

Improved Canny Edge Detection Algorithm

Hawraa Sabah Naser¹

¹Ministry of Education

Publication Date: 2026/10/06

Abstract: Detect the edge consider as a very important part of the image processing in various fields such as recognizing objects, medical field robot vision ,etc. using improved canny technique and add a pre-processing step that help to make enhanced image to a better edge detect result ,the improved canny technique used the following step which is Gaussian smoothing, gradient calculation ,non maxing threshold and OTSU technique give more accurate result, the improved canny technique show better accuracy , noise resistance , edge continue .

How to Cite: Hawraa Sabah Naser (2026) Improved Canny Edge Detection Algorithm. *International Journal of Innovative Science and Research Technology*, 11(9), 3012-3014. <https://doi.org/10.38124/ijisrt/26sep1156>

I. INTRODUCTION

Edge detection in image processing is very important in many fields especially with this technical development such as robot vision , image enhancement , recognition , and document analysis. [1,2] the traditional algorithms such as (Robert ,sobel, prewitt) operators use directional variation of mathematical processing method to detect the edge based on gray value variations in each pixel neighborhood in the original image .these methods are very sensitive to noise while canny merge show anti-interference capabilities to signal to noise ratio and accuracy [3] .

II. LITERATURE REVIEW

➤ The Principles of Canny Operators

The basic concept of the canny algorithm is done by applying an operator to detect the edge which has multi step of 3 basic indicator [1]:-

- Low error rate.
- Superior positioning accuracy .
- Effective suppression of false edge .

Applying of Gaussian filter the first step in the method ,the goal of this step is to make sure that this convolution operation can be changed and combined , a zero- mean Gaussian filter of two dimension is applied .hence, a convolution operation on the image . the previous step give a smooth image and eliminate the noise using the following equations[4] :

$$G(x, y) = \frac{1}{2\pi\sigma^2} e^{\frac{-x^2+y^2}{2\sigma^2}} \quad (1)$$

$$I(x, y) = G(x, y) * f(x, y) \quad (2)$$

The original image is represent in the equation as (x, y) , $I(x, y)$ is the out put image that the two

dimensional Gaussian filter is applied on it . the parameter σ is the standard deviation of Gaussian filter function . this step smooth the image and enhance it the next step is calculating the direction and amplitude of the image gradient by use 2×2 template on the gray image and in x, y directions as shown in the following equation [3]

$$G_x(x, y) = [I(x, y + 1) - I(x, y) + I(x + 1, y + 1) - I(x + 1, y)]/2 \quad (3)$$

$$G_y(x, y) = [I(x, y) - I(x + 1, y) + I(x, y + 1) - I(x + 1, y + 1)]/2 \quad (4)$$

After the convolution of the previous equations with the image pixels the output equations will be:

$$E_x = \frac{\partial G}{\partial x} f(x, y) \quad (5)$$

$$E_y = \frac{\partial G}{\partial y} f(x, y) \quad (6)$$

The gradient amplitude $A(x, y)$ and direction $\theta(x, y)$ of the point (x, y) will be obtained by the following equations :

$$A(x, y) = \sqrt{E_x^2(x, y) + E_y^2(x, y)} \quad (7)$$

$$\theta(x, y) = \arctan \left[\frac{E_y(x, y)}{E_x(x, y)} \right] \quad (8)$$

Then a segmentation for the gradient value will apply to ensure the precision of the edge by using the maximum value and set a zero value to the value less than the maximum value , finally apply a double threshold edge connection processing . canny method connect th edge pixels by using 2 threshold T_H and T_L high and low threshold were any point less than T_L discarded and the value greater than T_H are retrained the pixel p is kept as

represent $T_L < p < T_H$ this step will increase the equality of detected edge .

➤ AMF

The initial steps of image enhancement by denoising and smoothing use to inhibit the false edge of noisy pixels instead of gaussian filter using AMF because this filter is more effective with salt and pepper noise as shown in next steps[1]:

- Create an initial population W_j , the window size is set at 3 and the w_{max} is the maximum size. The gray value in the moving window are F_{min}, F_{max} which represent the minimum and maximum value .
- Use the condition $F_{max} > f(x,y) > F_{min}$ to represent the denoised pixel and if it does not set move to step 3.
- If the pixel classified as noise the output pixel will set as median gray value F_{mid} as following $F_{max} > F_{mid} > F_{min}$ other wise move to step 4.
- If the value of the window classified as noise the window will expand by one , if it smaller than maximum window size thw process will return to step 2 .
- Calculate the remaining pixels value average by their distance from center using the equation

$$f_{ag} = \frac{f_1 n_1 + f_2 n_2 + \dots + f_k n_k}{\sum_{i=1}^k n_i} \quad (9)$$

Where f_i is the remaining pixels and n_i is the corresponding weight f_{ag} where the close the pixel to the center the greater weight they have .

