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A Review Paper: On Various Edge Detection Techniques

Dr. Krishna Raj[1], Pragya Gautam[2] , Kapil Dev Tiwari[3] , Vipul Goel[4]
[1,2,3,4] *Department of Electronics Engineering, Harcourt Butler Technical University Kanpur, India*

Abstract: Edge detection is an important phenomenon in image segmentation. In general kernel based methods like Sobel, Canny, Roberts etc. are used which are based on first and second derivatives pixels intensity. Due to the some of the limitations of such approaches soft computing based methods are also evolved. This paper presented an overview of the kernel and soft computing based methods along with notable research done in the field of edge detection. Basis analogies of the methods have been described along with literature survey of each class of methods.
Keywords: Edge detection, swarm intelligence, fixed thresholding

I. INTRODUCTION

Edge detection is a technique which denotes the process of identifying and locating sharp discontinuities in an image. These discontinuities are sudden changes within the pixel intensity which symbolize the edges of objects in a picture. Preceding edge detection performance is performed by convolving the image with an associate operator (a 2D filter) [1-2] that's created up to be prone to huge gradients within the image whereas returning the values of zero in associate uniform regions. There are numerous edge detection operators are out there that are designed to be sensitive to the certain kinds of edges. Edge discovery is generally vital for picture examination like division, enrollment and distinguishing proof of scene's articles. It is the most utilized shapes for identifying the valuable discontinuities in the gray level picture.

II. EDGE DETECTION TECHNIQUES

A. Sobel Operator

The operator consists of a pair of 3×3 convolution kernels as shown in Figure 2.1. One kernel is simply the other rotated by 90°.

-1	0	+1
-2	0	+2
-1	0	+1

G_x

+1	+2	+1
0	0	0
-1	-2	-1

G_y

Figure 2.1: Sobel kernels in x and y directions

These kernels are designed to respond maximally to edges running vertically and horizontally relative to the pixel grid, one kernel for each of the two perpendicular orientations. The kernels can be applied separately to the input image, to produce separate measurements of the gradient component in each orientation (call these G_x and G_y). These can then be combined together to find the absolute magnitude of the gradient at each point and the orientation of that gradient. The gradient magnitude is given by [3]:

$$|G| = \sqrt{G_x^2 + G_y^2}$$

Typically, an approximate magnitude is computed using:

$$|G| = |G_x| + |G_y|$$

which is much faster to compute.

The angle of orientation of the edge (relative to the pixel grid) giving rise to the spatial gradient is given by:

$$\theta = \arctan(G_y / G_x)$$

B. Robert's Cross Operator

The Roberts Cross operator performs a simple, quick to compute, 2-D spatial gradient measurement on an image. Pixel values at each point in the output represent the estimated absolute magnitude of the spatial gradient of the input image at that point. The operator consists

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of a pair of 2×2 convolution kernels as shown in Figure 2.2. One kernel is simply the other rotated by 90°. This is very similar to the Sobel operator.

+1	0
0	-1

G_x

0	+1
-1	0

G_y

Figure 2.2: Robert kernels in x and y directions

These kernels are designed to respond maximally to edges running at 45° to the pixel grid, one kernel for each of the two perpendicular orientations. The kernels can be applied separately to the input image, to produce separate measurements of the gradient component in each orientation (call these G_x and G_y). These can then be combined together to find the absolute magnitude of the gradient at each point and the orientation of that gradient. The gradient magnitude is given by:

$$|G| = \sqrt{G_x^2 + G_y^2}$$

although typically, an approximate magnitude is computed using:

$$|G| = |G_x| + |G_y|$$

which is much faster to compute.

The angle of orientation of the edge giving rise to the spatial gradient (relative to the pixel grid orientation) is given by:

$$\theta = \arctan(G_y / G_x) - 3\pi / 4$$

C. Prewitt's Operator

Prewitt operator is similar to the Sobel operator and is used for detecting vertical and horizontal edges in images.

