Convolution Based Composite Edge Detector for Gray-Scale and Colour Images

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Abstract— Edge detection techniques assume importance in image segmentation, as it forms the basis for boundary or region detection. In this paper, a new edge detection technique namely Convolution Based Composite Edge Detector (CCED) for gray-Scale and colour Images is presented. The performance of CCED is confirmed to be better than the standard edge detection techniques Sobel, Prewitt and Canny. This technique is proved to perform well on the images of varying contrast and brightness. This edge detection technique is ideally found to work well on grayscale and color images. Hence, it is acclaimed to be image-independent edge detection method.

Index Terms— Canny,Convolution, Edge Detection, Gradient , Laplacian, Prewitt, Sobel

1 Introduction

Edge detection is an important element of digital image processing using which the attributes of objects in images or videos can be elucidated. Edges are characterized by the local changes in the intensity of pixels with reference to its neighborhood. In other words, edges form the boundary between two distinct regions/objects in an image. These features are normally exploited by the mid/high level image processing techniques, such as segmentation, representation, analysis, description and recognition [1] , [2].

Edge detection techniques intend to identify and locate the sharp discontinuities or luminous changes in an image [3],[4]. The standard edge detection techniques such as Sobel, Prewitt and Canny as well as the gradient, morphological processing [4], [5] and soft computing techniques are widely employed due to the efficiency exhibited by these techniques [6], [7].

This article describes the working principle and the computational efficiency of a newly devised edge detection technique, Convolution Based Composite Edge Detector (CCED) using the principle of modest mask technique with histogram equalization. Then, the gamma corrected edges are refined with simple threshold and the boundary edges are found by removing interior pixels with morphological *remove* operation. The merit of this method is endorsed by the visual perception of the detected edges.

The literature review on edge detection techniques is explained in section II and the proposed methodology is explained in section III. The results and discussions on CCED are given in section IV and the conclusion is drawn in section V.

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2 Edge Detection Techniques

Edge detection techniques are broadly grouped into two categories as Gradient-based and Laplacian-based. The former detects the edges using the maximum and minimum of the first derivative of the image. The Laplacian methods explore zero crossings in the second derivative of the image to find edges [8], [9].

2.1.1 Gradient Edge Detector

The gradient vector of every image contains information about two distinct measures namely, magnitude and direction. These components depict the rapidness of intensity discontinuities among the pixels. The direction of gradient is always perpendicular to the direction of an edge. So the magnitude of the gradient provides information about the strength of the edges [10].

2.1.2 Laplacian Edge Detector

Laplacian is the 2-Dimensional (2D) second order derivative that searches zero crossing and highlights the intensity discontinuities in an image. It deemphasizes the regions with slowly varying intensity levels. Initially it blurs the image by convolving the image with a Gaussian function. Then it performs Laplacian on the blurred image and finds its zero crossing. In the next step, the local variance with a threshold value and the pixel value greater than the threshold, detects the presence of edges in an image. Finally median filtering is applied, in order to suppress the spot noise and also to present the edge details [11], [12].

2.2 Sobel Edge Detector

The Sobel operator performs a 2D spatial gradient measurement on an image and identifies the pixels of high spatial frequency that correspond to edges. Typically it is used to find the approximate absolute gradient magnitude at each point, in an input image [13]. The convolution masks of the Sobel detector are depicted in Fig.1(a).

The Sobel edge detection technique is similar to that of the Roberts Cross algorithm. Though design of Sobel and Robert are common, their kernels are quite different to obtain the

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gradient of an image. The Sobel kernels are more suitable to detect edges along the horizontal and vertical directions whereas the Roberts's ability lies in detecting the edges along the vertical directions of 45° and 135° [14].

2.3 Prewitt Edge Detector

The Prewitt operator for edge detection ideally estimates the magnitude and orientation of an edge. The Prewitt operator is limited to 8 possible orientations; however the diagonal direct orientation estimates are not found to be accurate. This gradient-based edge detector is estimated in the order of 3x3 neighbourhood for 8 directions [15]. The convolution masks of the Prewitt detector are shown in Fig.1(b).