The improved AMF algorithm decide if the current pixel is noise before continue to the output directly and expand the window to obtain the median value as extra step to more accurate result by using maximum and minimum value with the window and use the average weight to replace the pixel that has noise all these adjustment make the output more efficient than the traditional methods[5].

➤ Calculation Image Gradient Amplitude

To improve the efficiency of edge detection we will extend the traditional procedure by add another direction to calculate the gradient $x, y, 45^\circ, 135^\circ$ that will add more interpolating [12]

$$G_x(x, y) = I(x+1, y) - I(x-1, y) \quad (10)$$

$$G_y(x, y) = I(x, y+1) - I(x, y-1) \quad (11)$$

$$G_{45^\circ}(x, y) = I(x-1, y+1) - I(x+1, y-1) \quad (12)$$

$$G_{135^\circ}(x, y) = I(x+1, y+1) - I(x-1, y-1) \quad (13)$$

The expressions of calculate the gradient amplitude and direction in the image by using the following equations.

$$G_x(x, y) = \sqrt{G_x(x, y)^2 + G_y(x, y)^2 + G_{45^\circ}(x, y)^2 + G_{135^\circ}(x, y)^2} \quad (14)$$

$$\theta(x, y) = \arctan \left[\frac{G_y(x, y)}{G_x(x, y)} \right] \quad (15)$$

The improved method will increase the accuracy of edge detection in the following equation .

➤ Non Maximum Suppression of Gradient Amplitude

The non maximum of gradient amplitude in canny algorithm consider as a significant feature were this apply on every potential edges and pixel in the image and compare the gradient value of the pixel with the 2 neighboring pixels and the less value will consider as not edge pixel and set to zero this method give more accuracy to edge detection in canny algorithm[6,7].

➤ OTSU Algorithm

The canny operator use a manually threshold set which lack the effect of edge detecting this research use the OTSU algorithm (the maximal inter class variance) that auto select the threshold in the gray image to enhance the edge connection using this two dimensional algorithm which combine the distribution of initial grayscale value and the distribution of the mean grayscale value in the neighborhood to create a 2-dimentional threshold vector to determine optimal threshold value by find the maximum value [8,9]. This method gives satisfactory results when the numbers of pixels in each class are close to each other. Generally intensity is the easiest property which is shared by „pixels“ in particular region. So thresholding is normally used for the segmenting light and dark regions. Here grey level image is converted in to binary image by changing all of the pixels below certain threshold value to ZERO and all above threshold value to ONE [10,11].

• Algorithm:

- ✓ Step 1: Compute histogram for a 2D image.
- ✓ Step 2: Calculate foreground and background variances (measure of spread) for a single threshold.
 - Calculate weight of background pixels and foreground pixels.
 - Calculate mean of background pixels and foreground pixels.
 - Calculate variance of background pixels and foreground pixels.
- ✓ Step 3: Calculate “within class variance”

Consider that we have L gray level in the image $[1, 2, \dots, L]$

The number of the point with gray level at i is denoted by X_i and the total number of points is $X = x_1 + x_2 + \dots + x_L$ the histogram distribution of gray level is:

$$P(i) = \frac{x_i}{X}, x_i \geq 0, \sum_{i=1}^L x_i = 1 \quad (16)$$

Te pixels of the image will divided in two sections C_0, C_1 the foreground and the background and the threshold

t, where C_0 represent pixels in levels $[1, 2, \dots, t]$ and C_1 represent the levels $[t+1, \dots, L]$ the probabilities of the class is show in the following equations:

$$\omega_0 = \omega(t) = \sum_{i=1}^t P(i) \quad (17)$$

$$\omega_1 = 1 - \omega(t) = \sum_{i=t+1}^L P(i) \quad (18)$$

$$\mu_0 = \sum_{i=1}^t \frac{i \cdot P(i)}{\omega_0} = \frac{1}{\omega(t)} \sum_{i=1}^t i \cdot P(i) \quad (19)$$

$$\mu_1 = \sum_{i=t+1}^L \frac{i \cdot P(i)}{\omega_1} = \frac{1}{1-\omega(t)} \sum_{i=t+1}^L i \cdot P(i) \quad (20)$$

Where the ω_0 is the probabilities of foreground, ω_1 is the probabilities of background and μ_0 is the mean gray level in the foreground of the gray image, μ_1 is the mean gray level in the background.

