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Performance Evaluation of Edge Detection Techniques on Photographic Images

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Abstract: Edge detection is a fundamental tool for image processing and segmentation. In this paper an attempt is made to study the performance of most commonly used edge detection techniques for image segmentation. Image segmentation plays a vital role in image processing over the last few years. The goal of image segmentation is to cluster the pixels into salient image regions i.e., regions corresponding to individual surfaces, objects, or natural parts of objects. Also the comparison of these techniques is carried out on the performance on different images by using MATLAB software.

Keywords: Canny, Edge Detection, Laplacian, Prewitt, Robert, Sobel, etc.

I. INTRODUCTION

The effectiveness of many image processing and computer vision tasks depends on the perfection of detecting meaningful edges. Edge detection has been a challenging problem in low level image processing. It becomes more challenging when color images are considered because of its multi dimensional nature. Color images provide accurate information about the object which will be very useful for further operations than gray scale images. Due to some unavoidable reasons such as distortion, intensity variation, noise, segmentation errors and overlapping of objects in digital images, it is usually impossible to extract complete object contours or to segment the whole objects. Due to lack of object edge information the output image is not visually pleasing [1]. This task is hard and very important, since the output of an image segmentation algorithm can be fed as input to higher-level processing tasks, such as model-based object recognition systems.

Edge detection refers to the process of identifying and locating sharp discontinuities in an image. The discontinuities are abrupt changes in pixel intensity which characterize boundaries of objects in a scene. Classical methods of edge detection involve convolving the image with an operator or filter which is constructed to be sensitive to large gradients in the image while returning values of zero in uniform regions. There are an extremely large number of edge detection operators available, each designed to be sensitive to certain types of edges [2]. Variables involved in the selection of an edge detection operator include:

a. ***Edge Orientation:*** The geometry of the operator determines a characteristic direction in which it is most sensitive to edges. Operators can be optimized to look for horizontal, vertical, or diagonal edges.

b. ***Noise Environment:*** Edge detection is difficult in noisy images, since both the noise and the edges contain high-frequency content. Attempts to reduce the noise result in blurred and distorted edges. Operators used on noisy images are typically larger in scope, so they can average enough data to discount localized noisy pixels. This results in less accurate localization of the detected edges.

c. ***Edge Structure:*** Not all edges involve a step change in intensity. Effects such as refraction or poor focus can result in objects with boundaries defined by a gradual change in intensity. The operator needs to be chosen to be responsive to such a gradual change in those cases. Newer wavelet-based techniques actually characterize the nature of the transition for each edge in order to distinguish, for example, edges associated with hair from edges associated with a face.

II. METHODOLOGY

There are a number of methods available for edge detection in image processing. Here some of them are discussed and analyzed.

a. ***Robert Filter:*** The Roberts Cross operator performs a simple, quick to compute, 2-D spatial gradient measurement on an image. Pixel values at each point in the output represent the estimated absolute magnitude of the spatial gradient of the input image at that point. These kernels are designed to respond maximally to edges running at 45° to the pixel grid, one kernel for each of the two perpendicular orientations. The kernels can be applied separately to the input image, to produce separate measurements of the gradient components [1][2].

b. ***Prewitt Filter:*** Prewitt operator is similar to the Sobel operator and is used for detecting vertical and horizontal edges in images. The Prewitt edge detection is proposed by Prewitt in 1970. To estimate the magnitude and orientation of an edge Prewitt is a correct way. Even though different gradient edge detection wants a quite time consuming calculation to estimate the direction from the magnitudes in the x and

y-directions, the compass edge detection obtains the direction directly from the kernel with the highest response. It is limited to 8 possible directions; however knowledge shows that most direct direction estimates are not much more perfect [3].

c. ***Sobel Filter:*** The Sobel edge detection technique is similar to that of the Roberts Cross algorithm. Despite the design of Sobel and Robert are common, the main difference is the kernels that each uses to obtain the image is different [1,2]. The Sobel kernels are more suitable to detect edges along the horizontal and vertical axis whereas the Roberts's able to detect edges run along the vertical axis of 45° and 135°.

d. ***Laplacian Filter:*** The Laplacian is a 2-D isotropic measure of the 2nd spatial derivative of an image. The Laplacian of an image highlights regions of rapid intensity change and is therefore often used for edge detection. The Laplacian is often applied to an image that has first been smoothed with something approximating a Gaussian Smoothing filter in order to reduce its sensitivity to noise. The operator normally takes a single graylevel image as input and produces another graylevel image as output [1][2].

e. ***Canny Filter:*** Canny filter follows a list of criteria to improve method of edge detection [4]. The first and most obvious is low error rate. It is important that edges occurring in images should not be missed and that there be no responses to non-edges [5]. The second criterion is that the edge points be well localized. In other words, the distance between the edge pixels as found by the detector and the actual edge is to be at a minimum.

III. RESULTS & DISCUSSIONS

This section presents the relative performance of various edge detection techniques. Their visual comparison in shown in Fig. 1 and Fig. 2.