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

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

(a)

1	1	1
0	0	0
-1	-1	-1

-1	0	1
-1	0	1
-1	0	1

(b)

Fig. 1 (a) Sobel Convolution Mask (b) Prewitt Convolution Mask

2.4 Canny Edge Detector

Canny finds the edges by isolating noise from the image, without affecting the edge details. It smoothens the image using Gaussian filter to eliminate noise in the first step and then finds the image gradient to highlight the regions with high spatial deviations. Then, it performs tracking along these regions and suppresses each pixel whose intensity is not the maximum, thereby the gradient array is reduced. It uses two thresholding values such as high and low [16]. If the magnitude is below the low threshold, then it is set as zero. Otherwise, it is considered as an edge. It is mathematically represented as:

$$g_{NH}(x,y) = g_N(x,y) > T_H \quad (1)$$
$$g_{NL}(x,y) = g_N(x,y) > T_L \quad (2)$$

where $g_N(x,y)$ is non-maxima suppressed image, $g_{NH}(x,y)$ is strong edge pixels , $g_{NL}(x,y)$ is weak edge pixels, T_H is high threshold and T_L is low threshold. Finally, the connectivity analysis is performed to detect and link the edges [17].

3 Methodology of CCED

This CCED aims to find the edges of a given image in a better way against the Sobel, Prewitt and Canny edge detectors. The methodology of CCED is described below:

Algorithm : Convolution Based Composite Edge Detector for Gray-Scale and Colour Images

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Input : Grayscale or Color image ***in_img***
Output : Edge Detected Image ***ed_img***

BEGIN

1. Read ***in_img***
2. Perform histogram equalization on ***in_img*** and obtain ***p_img***
3. Initialize $w \leftarrow 1$ // w is window of size 3x3
4. For each subimage S of ***p_img*** in the order of 3x3, do
5. Compute t1= min(***p_img***)
6. $S1_{ij}$ = t1 , // $S1_{ij} \in S$
7. Compute t2 = max(***p_img***)
8. $S2_{ij}$ = t2 , // $S2_{ij} \in S$
9. Compute ***ed_msk*** = S2 - S1 // obtain the edge mask
10. Set ***max_int*** = max(***ed_msk***)
11. Set gamma = 0.7
12. ***ed_msk*** = max_int*((0: max_int)/ max_int)^ gamma
13. Transform ed_msk to in_img image class and obtain ***cast_img***=T_r(***ed_msk)***, where T_r image class Transform operation
14. Compute ***Th*** = (mean(***cast_img***)+ median(***cast_img***))/2 //***Th*** is the Threshold
15. Construct binary image ***bi_img*** using
16. $\boldsymbol{bi\_img} = \begin{cases} 1, & cast\_img < T \\ 0, & cast\_img \geq T \end{cases}$
17. Perform morphological ***remove*** operation to find edge image ***ed_img***
18. Output ***ed_img***

END

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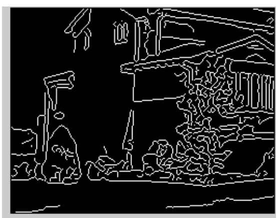
4 Results and Discussion

The CCED is developed using Matlab 7.8 and its results are compared with those of Sobel, Prewitt and Canny detectors for the purpose of performance evaluation. The obtained results of CCED are depicted in Fig.2-6. The CCED was tested on about fifty images including the standard and real-time images. It is evident that the results are found to be better than its competitors. For illustrative purpose the results obtained for house image, hand image, lilly image, mandrill image and cameraman image are depicted in Fig.1. – Fig.5. (a) The edges detected by Sobel, Prewitt, Canny and CCED are depicted in Fig.1. – Fig.5.(b), Fig.1.- Fig.5.(c), Fig.1.- Fig.5.(d), Fig.1. – Fig.5.(e) respectively.

