International Journal of Computer Science Trends and Technology (IJCST) – Volume 12 Issue 3, May - Jun 2024

RESEARCH ARTICLE OPEN ACCESS

Edge Detection Using Canny Edge Detector Algorithm In Image Processing

M. Rega [1], Dr. S. Sivakumar [2]

[1] Research Scholar, Department of Computer and Information Science, Annamalai University,Annamalainagar
[2] Assistant Professor, PG Department of Computer Science,Government Arts College,Chidambaram
Deputed from Annamalai University, Annamalainagar

ABSTRACT

The concept of edge detection is used to detect the location and presence of edges by making changes in the intensity of an image. Different operations are used in image processing to detect edges. It can detect the variation of grey levels but it quickly gives response when a noise is detected. In image processing, edge detection is a very important task. Edge detection is the main tool in pattern recognition, image segmentation and scene analysis. It is a type of filter which is applied to extract the edge points in an image. Sudden changes in an image occurs when the edge of an image contour across the brightness of the image. In image processing, edges are interpreted as a single class of singularity. In a function, the singularity is characterized as discontinuities in which the gradient approaches are infinity. The Canny edge detector is an edge detection operator that uses a multi-stage algorithm to detect a wide range of edges in images. Canny edge detection is a technique to extract useful structural information from different vision objects and dramatically reduce the amount of data to be processed. It has been widely applied in various computer vision systems.

Keywords— Edge detection, canny edge detector algorithm, Image processing

I. INTRODUCTION

Image processing is the process of transforming an image into a digital form and performing certain operations to get some useful information from it. The image processing system usually treats all images as 2D signals when applying certain predetermined signal processing methods. Edge detection is an image processing technique for finding the boundaries of objects within images. It works by detecting discontinuities in brightness. Edge detection is used for image segmentation and data extraction in areas such as image processing, computer vision, and machine vision. Canny edge detection algorithm [14] is one of the most reliable algorithms for edge detection. Our results show that for most cases, the shapes of crystals are kept intact in the resulting edge image. An edge image can contain many edges which may or may not be part of the crystals. The Canny edge detector is an edge detection operator that uses a multistage algorithm to detect a wide range of edges in images. Edges characterize boundaries and are therefore a problem of fundamental importance in image processing. Image Edge detection significantly reduces the amount of data and filters out useless information, while preserving the important structural properties in an image. Since edge detection is in the forefront of image processing for object detection, it is crucial to have a good understanding of edge detection algorithms. Gradient based Edge Detection: The gradient method detects the edges by looking for the maximum and minimum in the first derivative of the image. Laplacian based Edge Detection: The Laplacian method searches for zero crossings in the second derivative of the image to find edges. An edge has the one-dimensional shape of a ramp and calculating the derivative of the image can highlight its location.

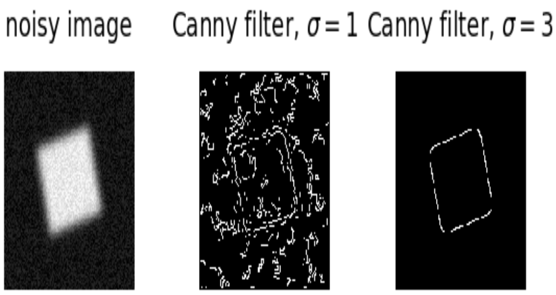
II. RELATED WORKS

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 performance of the Canny algorithm depends heavily on the adjustable parameters, α, which is the standard deviation for the Gaussian filter, and the threshold values, ‘T1’ and ‘T2’. α also controls the size of the Gaussian filter. The bigger the value for α, 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. Raman Maini & Dr. Himanshu Aggarwal International Journal of Image Processing (IJIP), Volume (3): Issue (1) 1 Study and Comparison of Various Image Edge Detection Techniques.

Shashank Mathur and Anil Ahlawat [2], proposed an edge detection algorithm using windowing technique. This is based on fuzzy relative pixel values in the 3*3 pixels mask for scanning of image. Their technique based to a set of fuzzy condition used to check the pixel magnitude gradient in the window by made comparison of pixel values with adjacent pixels.

Yasar Beceriklil and Tayfun [3], proposed fuzzy rule-based algorithm provide the flexibility in handling edge thickness in the processed image. They studied that edge detection which is use full is used in image segmentation, registration and identification purposes. Variation of intensity/gray level defines their shape and size.

III. THE PROPOSED MODEL



There are 5 edge detection operators they are as follows:

1. Sobel Edge Detection Operator

The Sobel edge detection operator extracts all the edges of an image, without worrying about the directions. The main advantage of the Sobel operator is that it provides differencing and smoothing effect.

Sobel edge detection operator is implemented as the sum of two directional edges. And the resulting image is a unidirectional outline in the original image.

