A Modified Canny Edge Detection Algorithm with Variable Sigma

Biman Debbarma and Dibyendu Ghoshal

Abstract*— *Canny Edge Detector is the most widely used and studied edge detection algorithm because of its robustness to noise. In this paper a modified Canny Algorithm has been proposed which uses variable sigma for different parts of the image.

***Index Terms*— Edge Detection, Canny Algorithm, Gaussian Filter, Sigma, Entropy.**

I. INTRODUCTION

Edge detection literally means finding edge points of an image or finding discontinuity in an image. Edge detection is of great importance as a good edge detection technique improves the performance of other processing units. Various approach has been adopted for detecting edges e.g. The Marr-Hilderth edge detector [1], Local Threshold and Boolean Function Based edge detector [2], Canny Edge Detector [3] etc. Among these, Canny edge algorithm the most popular one. Various modifications of Canny algorithm have been proposed in literature [4]-[11]. In this paper a new approach has been adopted for better response where the gradient values of different parts of the image differ by a great amount.

II. CANNY ALGORITHM

The aim of Canny algorithm was to have good detection (minimum number of false edges), good localization (closeness of the real edge and the detected edge) and minimal response (one edge should be detected only once). Canny algorithm is a step-by-step process and the steps are shown in fig. 1.

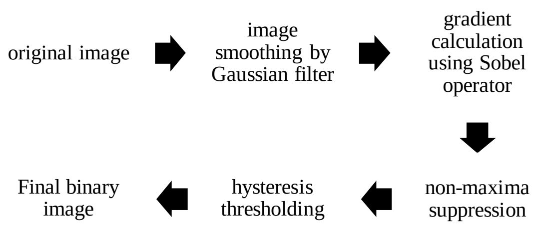

Fig. 1: Steps of Canny Algorithm

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The Canny edge detector uses a Gaussian filter. The image is convolved with the filter. The filter blurs the image to a degree specified by σ to minimize the effect of unwanted information. Fig. 2 (b) is the output of a 5X5 Gaussian filter with σ=1.4 whose input is fig. 2 (a).

Figure 2(a): A test image

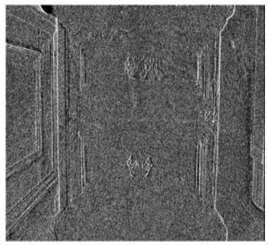

Figure 2(b): Filtered image

The point of interest in the proposed method is the Gaussian filter of the Canny Edge Detector. The filter is used for blurring the image before processing so that unwanted edges or noises are not detected as edges. The Gaussian function is given by.

$$h(x, y)=\exp(-\pi(x^2 + y^2)/\sigma)$$

where the parameter σ (sigma) determines the width of the filter and hence the degree of blurring i.e. the greater the value of sigma the more the blurring is. But this approach gives average results when there are prominent edges and faint edges in the image both of which may be of great significance. If the value of sigma is very high then faint edges will not be detected. On the other hand if sigma is very low then noise may also get detected as edges.

III. PROPOSED METHOD

An easy but effective approach is proposed in this paper in which different values of sigma are applied in different parts of the image instead of processing the entire image with a single value of sigma.

In this approach, the image is divided into a number of sub-images. This number will determine the level of accuracy of the final output i.e. more number of sub-images will give better results. After dividing the image, the mean pixel value of each sub-image is calculated and depending upon these values each sub-image will be processed by a Gaussian filter with different sigma values. It is quite evident that sub-images having very high or very low mean pixel values are likely to have faint edges while the ones with intermediate mean values are likely to have prominent edges. Therefore, the sub-images with higher or lower mean values are processed with small values of sigma while others are processed with high values of sigma.

A. *Proposed Algorithm:*

input: An image I; number of sub-images(k); sigma value (σ) assignment for a corresponding range of mean values.
output: a binary image of edges (O).
A (1,2,…k)←sub-images of I;
for i=1:k
    M(i)=mean A(i);
    σ ← f(M(i));
    C(i)=Canny(A(i), σ);
end

O={C(1), C(2), ……..,C(K)};Final Stage

B. *Experimental Results:*

Experiments were conducted on various images and better results were observed. One of them is shown in fig. 3(a)-3(f). From fig. 3(f) it is evident that the proposed method gives better results than the original algorithm. Here only sigma is varied and other components e.g. thresholding values are kept constant.

Fig. 3(a): Original Image

Fig. 3(b): σ=1.5

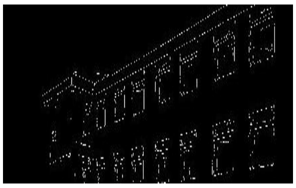

Fig. 3(c): σ=3.0

Fig. 3(d): σ=5.0

Fig. 3(e): σ=10.0

Fig. 3(f): σ is variable

C. *Entropy Calculation:*

Entropy is defined as measure of average uncertainty and is given by the formula-

$$H=-\sum p\log_2 p$$

where p is the histogram count.

Table I: ENTROPIES OF FIGURES 3(a)-3(f)

Image	Entropy (H)
Original image	**5.6599**
σ=1.5	**3.8562**
σ=3	**3.5322**
σ=5	**3.4533**
σ=10	**3.3153**
Proposed method	**3.2370**

From Table I it is clear that the proposed method has the lowest entropy. The canny algorithm can have lower entropy than the proposed method but the information will be highly degraded because of removal of significant edges.

The following figures 4(a)-4(f) show the Histograms of Fig. 3(a)-3(f) respectively.

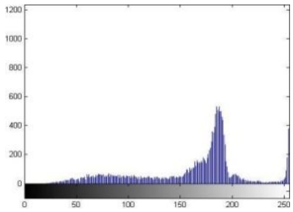

Fig. 4(a): Histogram of Fig. 3(a)

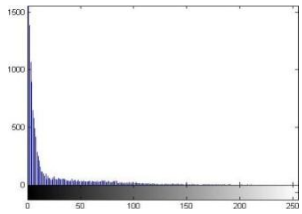

Fig. 4(b): Histogram of Fig. 3(b)

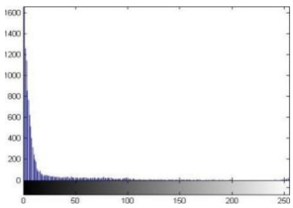

Fig.4(c): Histogram of Fig. 3(c)

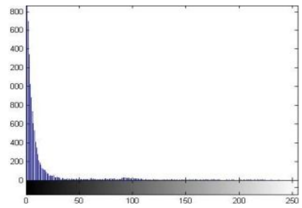

Fig. 4(d): Histogram of Fig. 3(d)

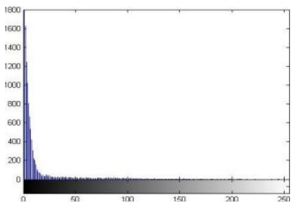

Fig. 4(e): Histogram of Fig.3(e)

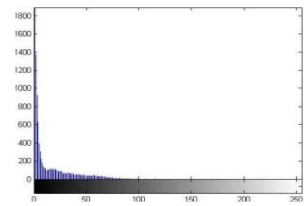

Fig. 4(f): Histogram of Fig. 3(f)

IV. CONCLUSION

The proposed modified Canny algorithm uses different values of sigma for different parts of the image. The values of sigma were chosen carefully so that the output image has true edges only. In future the exact relationship between mean pixel value and sigma may be found out. MATLAB was used for generating the output images.

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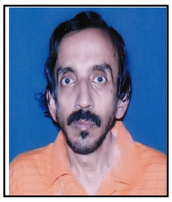

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