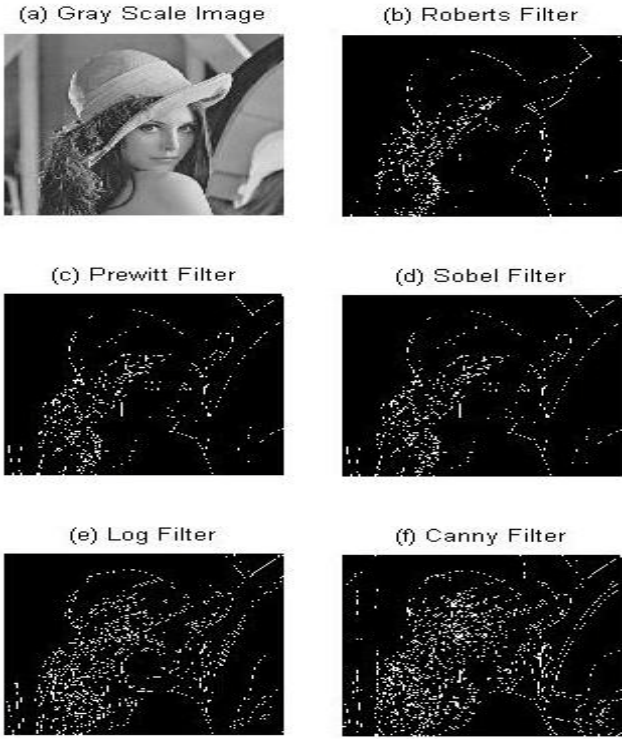

Figure. 1 Visual Comparison of Various Filters

a. ***Performance Evaluation:*** Gradient based algorithms such as the Prewitt filter have a major drawback of being very sensitive to noise. The size of the kernel filter and coefficients are fixed and cannot be adapted to a given image. An adaptive edge-detection algorithm is necessary to provide a robust solution that is adaptable to the varying noise levels.

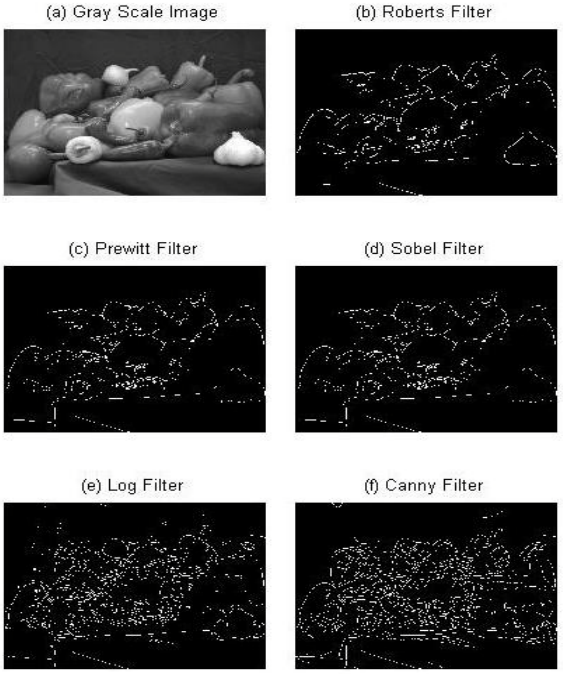

Figure. 2 Visual Comparison of Various Filters

Gradient-based algorithms such as the Prewitt filter have a major drawback of being very sensitive to noise. The size of the kernel filter and coefficients are fixed and cannot be adapted to a given image. An adaptive edge-detection algorithm is necessary to provide a robust solution that is adaptable to the varying noise levels of these images to help distinguish valid image contents from visual artifacts introduced by noise. The performances of these filters are shown in Fig.1 and Fig.2. The performance of the Canny algorithm depends heavily on the adjustable parameters, σ, which is the standard deviation for the Gaussian filter. The bigger the value for σ, the larger the size of the Gaussian filter becomes. This implies more blurring, necessary for noisy images, as well as detecting larger edges. As expected, however, the larger the scale of the Gaussian, the less accurate is the localization of the edge. Smaller values of σ imply a smaller Gaussian filter which limits the amount of blurring, maintaining finer edges in the image. The user can tailor the algorithm by adjusting these parameters to adapt to different environments.

The Canny edge detection algorithm is known to many as the optimal edge detector. Canny's edge detection algorithm is computationally more expensive compared to Sobel, Prewitt and Robert's operator. However, the Canny's edge detection algorithm performs better than all these operators under almost all scenarios.

a. ***Merits of Canny Filter:*** Although this algorithm is very much complex, the performance of Canny edge detector is superior to the other algorithms. Since the error rate is very small and all the edges of any images are found. The detected edges are as close as possible true edges.

IV. CONCLUSION

Image segmentation has become a very important task in today's scenario. In the present day world computer vision has become an interdisciplinary field and its applications can be found in any area be it medical, remote sensing, electronics and so on. Thus, to find an appropriate segmentation algorithm based on a particular application and the type of inputted image is very important. A few application specific segmentation algorithms which also take into consideration the type of image inputted like color, gray scale and text.

V. REFERENCES

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