Sobel Edge detection operator consists of 3x3 convolution kernels. Gx is a simple kernel and Gy is rotated by 90°

These Kernels are applied separately to input image because separate measurements can be produced in each orientation i.e Gx and Gy.

Following is the gradient magnitude:

$$|G| = \sqrt{Gx^2 + Gy^2}$$

As it is much faster to compute An approximate magnitude is computed:

$$|G| = |Gx| + |Gy|$$

2. Robert's cross operator

Robert's cross operator is used to perform 2-D spatial gradient measurement on an image which is simple and quick to compute. In Robert's cross operator, at each point pixel values represents the absolute magnitude of the input image at that point.

Robert's cross operator consists of 2x2 convolution kernels. Gx is a simple kernel and Gy is rotated by 90o.

+1	0
0	-1

Gx

0	+1
-1	0

Gy

3. Laplacian of Gaussian

The Laplacian of Gaussian is a 2-D isotropic measure of an image. In an image, Laplacian is the highlighted region in which rapid intensity changes and it is also used for edge detection. The Laplacian is applied to an image which is been smoothed using a Gaussian smoothing filter to reduce the sensitivity of noise. This operator takes a single grey level image as input and produces a single grey level image as output.

$$L(x, y) = \frac{\Delta^2 I}{\Delta x^2} + \frac{\Delta^2 I}{\Delta y^2}$$

4. Prewitt operator

Prewitt operator is a differentiation operator. Prewitt operator is used for calculating the approximate gradient of the image intensity function. In an image, at each point, the Prewitt operator results in gradient vector or normal vector. In Prewitt operator, an image is convolved in the horizontal and vertical direction with small, separable and integer-valued filter. It is inexpensive in terms of computations.

$$h_1 = \begin{pmatrix} 1 & 1 & 1 \\ 0 & 0 & 0 \\ -1 & -1 & -1 \end{pmatrix}$$

$$h_2 = \begin{pmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{pmatrix}$$

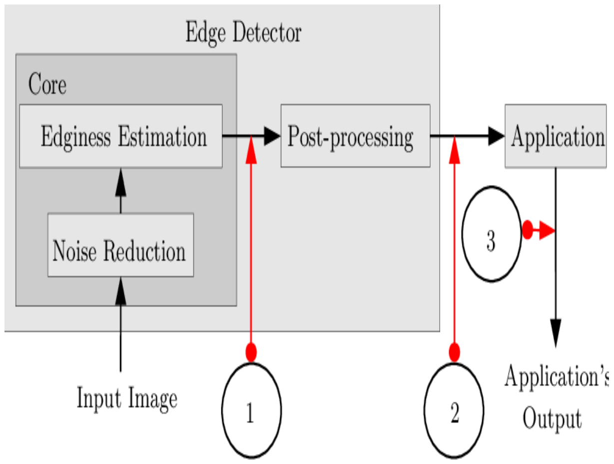
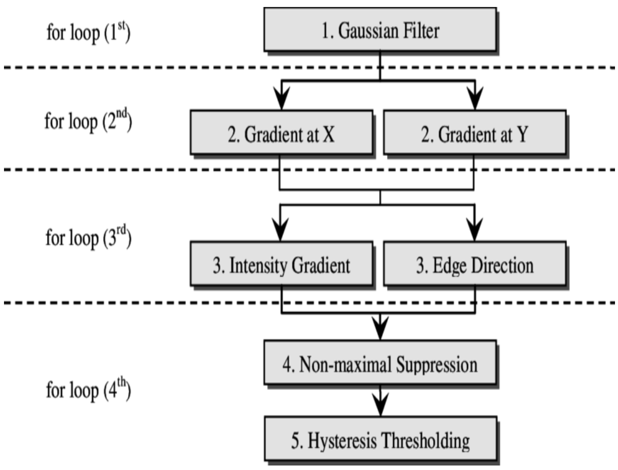


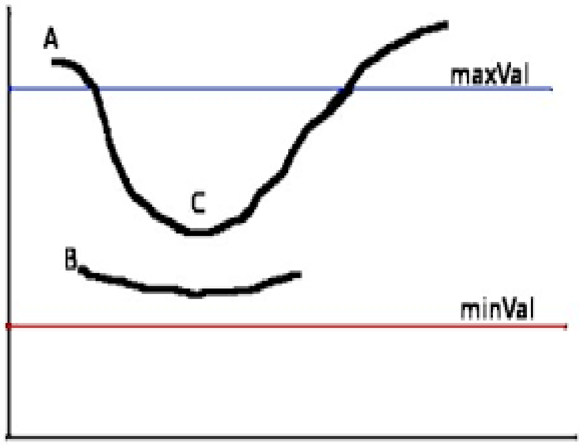
Figure 1: The cameraman image and its edges extracted

