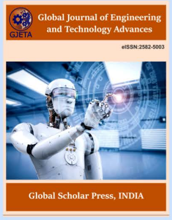
Global Journal of Engineering and Technology Advances

eISSN: 2582-5003

Cross Ref DOI: 10.30574/gjeta

Journal homepage: https://gjeta.com/



(Review Article)

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Subject review: Image edge detection techniques

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Global Journal of Engineering and Technology Advances, 2024, 19(01), 001–005

Publication history: Received on 20 February 2024; revised on 29 March 2024; accepted on 01 April 2024

Article DOI: https://doi.org/10.30574/gjeta.2024.19.1.0054

Abstract

The effective interpretation of an image's content and the extraction of relevant information from it are two of the process' key goals. Many researchers in the field of picture interpretation have brought this to our attention. To properly mine the edges information from the image is one of the most difficult steps in image interpretation. The contours of an item may be used to create edges, which are the basic elements of a picture. Edge detection is a commonly used imaging technique that may be created from an object's outline. Edge detection is frequently employed in image processing and analysis. There are several types of algorithm to detect the edges. In this paper, the comprehensive analysis is done on the several edge detection techniques such as Prewitt, Sobel, Canny, Roberts and Laplacian of Gaussian and other methods.

Keywords: Image segmentation; Edge detection; Prewitt; Sobel; Laplacian of Gaussian; Canny; Roberts fuzzy; Hopfield neural

1. Introduction

The technique of discovering and recognizing abrupt discontinuities in a picture is known as edge detection. The borders of objects in a scene are marked by discontinuities, which are sharp variations in pixel intensity. The picture is convolved with an operator (a 2-D filter) in traditional edge detection techniques. This operator is designed to be sensitive to significant gradients in the image while returning values of zero in uniform regions. There are a plethora of edge detection operators available, each of which is made to be sensitive to a particular kind of edges. Edge orientation, noise environment, and edge structure are factors that are taken into consideration while choosing an edge detection operator. An typical direction in which the operator is most sensitive to edges is determined by its geometry. Operators can be tuned to search for edges that are horizontal, vertical, or diagonal. In noisy photos, edge recognition is challenging because both the noise and the edges have high frequency content. Edges get twisted and blurred as a result of noise reduction efforts. Since noisy image operators frequently have greater coverage areas, they can average enough data to account for isolated noisy pixels. As a result, the identified edges' localization is less precise. Not every edge entails a sharp decrease in intensity. location of the edges that were found. Not every edge entails a sharp decrease in intensity. It is possible for things to have borders that are defined by a slow shift in intensity due to phenomena like refraction or poor focus [1].

2. Edge Detection Techniques

The quantity of information that must be processed, including crucial details about an object's shape in a picture, is reduced by the edge presentation of the image. Localized fluctuations in picture intensity are called edges. Between the borders of two zones, the edge develops. The edge may be mined for the essential data. The method of finding edges with appropriate orientation is called edge detection, and it is a crucial tool for segmenting images. With the use of

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operators, the edge detection technique converts the original picture into the edge image. Finding the discontinuities in intensity values is a well-known procedure. The picture is entered initially and turned into a grayscale image throughout the edge detection phase. Apply the edge detector after that to find and extract any edges present in the output of the image. The various techniques are available for detecting the edges information such as Roberts, Prewitt, Sobel, Laplacian of Gaussian, Canny and otherwise . These techniques are described as follows [2,3].

3. Literature Survey

Lawrence Roberts in 1965, suggested the Roberts edge detection method for identifying the edges in image. It is an easy and effective computational strategy. It calculates an image's spatial gradient. the estimated absolute magnitude value of the spatial gradient of the inputted picture at that position is represented by the pixel value at that location in the final image. It creates edges that are present in the input picture, which is a grayscale image. The primary drawbacks of this method are that it is not symmetrical and that it cannot identify certain types of edges that are multiplied by 45 degrees. The pair of 2x2 convolution masks are contained in the Robert operator [4,5].

Prewitt, in 1970 proposed the Prewitt edge detection method. The algorithm used to determine the size and direction of the edges is appropriate. With the highest reaction from the mask, this method directly assesses edge directions. There are eight directions. However, even the closest straight instructions are not always accurate. Similar to a Sobel operator, the Prewitt operator is simpler to use than a Sobel operator but occasionally yields noisier results. the pair of 8-direction 3x3 convolution masks [4,6,7].

