Analytical Comparison between Sobel and Prewitt Edge Detection Techniques

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Abstract— Edge detection is the process of identify the presence and location of edges by sharp discontinuities of image. Edge detection plays an important role in image processing and helps in solving many complex problems. Edges are the boundaries between various regions within an image. Detection of edge in the image filters noise and unwanted data while preserves the structural properties of the image. Edge detection techniques transform original image into edge images which can be used for feature extraction, object recognition, data compression and image matching. In this research paper, two edge detection techniques, Sobel edge detection and Prewitt edge detection technique, are used to extract edges from the images of flowers. Performance of algorithm is judged by computing the pixels of the image to show which algorithm works better. From experimental results, it is observed that the Prewitt edge detection technique works better as compared to Sobel edge detection technique.

Index Terms—Edges, Edge Detection, Filter Design, Image Processing , Image Segmentation,, Prewitt Edge Detection, Sobel Edge Detection.

1 INTRODUCTION

EDGE detection techniques are widely used in image processing. There are many edge detection algorithms exist but no algorithm is suitable for all applications. Image segmentation and detection is the main application of edge detection technique [1]. There are many applications of edge detection such as image segmentation, image compression, image enhancement, medical diagnosis, computer vision, security surveillance etc. Edge detection operators are sensitive to noise but used to detect the variation in gray levels of the image. It is the most preferably used tool in pattern recognition and image segmentation. Edge detection operators are used to extract edges in the image and an edge is point in the image where sharpness or intensity of the pixel changes suddenly. Edges can be described as discontinuities in an image and its gradient value leads to infinity [2]. Edge comprises many meaningful features and significant information. It reduces the image size and removes noise and irrelevant data still preserves the structural properties of the image. Sometime redundant edges can be removed by detecting edges and replaced by reconstruction. Here's the role of edge detection comes. It also reduces the size of the image.

2 EDGES AND ITS TYPES

Edges are the main parts of image which shows variations in object. Physical edges are produced by variation in the reflectance, orientation, illumination, and depth of scene surfaces. Discontinuities in image intensity can be Step edge, Line edge. These discontinuities are rare in real images because of instant changes are rarely occurred [5]. The changes occurred in an image intensity over a time therefore, step edges is changed to Ramp edges and Line edges changed to Roof edges.

2.1 Types of Edges

There are four types of edges which are described below:

1) **Step Edge-** The intensity of image abruptly varies from one value to one side of the breakage to a different value on other side.
2) **Ramp Edge-** When the intensity change is not spontaneous and appears a limited distance then step edges are changed to ramp edges.
3) **Ridge/Line Edge-** The intensity of image suddenly changes values and then returns to the starting point within short distance.
4) **Roof Edge-** When intensity change is not spontaneous and appears over a finite distance usually generated by connectivity of surfaces then line edges becomes roof edges.

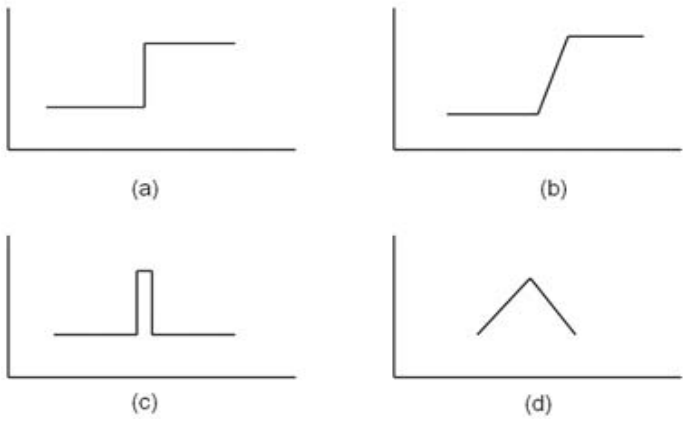

Fig 1. a) Step edge, b) Ramp edge, c) Line edge, d) Roof edge.

2.2 Edge detection steps:

2.2.1 Filtering

Edge detection methods are difficult to apply in noisy images because noise and and edges contain high frequency data and it became very difficult to find edges in the image. Noise is unpredictable contamination on the image [3]. There are two types of noise white noise and "salt and pepper" noise.

2.2.2 Enhancement

It improves the quality of digital image. It produces a better and more suitable image than original image. Eg. Edge filters, which can be used to solve many image enhancement problems.