Sample images

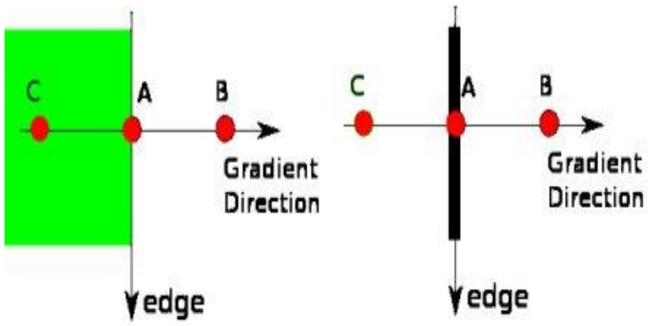


Looping process

This stage decides which are all edges are really edges and which are not. For this, we need two threshold values, minVal and maxVal. Any edges with intensity gradient more than maxVal are sure to be edges and those below minVal are sure to be non-edges, so discarded. Those who lie between these two thresholds are classified edges or non-edges based on their connectivity. If they are connected to "sure-edge" pixels, they are considered to be part of edges. Otherwise, they are also discarded. See the image below:



After getting gradient magnitude and direction, a full scan of image is done to remove any unwanted pixels which may not constitute the edge. For this, at every pixel, pixel is checked if it is a local maximum in its neighborhood in the direction of gradient. Check the image below:



Smoothened image is then filtered with a Sobel kernel in both horizontal and vertical direction to get first derivative in horizontal direction (Gx) and vertical direction (Gy). From these two images, we can find edge gradient and direction for each pixel as follows:

Edge_Gradient(G)=G2x+G2y/
√Angle(θ)=tan−1(GyGx)

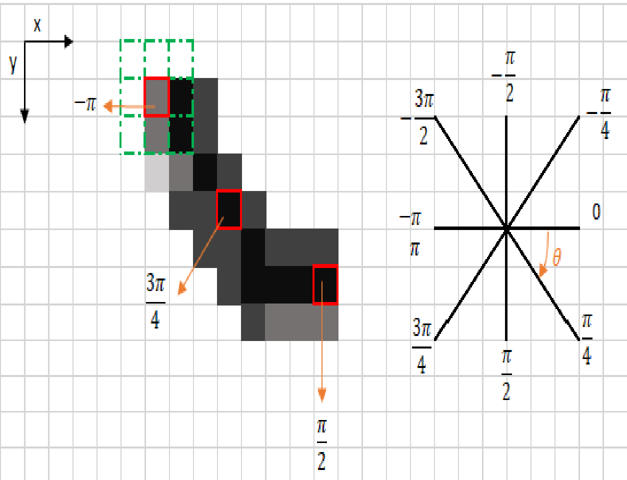
Since the mathematics involved behind the scene are mainly based on derivatives (cf. Step 2: Gradient calculation), edge detection results are highly sensitive to image noise. One way to get rid of the noise on the image, is by applying Gaussian blur to smooth it. To do so, image convolution technique is applied with a Gaussian Kernel (3x3, 5x5, 7x7 etc…). The kernel size depends on the expected blurring effect. Basically, the smallest the kernel, the less visible is the blur. In our example, we will use a 5 by 5 Gaussian kernel. The equation for a Gaussian filter kernel of size $(2k+1)\times(2k+1)$ is given by:

$$H_{ij} = \frac{1}{2\pi\sigma^2}\exp\left(-\frac{(i-(k+1))^2+(j-(k+1))^2}{2\sigma^2}\right); 1 \le i, j \le (2k+1)$$

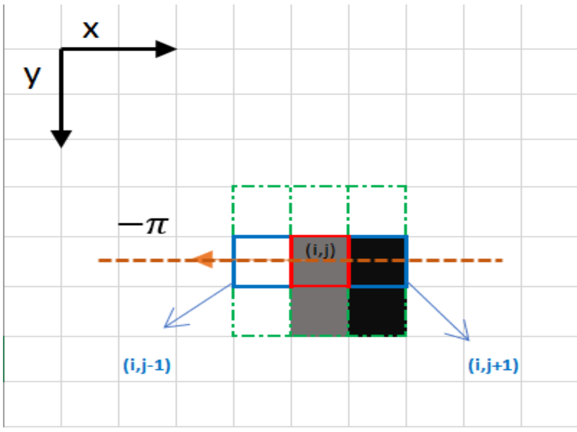
The Gradient calculation step detects the edge intensity and direction by calculating the gradient of the image using edge detection operators. Edges correspond to a change of pixels' intensity. To detect it, the easiest way is to apply filters that highlight this intensity change in both directions: horizontal (x) and vertical (y). When the image is smoothed, the derivatives ***Ix*** and ***Iy*** w.r.t. ***x*** and ***y*** are calculated. It can be implemented by convolving ***I*** with Sobel kernels ***Kx*** and ***Ky***, respectively:

$$K_x = \begin{pmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{pmatrix}, K_y = \begin{pmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{pmatrix}.$$