Irwin Sobel, in 1970, has proposed the Sobel edge detection method. While averaging, the Sobel kernel prioritizes the center pixel since it depends on the central difference. Better noise suppression qualities are one of the benefits of Sobel kernel over Prewit kernel. The pair of 3x3 convolution masks shown in Figure 3 are part of the Sobel edge detection algorithm. One mask is just 90 degrees turned around the other. This mask is capable of handling edges that angle 45 degrees from the pixel grid. The input picture may clearly be applied to this mask to get gradient components in any direction. [4,5,8].

Marr in 1982, The Gaussian Laplacian (LOG) approach has been introduced. On the second order derivative, LOG is based. LOG computes the Laplacian after first smoothing the picture. The double edge picture is the result of this procedure. After locating edges, it looks for the zero crossing that occurs between two edges. A pair of 3x3 convolution masks are used in the LOG edge detection method [5.9].

John Canny in 1983, presented the clever edge detecting method. It is the most common, effective, and widely utilized edge detection technique. Before extracting the edges, it removes the noise from the picture. Compared to other approaches currently in use, Canny yields superior results when it comes to extracting edges. The Canny operator effectively suppresses noise and has control over many aspects of the edge picture.Two 3x3 convolution masks are used in the OG edge detection method [4,8.10] .

C.Nagaraju et.al in 2011, suggested a revolutionary edge identification technique based on the multi-component morphology of eight different bearings. A constructed weighted strategy is then used to obtain the final edge findings. Comparing the suggested technique to standard numerical morphological edge detection algorithms and differential edge detection operators, it is more productive. G.T. Shrivakshan 1,[11].

Dollár and Zitnick in (2013), this approach uses the resilience of random decision forest to recognize straight line boundaries in various places and directions inside the picture, and trains a random forest classifier to understand the mapping connection between image pixels and label set. For the majority of tiny photos with huge, smooth objects, the technique still offers excellent edge recognition benefits even though it overlooks certain curve borders and connection points. The method's training time is significantly reduced as compared to the structured forest algorithm, and its training memory stays relatively modest [12].

Dollár and Zitnick, in 2014, suggested a generalized structured learning algorithm (SE) for edge detection that, given a block of input photos, converts the edge detection issue into a prediction of local segmentation masks. The structured information innate to the picture edge pixels is captured by this approach using a random forest structure. Structured labels are then used to ascertain the splitting function for each branch in the tree. However, the structured output space is high-dimensional or complicated, and the information gain of structured labels is not well defined, making it difficult to train random forests using structured labels. Then, each tree predicts an edge pixel label, and Dollár et al. convincingly transferred structured labels to a discrete space where conventional information gain metrics can be assessed. A random forest is then used to aggregate the final picture edge detection findings by integrating the outputs of several trees. Multiscale detection modules and sharpening (SH) are also included to improve the outcome [13.14.15].

Malhotra in 2013, outlined techniques for edge segmentation of satellite photos that used edge detection to explain several forms of fuzzy logic. further discussed the Bacterial Foraging Optimization Technique and the CBIR Technique. Wisam F. AI-Azzo2, Thabit Sultan Mohammed1, and others are able to quickly and accurately identify edges from hazy photos. First, the fast multilevel fuzzy enhancement (FMFE) technique is used to improve the contrast of the picture by utilizing a simple transformation function that is based on two image thresholds. Second, the two-stage edge detection operator extracts the edges from the enhanced picture by first identifying the edge candidates based on the image's local features. Next, the edge detection operator uses the gradient values' extremes to identify the real edge pixels. They showed that the approach performs better than the Sobel operator, Canny operator, standard fuzzy edge detection technique, and other multilayer fuzzy edge detection algorithms because it can extract the thin edges and eliminate the incorrect edges from the image [16].

Lu et al. suggested using a fuzzy neural network system to identify and improve edges by recovering lost edges and removing noise-induced false edges. Three phases made up the algorithm: edge detection using a three-layer feed forward fuzzy neural network, edge enhancement via a modified Hopfield neural network, and adaptive fuzzification via fuzzification of the input patterns. A fuzzy neural network was trained by first fuzzifying and using the typical sample patterns. The edge elements with eight orientations may be identified by the trained network. High edge membership pixels were traced for further processing. Neuron linkages in the Hopfield neural network were established based on the competitive process and constraint fulfillment. To determine the ultimate stable result containing the improved edge measurement, a criterion was given [17].

Liang and Looney, presented the technique for competitive fuzzy edge detection. They used a fuzzy set membership function based on extended ellipsoidal Epanechnikov functions and a fuzzy classifier that divides picture pixels into six groups: background (no edge), speckle (noisy edge), and four distinct types of edges (in four orientations)[18].