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

III. NOTABLE CONTRIBUTIONS

A. Kernel Based Methods

Edward. et al. [4] have suggested a sub-pixel procedure for finding edges of an object which enhance the accuracy of measurement quickly. We normally requires Sub-pixel edge detection technique and localization tools in the noisy images for the artificial vision applications, particularly for having on line dimensional control of developed components. Numerous edge detection methodologies with pixel resolution are quite famous well and a portion of them are developed to be robust against image corruption.

1) *Xin et al. (2012):* proposed an algorithm which is a advanced version of the canny edge detection algorithm to operate on colour images [5]. The proposed algorithm is based on quaternion weighted average filter (QWAF) and vector analysis to deal with the weakness of the traditional canny edge detection. The algorithm used QWAF with a sliding window of 9x9 to suppress the Gaussian noise present in the image, and non-maximum suppression (NMS) which is based on interpolation for edge thinning. The Sobel operator is used to calculate the gradient of the image. The overall performance of the algorithm is very much depended on the size of the sliding window. This leads to the more blurring and thicker edges. The outline of broken and false edges reduces using this algorithm but the computation time is more due to the sliding window.
2) *Gupta and Mazumdar (2013):* proposed an extension of the Sobel edge detection algorithm for image edge detection process [6]. The Sobel edge detection method considers a 3x3 convolution kernel on an image. This kernel is extended to a 5x5 convolution kernel. However, the gradient approximation it produces is inaccurate, thus false, broken and thick edges exist in the output image.
3) *Katiyar and Arun (2014):* proposed a comparative analysis of common edge detection technique [7]. The comparison is made between the existing edge detection algorithms such as the Sobel, Prewitt, Canny and the Laplacian. It was found that the performance of canny edge detection algorithm is better than other method with lesser number of detected false edges. However, false and broken edges cannot be suppressed using these techniques.

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4) *K. K. Jena (2015):* investigated an edge detection method that computes image edges using the concept of Center of Mass with Sobel Operator (COM-SOBEL) [8]. This method can be used as template for multi-scale image edge detectors. They also compares the proposed method with conventional Sobel operator.
5) *J. J. Hwang and T.L. Liu (2015):* they consider contour detection using per-pixel classifications of edge point. To make possible process, convolutional neural networks (CNNs) is used to extort an instructive feature vector for every pixel and uses an SVM classifier to complete contour detection [9].

B. Soft Computing Approaches

We normally use three different soft computing methodologies to edge detection for image segmentation. These three methodologies are as follows (1) Fuzzy based Approach [10], (2) Genetic Algorithm based approach [11] and (3) Neural Network based Approach [12]. These are explained underneath:

1) *Fuzzy based Approach :* We have a number of possibilities for development of edge detections based on fuzzy logic [11]. One of the methods is of defining a membership function showing the edginess degree in each neighbourhood [11]. We can consider it as a true fuzzy approach in the case of fuzzy concepts is too applied to make the modification in the membership values. By making use of proper fuzzy if-then rules, we can produce normal or dedicated edge detections in pre-defined neighbourhoods. We can test the similarity of two regions under consideration by Homogeneity in the process of segmentation.
2) *Genetic Algorithm Approach :* Normally, a genetic algorithm comprises three prime processes: selection, crossover, and mutation. The process of selection makes evaluation of all elements and keeps just the perfect ones [12]. Along with these, certain less fit ones could be chosen as per a small probability [12]. The others are expelled from the present population. The crossover makes the recombination of two individuals in order to get new ones which may give improved results. Changes are induced by the mutation operator induces in a few chromosomes units. This is done in order to keep up the population diversified to the extent at the time of the optimization process [12]. The purpose of Image segmentation is of making partitions of an image into homogeneous zones. A huge measure of segmentation strategies are detailed in the article to segment images as per the different criteria like colour, grey level, or texture. This process is not easy and quite vital, due to the reason that the yield of an image segmentation methodology can be encouraged as contribution to higher-level processing tasks, for example model-based object recognition frameworks. As of late, researchers have researched the utilization of genetic methodologies into the image segmentation issue [12].
3) *Neural Network Approach :* We know that Neural networks are developed by numerous elements that are associated by links with different variable weights [13]. Artificial neural networks (ANN) are widely applied for pattern recognition [14]. For clustering, their nonlinear attributes and processing potential are used. We have Kohonen Feature Map (SOFM) network as a decent tool for clustering [13]. The strategy can be detailed as follows. It comprises two free neural networks one each for intensity planes and saturation. This has three layers which are input layer, hidden layer, and output layer. In the input layer, the neuron input is standardized between [0-1], while that of output value is between [0-1]. Every layer is consisting of a definite measure of neurons equal to the size (I x J) of the image. Each neuron has basic connection weight defined as 1[13]. Every neuron in one layer is associated to concerned neuron in the past layer with its d order neighbourhood as appeared in the accompanying Figure 3.

