# One Dimensional Processing of Images

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*Abstract*— **A method of one-dimensional processing to find gray level transitions in an image is presented in this paper. 1-D Gaussian function is used for smoothing the image along horizontal (or vertical) scan lines to reduce noise. First derivative of 1-D Gaussian function is then used in the orthogonal direction (i.e., along vertical (or horizontal) scan lines) to find the gray level transitions. Different edge strengths are obtained depending on the gray level transitions. This method of processing of an image differs from traditional operators in the sense that smoothing is done in one direction and the differential operator is applied along the orthogonal direction. 2-D operators generally smooth the image in all directions resulting in de-enhancing the gray level transitions of the edge while smoothing the noise. The performance of the proposed method is compared with 2-D Canny's method for gray level images.**

*Keywords*— **1-D processing, edge strengths, differential operator, 2-D Canny's method.**

## I. Introduction

Edge detection is most widely used step for segmentation of an image or for the purpose of identification of objects in an image. Edges have the desirable property of drastically reducing the amount of data to be processed while preserving information about the shapes of objects in the scene. Traditional edge detection operators such as Robert, Sobel, Prewitt [1,2] are difference operators, are sensitive to noise. For noisy images, the performance of the edge-detection operators, such as LOG [1], wavelet transform [3, 4] and Canny [5] is better compared to the difference operators. Strength of an edge pixel is an important characteristic, which denotes the nature of the gray level transition. A strong edge has large gray level transition and thinner edge width, while a weak edge has small gray level transition and thicker edge width.

For feature extraction in the case of textured images, preprocessing is done using 2-D Gabor filters [6, 7] to avoid highlighting the micro-edges due to texture elements. Gray level based edge detection operators produce micro-edges, and hence are not useful for the purpose of edge detection in texture images. In general, our inability to effectively integrate the local and global information by means of an algorithm is mainly responsible for the poor performance of many edge extraction methods, compared to the performance of human visual system.

Edge extraction methods using 2-D operators smear the edge information, if a smoothing operation precedes it. Smoothing is essential in the case of noisy images, since differential operators produce noisy micro edges. Without smoothing, the edge image is not useful to derive the crucial high-level information for object representation or for other similar tasks. On the other hand, smoothing reduces the contrast level of the image and attenuates the gray level transitions across an edge.

## II. Method of 1-D Processing

To extract the edges in texture images, a new method has been proposed in [8, 9] using 1-D Gabor filter [10] and 1-D differential operator (first derivative of Gaussian function). The advantage of 1-D Gabor filtering is that smearing of edges takes place only along a particular direction only, i.e., along the direction of the 1-D smoothing function. Since an edge is a directional (1-D) property, the edge information along the other direction (orthogonal to the smoothing function) is still preserved. A 1-D differential operator (first derivative of Gaussian) applied along the orthogonal direction will bring out the edge information effectively. This method however does not produce edges along the direction in which the Gabor filter is applied. This is because the Gaussian function associated with the Gabor filter will smear the edge information. In order to extract the correct edge information, the 1-D Gabor filter is also applied separately along the orthogonal direction, and is subsequently processed using 1-D differential operator.

The above idea of 1-D processing can be extended for extracting the edge information from gray level images also. The proposed 1-D processing method provides not only a significant computational advantage, but also gives better output even for noisy images. Since noise must be reduced for edge enhancement, it is better to reduce the effect of noise by 1-D processing of the same pixels, by smoothing in one direction and differencing in the orthogonal direction. In the case of 2-D operators, the pixels undergo the smoothing and differencing operations simultaneously. In the proposed method, 1-D smoothing provides a significant advantage to reduce noise. This does not alter the gradient information in the orthogonal direction, which can now be extracted using a 1-D differential operator.

For a gray level image, the smoothing filter could be a 1-D Gaussian filter and the differential operator a first order derivative of the 1-D Gaussian function as shown in Fig.1.

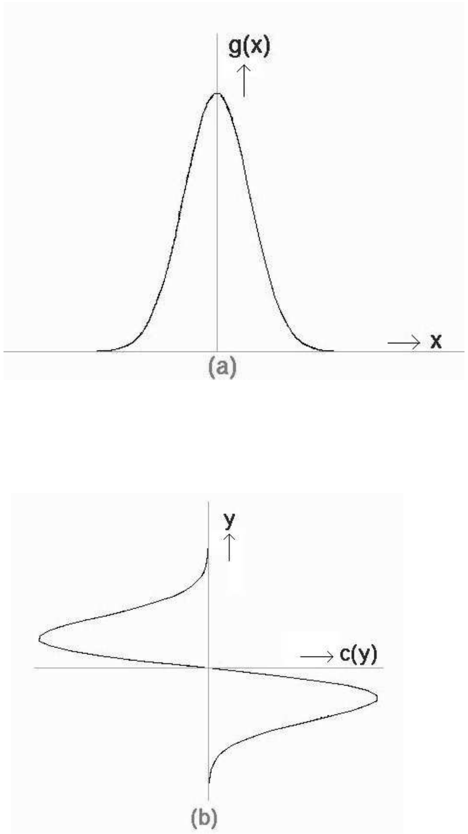


Fig. 1. (a) Gaussian in horizontal direction and (b) first derivative of Gaussian in vertical direction