The between class variance σ_B^2 of the C_0, C_1 classes is:

$$\sigma_B^2 = \omega_0(\mu_0 - \mu_T)^2 + \omega_1(\mu_1 - \mu_T)^2 \quad (21)$$

The maximum σ of threshold is $= \max \sigma_B^2, 1 \leq t \leq L$.

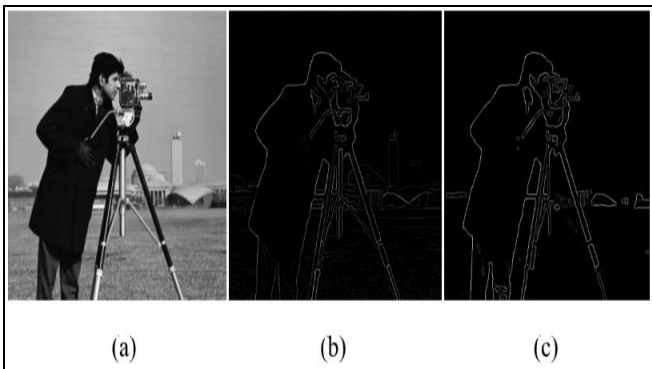


Fig 1 (a) Input Image (b) Traditional Canny Method (c) the Improved Canny Method

III. CONCLUSION

Traditional edge detection methods may have lack accuracy in the detect process because of the various kind of the noise that could happen to any image such as salt & pepper. This improved canny method use a multi steps to enhance the result from Gaussian filter to AMF method, threshold and OTSU method with four all these steps gives a smooth and continuous edge detection that have more accuracy and efficiency.

REFERENCES

- [1.] Nana tao, (2023), enhanced canny algorithm for image edge detection in print quality assessment, IIETA, vol 40, no 3 pp 1281-1287.
- [2.] Daniel van zyl, thambo nyathi, nelishia pillay, Canny genetic programming (CGP) for edge detection.
- [3.] Qibao yan, Rongyu ge, Jian wang, Research on weld edge detection based on improved canny

algorithm, journal of physics: conference series 3068(2025)012152.

- [4.] Ahmed hamid ahmed, Image Edge Detection Using Canny and Sobel Techniques, Journal of al-turath university college (JATUC), vol: 43 no:2.2026 pp.256-274.
- [5.] Junfeng Jing, Shenjuan Liu, Gang Wang, et al. Recent advances on image edge detection: A comprehensive review. Neurocomputing 2022; 503:259–271. doi: 10.1016/j.neucom.2022.06.083.
- [6.] Bin Tian, Wei Wei. Research Overview on Edge Detection Algorithms Based on Deep Learning and Image Fusion. Security and Communication Networks 2022; 2022:1–11. doi:10.1155/2022/1155814.
- [7.] G. Ravivarma, K. Gavaskar, D. Malathi, et al. Implementation of Sobel operator based image edge detection on FPGA. Materials Today: Proceedings 2021; 45:2401–2407. doi:10.1016/j.matpr.2020.10.825.
- [8.] John Canny. A Computational Approach to Edge Detection. IEEE Transactions on Pattern Analysis and Machine Intelligence 1986; PAMI-8(6):679–698. doi:10.1109/TPAMI.1986.4767851
- [9.] Rui Sun, Tao Lei, Qi Chen, et al. Survey of Image Edge Detection. Frontiers in Signal Processing 2022; 2:826967. doi:10.3389/frsip.2022.826967.
- [10.] Ehsan Akbari Sekehravani, Eduard Babulak, Mehdi Masoodi. Implementing canny edge detection algorithm for noisy image. Bulletin of Electrical Engineering and Informatics 2020; 9(4):1404–1410. doi:10.11591/eei.v9i4.1837.
- [11.] Ravivarma, G., Gavaskar, K., Malathi, D., Asha, K.G., Ashok, B., Aarthi, S. (2021). Implementation of Sobel operator based image edge detection on FPGA. Materials Today: Proceedings, 45: 2401-2407. <https://doi.org/10.1016/j.matpr.2020.10.825>.
- [12.] Wang, Z. X., & Wang, W. (2018). The research on edge detection algorithm of lane. EURASIP Journal on Image and Video Processing, 2018: 98. <https://doi.org/10.1186/s13640-018-0326-2>.