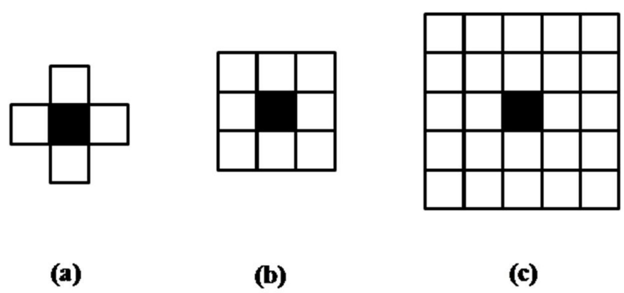

Figure 3: Neighborhoods of a pixel (a) First order neighborhood (b) Second order neighborhood (c) Sequence of neighborhood.

In the process of edge detection, begin the synaptic weights of the network, $V_j(0)$ to little, dissimilar, irregular numbers at iteration k=0. Draw a sample y from the input set. Discover the perfect matching (winning) neuron r(y) at iteration k, by making use of the least distance Euclidean criterion [13]

$$r(y) = \min \left\| y - V_j \right\|, j = 1, 2, ..., L.$$

Update the synaptic weight vectors using the update formula

$$V_{r(y)}^{k+1} = V_{r(y)}^{k} + \eta^{k}(y - V_{r(y)}^{k})$$

is the neighborhood pixel of r(y). Increment *k* by 1, go to input set, and continue until the synaptic weights reach their steady-state values.

C. Other Contributions

Here we are going to give a summary of a few of the previous researches by various researchers on image edge detection:

A comparison of numerous methods of image edge detection of Gradient and Laplacian based edge detection was proposed by Raman Maini & Dr. Himanshu Aggarwal [15]. Algorithms that are gradient-based like Prewitt filter have a noteworthy disadvantage of being quite delicate to noise. The size and coefficients of kernel are certain and can't be adjusted to a given image. As a result, there is a requirement of an adaptive edge detection algorithm which gives a vigorous solution that can generate the adjustments as per changing levels of noise levels. These images help in recognizing the contents of suitable image from the visual artifacts accessible by noise.

Edge detection in Blurred images was carried out by Shweta Agarwal by making use of Ant Colony Optimization Methodology [16]. She accomplished this Edge detection in blurred digital images by giving them priority with the help of various magnitudes of colour as per their quality and significance. At this point, algorithm don't contemplate deblurring of image thus with the elimination of any possibilities of loss of data and a number of edges are going to create by a blur image in an area of concern is few of those edges are going to be of not of significance.

Carlos Oppus and Anna Veronica Baerina used ACO for the purpose of edge detection in which they set up a pheromone matrix that denotes the information of edge at each pixel on the basis of routes developed by the ants [17].

At this point, outcomes depend on various parameter values maintaining the level of investigation of the ants. When we enhance the value of the parameter, we get smoother edges. It must be kept in mind that this value should not be equal to, 0 and 1 but must lie in between due to the reason that it will result in loss of certain important features. Subsequently, larger parameter values creating management on the degree of ant exploration measures good for pictures with less measure of details. On the other hand, lower values are appropriate for those that have more details.

IV. CONCLUSIONS

This paper describes various edge detection techniques and gives the background required to understand the concept of edge detection methods. This paper covers two classes of methods one is kernel based and other related to soft computing techniques. Finally, literature surveys of the recent techniques have been presented.