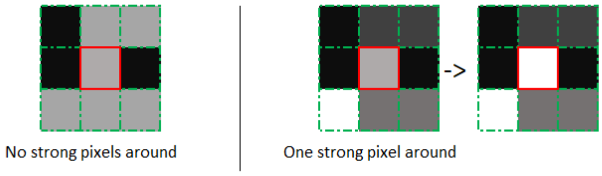
Ideally, the final image should have thin edges. Thus, we must perform non-maximum suppression to thin out the edges. The principle is simple: the algorithm goes through all the points on the gradient intensity matrix and finds the pixels with the maximum value in the edge directions.



The upper left corner red box present on the above image, represents an intensity pixel of the Gradient Intensity matrix being processed. The corresponding edge direction is represented by the orange arrow with an angle of -pi radians (+/-180 degrees).



Based on the threshold results, the hysteresis consists of transforming weak pixels into strong ones, if and only if at least one of the pixels around the one being processed is a strong one, as described below:



IV. CONCLUSION

Edge detection is an image processing technique for finding the boundaries of objects within images. It works by detecting discontinuities in brightness. Edge detection is used for image segmentation and data extraction in areas such as image processing, computer vision, and machine vision. Canny edge detection algorithm is one of the most reliable algorithms for edge detection. Canny edge detection is a technique to extract useful structural information from different vision objects and dramatically reduce the amount of data to be processed. It has been widely applied in various computer vision systems.

REFERENCES

[1] Raman Maini & Dr. Himanshu Aggarwal International Journal of Image Processing (IJIP), Volume (3) : Issue (1) 1 Study and Comparison of Various Image Edge Detection Techniques.

[2] Methods of Image Edge Detection: A Review Dharampal and Vikram Mutneja

[3] Study and Comparison of Different Edge Detectors for Image Segmentation By Pinaki Pratim Acharjya, Ritaban Das & Dibyendu Ghoshal.

[4] https://ieeexplore.ieee.org/abstract/document/6885761#:~:text=An%20improved%20Canny%20edge%20detection%20algorithm

[5] Edge connection based Canny edge detection algorithm, Ziqi Zhang &
Haiyang Liu

[6] Pustokhina IV, Pustokhin DA, Kumar Pareek P, Gupta D, Khanna A, Shankar K (2021) Energy-efficient cluster-based unmanned aerial vehicle networks with deep learning-based scene classification model. Int J Commun Syst 34(8):e4786

[7] Saeed S, Latif MA, Rajput MA (2021) Fuzzy-based multi-crop classification using high resolution UAV imagery. Quaid-EAwam Univ Res J Eng Sci Technol Nawabshah 19(1):1–8

[8] Lin D, Lin J, Zhao L, Wang ZJ, Chen Z (2021) Multilabel aerial image classification with a concept attention graph neural network. IEEE Trans Geosci Remote Sens 23:1–12

[9] Alshehri A, Bazi Y, Ammour N, Almubarak H, Alajlan N (2019) Deep attention neural network for multi-label classification in unmanned aerial vehicle imagery. IEEE Access 7:119873–119880

[10] Baranwal E, Raghvendra S, Tiwari PS, Pande H (2021) Health monitoring and assessment of the cultural monument through unmanned aerial vehicle (UAV) image processing. In: Advances in systems engineering. Springer, Singapore, pp 145–160

[11] Bashmal L, Bazi Y, Al Rahhal MM, Alhichri H, Al Ajlan N (2021) UAV image multi-labeling with data-efficient transformers. Appl Sci 11(9):3974

[12] Ragab, M., 2023. Leveraging mayfly optimization with deep learning for secure remote sensing scene image classification. *Computers and Electrical Engineering*, *108*, p.108672.

[13] Laban, N., Abdellatif, B., Ebied, H.M., Shedeed, H.A. and Tolba, M.F., 2020. Multiscale satellite image classification using deep learning approach. *Machine Learning and Data Mining in Aerospace Technology*, pp.165-186.

[14] Hilal, A.M., Al-Wesabi, F.N., Alzahrani, K.J., Al Duhayyim, M., Ahmed Hamza, M., Rizwanullah, M. and García Díaz, V., 2022. Deep transfer learning based fusion model for environmental remote sensing image classification model. *European Journal of Remote Sensing*, *55*(sup1), pp.12-23.