The 1-D Gaussian filter can be expressed as:

$$g(x) = \frac{1}{\sqrt{2\pi}\sigma_1} e^{-\frac{x^2}{2\sigma_1^2}} \tag{1}$$

where $\sigma_1$ is the spatial spread of the Gaussian. The first order derivative of 1-D Gaussian is given by

$$c(y) = \frac{-y}{\sqrt{2\pi}\sigma_2^3} e^{-\frac{y^2}{2\sigma_2^2}} \tag{2}$$

where $\sigma_2$ is the spatial spread of the Gaussian. The response of 1-D Gaussian filter applied along a particular scan line of an image in one direction (say, along the horizontal scan line $y_r$ of pixels) can be expressed as

$$h(x, y_r) = i(x, y_r) * g(x) \tag{3}$$

where $*$ denotes the 1-D convolution operator, $g(x)$ represents the 1-D Gaussian filter, $i(x, y_r)$ represents the $r^{th}$ row of the image $i$, and $h(x, y_r)$ is the corresponding filter response. The response is computed for all rows in the image to obtain $h(x, y)$. For the 1-D Gaussian filter output, $h(x, y)$, obtained from Eqn.3 for all rows, the differential operator is applied along each column $x_c$ to extract the edges oriented along the horizontal lines of the pixels. The result is given by

$$f(x_c, y) = h(x_c, y) * c(y) \tag{4}$$

where $c(y)$ denotes the 1-D differential operator, and $h(x_c, y)$ represents the $c^{th}$ column in the 1-D Gaussian filtered image $h(x, y)$. The resultant image $f(x, y)$ obtained by applying Eqn.4 for all columns produces the horizontal components of edge strengths in the image. Similarly, the vertical components of edge strengths are detected by applying the 1-D smoothing operator along all vertical scan lines of the image and further processing with 1-D differential operator along the orthogonal direction (i.e., along horizontal scan lines of pixels).

Finally, the partial edge information obtained in horizontal and vertical directions are combined to extract the edge map of the original image. The choice of the window width depends on the nature of the image and the edges. In fact, one should combine the results obtained by a set of operators, for real world images.

## III. Results and Discussion

Fig.2(b) shows the result of applying the 1-D Gaussian smoothing filter along the vertical direction, for the image given Fig.2(a), where the vertical components of edge strengths are extracted using the differential operator along the horizontal direction. The corresponding horizontal components of the edge strengths are shown in Fig.2(c). The partial edge information obtained along vertical and horizontal directions are combined to obtain the overall edge information of the original image, as shown in Fig.2(d). For comparison, the edge information extracted by 2-D Canny operator with $\sigma = 0.73$ is shown in Fig.2(e). The value of $\sigma$ was chosen to provide similar spatial spread of Gaussian functions in both the methods, although the choice of $\sigma$ was found to be not very critical. The value of $\sigma_1$ used in Eqn.(1) was set to $1.5\sigma_2$, where $\sigma_2$ is the spatial spread of the differential operator in Eqn.(2). This ratio of $\sigma_1/\sigma_2 = 1.5$, was found to work best, from emperical observations. The gradient images were not thresholded in order to provide a visual comparison of the methods.

The results show that the proposed method gives equally good or marginally better edge information compared to the 2-D Canny's method, but with significant advantage in computation. The proposed method takes only about 10% of the time required by the 2-D Canny's method. The advantage of the proposed method can be seen in the case of noisy images. The results of edge extraction using the proposed 1-D processing and the 2-D Canny's method are shown in Figs.3(b) and 3(c), respectively, for the noisy image shown in Fig.3(a). The results clearly demonstrate that the proposed method works well even for noisy images. The main reason for this advantage is that noise smoothing is performed on the pixels using only 1-D filtering, thus preserving the edge information in the orthogonal direction.

Fig.4(a) shows another gray level image, and the edges extracted by proposed method and 2-D Canny's method are shown in Figs.4(b) and 4(c), respectively. Fig.5 shows a similar comparative study of the performance in the presence of noise.

## IV. Conclusion

This paper proposes a new method of 1-D processing for gray level images. It exploits the 1-D property of the edges by smoothing along one direction and extracting the edge in the orthogonal direction. Comparison of the results with the 2-D Canny method shows that the proposed 1-D method performs better even for noisy images, besides providing significant computational advantage. Depending on the nature of the image, the edge information from the outputs of several filters with different $\sigma$s can be combined to provide better ouput in the case of complicated scenes and noisy images.

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