2.2.3 Detection

Some methods should be used to determine which points are edge points or not.

3 METHODOLOGY

Edge detection techniques removes noise and ineffective data still preserving the important structural properties of the image. In thus research paper, edge detection algorithms Sobel edge detection and Prewitt edge detection are compared to find the best algorithm out of these two.

3.1 Sobel Edge Detection

Sobel operator is discrete differential operator, computes an approximation of the gradient of the image intensity function. After applying Sobel operator, every point in the resulting image will be the corresponding gradient vector or norm of that vector. The Sobel operator is based on convolution of the image with a small, separable and integer valued filter is applied in vertical and horizontal directions which results in less computations therefore it is less expensive. And the result of gradient approximation is crude, in particular for high frequency variations in the image. Sobel Operator mask are:

Table 1. Vertical direction mask

-1	0	1
-2	0	2
-1	0	1

Table 2. Horizontal direction mask

1	2	1
0	0	0
-1	-2	-1

3.1.1 Sobel Filter Design

Most of the edge detection method are based on the assumption that edges are found in the image where there is discontinuity. Based on this assumption take the derivative of the intensity value and find those points where intensity derivatives have maximum value and then edges can be located[4].

The magnitude is given by:
$|G| = \sqrt{G_X^2 + G_Y^2}$

Approximation is given by:
$|G| = |G_X| + |G_Y|$
And the angle of orientation of the edge giving rise to spatial gradient is given by:
$\Theta = \arctan(G_X/G_Y)$ [10].

The Sobel operator calculates the gradient of the image intensity at each point, and also gives the direction of possible increase from light to dark and rate of change in direction. The results shows how abruptly or smoothly the intensity of the point changes and how likely it is the part of the image that represents an edge [4]. The result of Sobel operator at any point of the image is a region of constant image intensity

3.2 Prewitt Edge Detection

It is a discrete differentiation operator. It computes the approximation of gradient intensity function. The result of Prewitt operator is either the corresponding gradient vector or normal of this vector. It is based on the convolving the image with small, separable and integer valued filter in horizontal(x) and vertical(y) direction. It is computationally less expensive and faster method for edge detection. It is only appropriate for noiseless and well contrasted images [6]. The difference between Prewitt and Sobel operator is the spectoral response. It is an appropriate way to estimate the magnitude and orientation of an edge.

3.2.1 Prewitt Filter Design

Prewitt approximation is applied on the derivatives of intensity function. Its results in edges where gradient of intensity function has maximum value.
Prewitt operator detect two types of images: horizontal edges and vertical edges. The difference between the corresponding pixel intensities of the image results in edges. Derivative masks are used for edge detection technique.

The derivatives should have the following properties:

- Mask should contain opposite signs.
- Sum of mask should be equal to zero.
- More edge detection due to more weight.

Prewitt operator generates two masks, one for detecting edges in horizontal direction and other for vertical direction.

Table 1. Vertical direction mask

-1	0	1
-1	0	1
-1	0	1

Table 2. Horizontal direction mask

-1	-1	-1
0	0	0
1	1	1

3.3 Implementation

The algorithm of Sobel and Prewitt Edge detection technique is implemented in MATLAB 8.1. Here the set of colored flower images are used for implementation. First the colored images of flowers are converted into gray scale image and then Sobel and Prewitt edge detection techniques are applied to the resulting gray images which in turns gives the edges of image by Sobel and Prewitt method. Some of the images are shown below:

Fig 2. Example 1 of Sobel And Prewitt Edge Detection Techniques

Fig 3. Example 2 of Sobel And Prewitt Edge Detection Techniques

4 Conclusion

The purpose of this paper is to study about image processing and Image segmentation based on Edge Detection techniques specially Sobel and Prewitt edge detection technique. The experiments results shown that Prewitt edge detection technique is better than the Sobel edge detection technique. Though Prewitt technique is similar to Sobel but there is difference of spectral response. The relative performance between the edge detection technique is carried out with a set of images on MATLAB software. Despite of so many edges detection techniques are available in the literature, since it is a challenging task to the research communities to detect the exact image without noise from the original image

5 Future Scope

Edge detection techniques are very helpful in object recognition and image processing. The differentiation of edge detection techniques would be helpful for comparing various other edge detection techniques and can be further used for feature extraction.

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