(a)

(b)

(c)

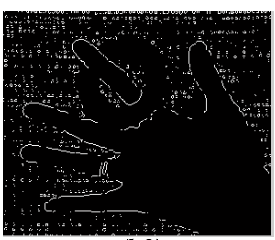


(d)

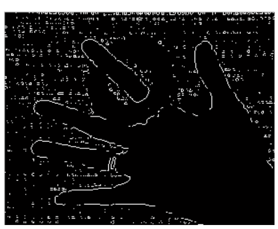
(e)

Fig.1. (a) house image; Edges detected by (b),Sobel;(c),Prewitt; (d),Canny ; (e), CCED

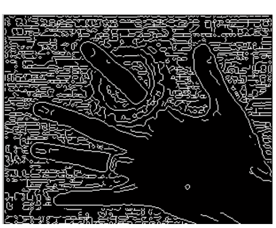
(b1)



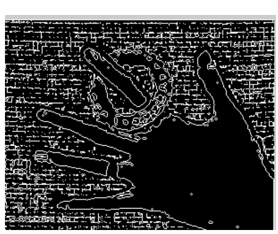
(b2)



(b3)



b(4)



b(5)

Fig.2. (a) hand image; Edges detected by (b),Sobel;(c),Prewitt; (d),Canny ; (e), CCED

(c1)

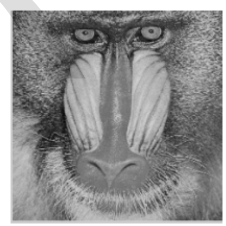
(c2)

(c3)

(c4)

(c5)

Fig.3. (a) lilly image;E dges detected by (b),Sobel;(c),Prewitt;(d),Canny ; (e), CCED



(d1)

(d2)

(d3)

(d4)

(d5)

Fig.4.(a)mandrill image; Edges detected by(b),Sobel;(c),Prewitt;(d),Canny;(e),CCED

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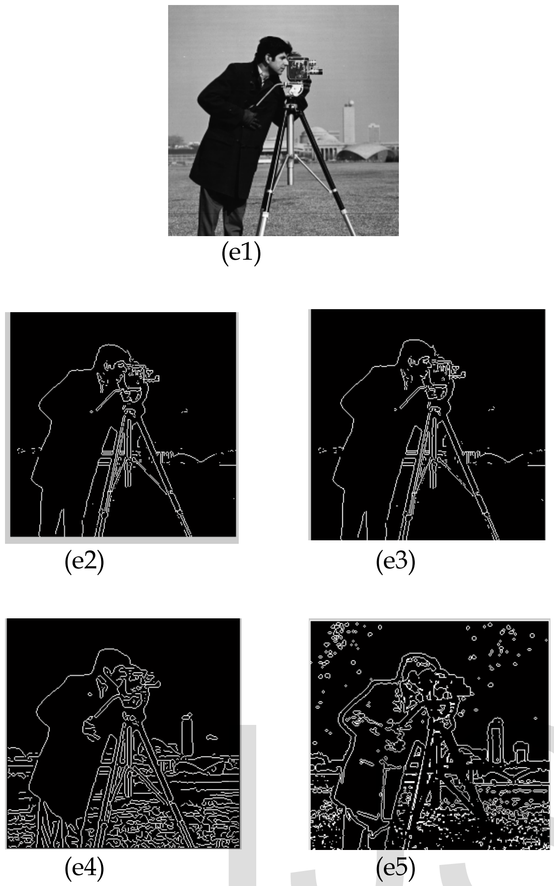

Fig.5. (a) cameraman image; Edges detected by (b),Sobel;(c),Prewitt; (d),Canny ; (e), CCED

It is visually apparent from the results that the proposed technique CCED has the potential to detect every edge in the input images. As the edges are the local attributes of an image, detection of the true edges would ultimately attribute to better results during region-growing, segmentation, etc., Moreover, this technique is computationally simple than its competitive methods.

5 Conclusion

The newly devised edge detection method, CCED is proved to perform better than the standard edge detectors, Sobel, Prewitt and Canny. This technique is observed to perform efficiently on both grayscale and color images. This technique is proved to be computationally simpler than the other edge detectors. Due to the computation accuracy and speed, CCED is conformed to have an edge over the other techniques. Moreover, this technique is highly generic, as it performs well on both grayscale and color images. Hence this technique easily finds a place in segmentation as well as classification.

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