny edge detection technique is to filter out the noise in the original image. This is done by converting the input image into gray scale by adjusting contrast and brightness, so that the image is blurred to remove the noise. Generally, a Gaussian filter is used for noise removal.

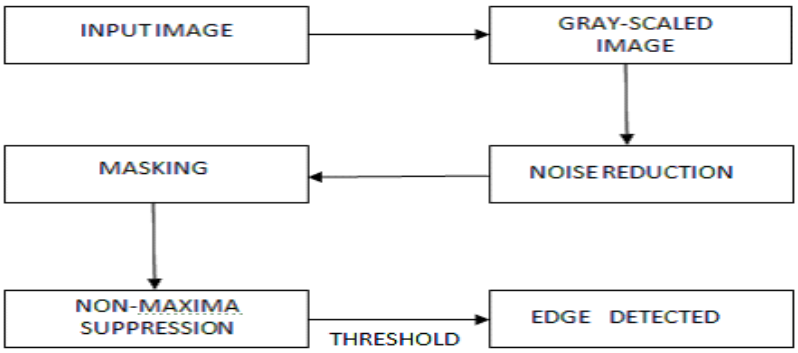
Step-II Finding Gradients: - Edge pixels are those where there is a sharp change in gray level values. These pixels are identified by computing the gradient of the image. The gradient is a unit vector which points in the direction of maximum intensity change. The vertical and horizontal components of the gradient are computed firstly and then the magnitude and the direction of the gradient is computed.

Step-III Non-Maxima Suppression: - Mainly edge thinning is performed in no-maxima suppression. In this step, on the basis of gradient magnitudes, the thick edges in the image are converted to approximately thin and sharp edges which can be further used for recognition purpose. In this process, the image is scanned along the edge direction and discards any pixel value that is not considered to be edge which will result in thin line in the output image.

Step-IV Double Thresholding: - Two threshold values are considered in canny edge detection technique, T1 = High Threshold, T2 = Low Threshold. The pixels having values of gray scale level higher than T1 are strong edge pixels, and the result is edge region. The pixels having values of gray scale level less than T2 are weak edge pixels, and the result is non-edge region. If

the pixels have values of gray scale level between T1 and T2, the result is depending on the neighboring pixels.

Step-V Edge Tracking by Hysteresis: - Edges that do not connect to a very certain (strong) edge are discarded in the final output image. Strong edges are interpreted as "Certain Edges" and are included in the final edge image. Edges that are not strong edges but are linked with strong edges are included in the output image.



Algorithm for Canny Edge Detection

The Canny Algorithm consists of the following steps executed sequentially: -

- Low pass filtering the image with a Gaussian Mask.
- Computing horizontal and vertical gradients at each pixel location.
- Computing the gradient magnitudes at each pixel location.
- Computing a higher and lower threshold based on the histogram of the gradients of the entire image.
- Suppressing Non Maximal Strong (NMS) edges.
- Performing hysteresis thresholding to determine the edge map.

Experimental Results

Step 1:

[Original butterfly]

Step 2:

[Gradient butterfly]

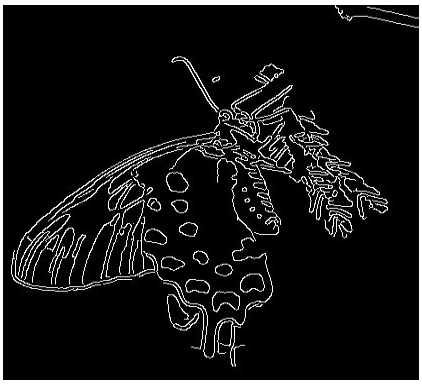
Step 3:

[Smooth butterfly]

Step 4:

[Non maximum suppress butterfly]

Step 5:



[Canny butterfly]

Importance of Canny Edge Detection Technique:

Although a number of various techniques for detection of edges are available, but amongst all these edge detection techniques, the canny edge detection algorithm is the best, most effective and the widely used method for edge detection because it consists of a number of adjustable parameters which can affect the speed and effectiveness of the algorithm.

- The size of the Gaussian Filter: The results of the detection of small and sharp lines are directly affected by the smoothing filter used in the first stage. A large filter causes more blurring, smearing out the value of a given pixel over a large area of image.
- The use of two Thresholds with hysteresis allows more flexibility than in a single-threshold. A very large value of threshold can result in loss of important information. On the other hand, a value of very low threshold may result in intensifying falsely irrelevant information (such as noise) as important.

Advantages of Canny Edge Detection Technique

- Improved signal-to-noise ratio.
- Good localization.
- Low spurious response (Single-edge response).
- Better detection in noise conditions.
- Implementing image processing algorithms on reconfigurable hardware minimizes the time-to-market cost.
- Enables rapid prototyping of complex algorithms.
- Simplifies debugging and verification.

Disadvantages of Canny Edge Detection Technique

- Complex and time-consuming computations as canny edge detection algorithm contains extensive pre-processing and post-processing steps.
- False zero crossing.
- It is difficult to give a generic threshold that works well on all images.
- High requirements on memory that results in large latency.

Conclusion

Representing an image by its edge has the advantage of reducing the amount of data required to be stored while retaining most of the image information. Transmission of the edge pixels in

an image or multimedia would result in compression of information of that image and there exists very reliable and effective algorithms to get the entire image back on the basis of that edge map. Canny operator can be applied to different situations. Canny operator can detect the edge clearly with higher accuracy. Canny edge detection technique is used for object recognition and pattern matching purposes where it is necessary to retain the features even in case of noisy images.

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