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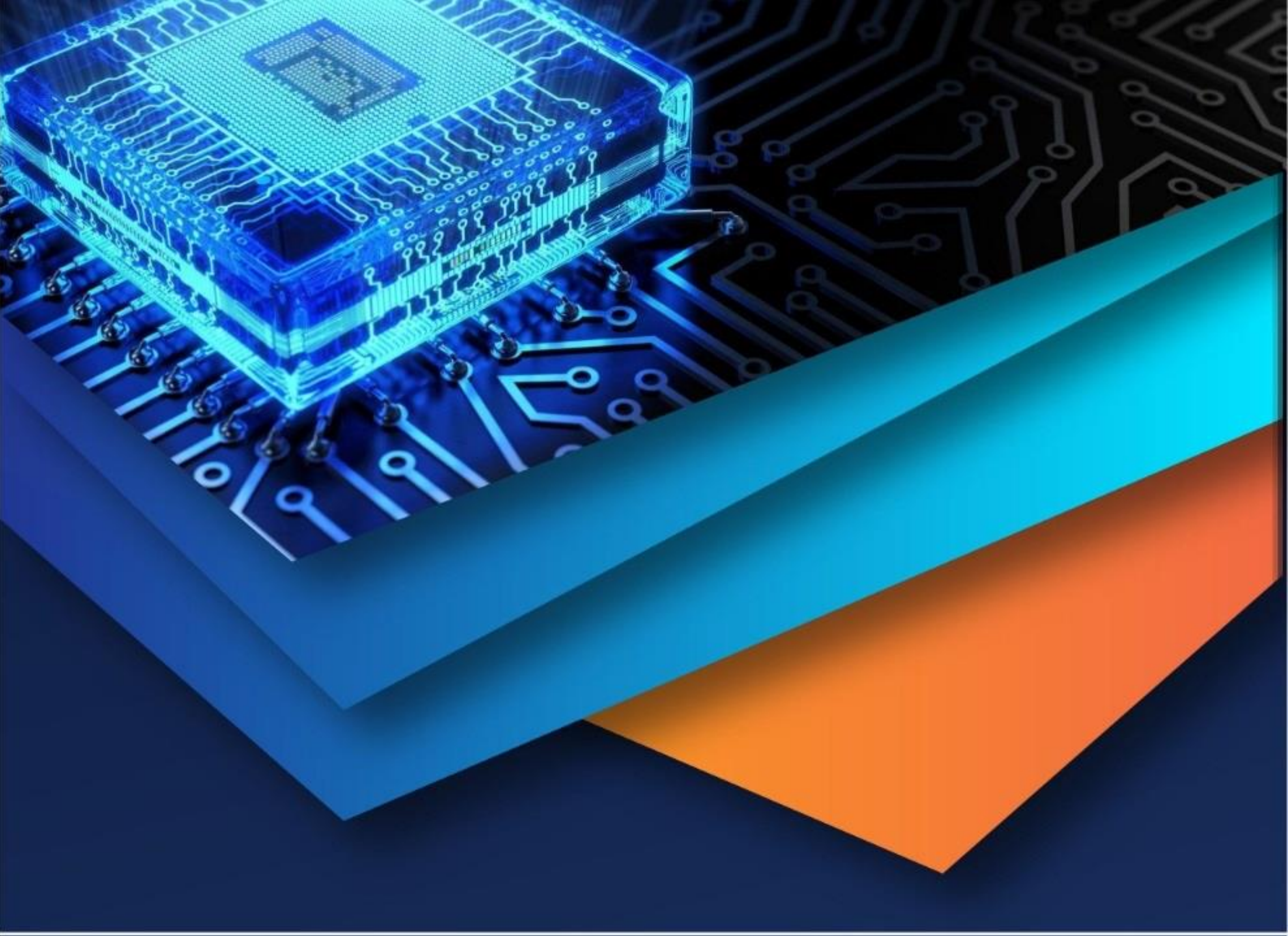

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