Chang, utilized a unique neural network architecture for edge identification. He developed the Contextual Hopfield Neural Network (CHNN) technique, which identifies edges in medical CT and MRl images. The CHNN maps the 2D Hopfield network at the original picture plane, in contrast to traditional 2D Hopfield neural networks. The network may address the issue of unconnected fractions by using direct mapping, which allows pixels' contextual information to be included into a pixel's labeling CHNN.

Furthermore, a quick convergence is achieved by mitigating the difficulty of satisfying stringent restrictions. The outcomes of our experiments demonstrate that the CHNN outperforms Laplacian-based, Marr-Hildreth's, Canny's, and wavelet-based approaches in obtaining more suitable and continuous edge points [19].

Koschan and Abidi [20] provided an overview of methods for identifying and categorizing edges in color photographs. Edge detection in color photos has not gotten the same attention as it has in grayscale images, which is a well-established field. Color pictures and gray-level images vary primarily in that each pixel in a color image is assigned a color vector, which is typically made up of three components. Thus, vector-valued image functions are handled rather than scalar image functions in color image processing.

Based on their basic methods, the techniques used for this can be divided into two classes: vector-valued techniques, which treat the color information as color vectors in a vector space supplied with a vector norm, and monochromatic-based techniques, which treat information from the individual color channels separately at first and then combine them together. They claimed that compared to gray-level edge operators, color edge operators can identify more edges.

As a result, color photos can provide extra information that grayscale images might not be able to. Nevertheless, whether or not these color edge qualities are necessary depends on the application. Apart from the quantitative and qualitative benefits of detecting edges with color, color information also makes edge classification possible. The assessment of color information is necessary for this kind of categorization[20].

Giraudon, suggested a method that, as opposed to a zero-crossing of the first derivative, finds a line at a negative local maximum of the image's second derivative. By convolving the picture with the difference between two Gaussians with near scales, he was able to estimate the second derivative. Along the gradient direction, a negative maximum is sought after. Since the gradient value is too tiny to be employed at the peak point, Giraudon's detector's primary flaw stems from its usage of gradients. Ziou created an optimum line detector using Canny's criterion and a 1D ideal roof model [21.22].

Haralick,suggested a polynomial-fitting technique. A linear combination of discrete bases of Tchebychev's polynomial of order less than or equal to three was used to fit the picture. At pixels where the first directional derivative zero-crosses in a direction that optimizes the second directional derivative, lines appear[23].

Yu and Chang . offered a context-based, adaptive edge detection method. The suggested method detects edges by utilizing the data from predictive error values that the gradient-adjusted predictor (GAP) generates. To generate the predicted values, GAP employs a context, which is a collection of the intensity values of nearby pixels that have already been analyzed and are determined by a template. The current pixel's status as an edge point is determined by examining its context inside the GAP casual template [24].

Shashank Mathur and Anil Ahlawat, suggested an edge detection technique for image scanning that makes use of windowing pixel values in the 3*3 pixel mask. Their method. This uses a fuzzy relative approach based on a series of fuzzy conditions to compare the values of nearby pixels in order to determine the gradient in pixel magnitude inside the window[25].

Dharampal et al. [26], proposed an by the variation in rules eas2ily. He suggested an enhanced approach to edge identification using type-1 fuzzy logic. The Sobel operator is used in this work in conjunction with a type-1 fuzzy inference system (T1FIS), and the authors find that T1FIS outperforms the conventional edge detection techniques[26]

4. Conclusion

According to this study, narrow edges and smooth continuous pixels may both be produced with the Canny method in an equally acceptable manner. The Laplacian approach has superior edge characteristics over the Robert, Prewitt, and Sobel methods, in contrast to the clever method. A thin, smooth edge cannot be produced by these techniques. Nevertheless, noise pixels frequently affect the Laplacian and Canny algorithms. Perfectly filtering a noisy picture is not always achievable. The results of edge detection will be impacted by noisy pixels that are not removed. After conducting our analysis, we have concluded that Canny edge detection produced a better result for CMFD pictures in MICC-F220 datasets than other edge detection methods.

But the fuzzy rules base has extra advantages, such as the ability to change the edge thickness by the addition of new rules or a change of parameters. For this reason, it is a flexible structure that can be used at any time to develop edge detection processes. In the future, we will detect edges using the fuzzy rule base since the fuzzy based edge detection approach offers less complexity and a flexible structure.

Compliance with ethical standards

Acknowledgments

The authors would like to thank the Mustansiriyah University (www.uomustansiriyah.edu.iq) Baghdad, Iraq for supporting this work.

Disclosure of conflict of interest

All authors declare that they have no conflict of interest.

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