

# Edge Detection of Image Using Image Divergence and Downsampling Method

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**Abstract:** Classically, the points where digital image brightness transforms rapidly are ordered into a group of curved line segments termed as edges. Edge detection is an important feature and tool in digital image processing to analyze the significant changes in gray level image intensity. In this paper, an edge detection method is proposed. In the proposed method divergent operation is applied to the image to compute the Laplacian of the image. After then the sample rate of Laplacian of image is decreased by downsampling. A threshold value is yielded by computing the mean on the down sample value. Laplacian of image and threshold value is compared and pixel values are set according to the threshold value. Then the morphological operation is performed on the processed image to produce the final edge detection image. The significance and value of this research are reducing image noise by downsampling and searching vital edge information through divergence operation. The present study introduces a new method of edge detection. The finding of this research work is to detect the edges of objects. The proposed method is compared with other existing edge detection methods i.e., Canny, Sobel, Robert, Zero cross, and Frei-Chen. Quantitative evaluation is performed through various metrics i.e., Entropy, Edge-based contrast measure (EBCM), F-Measure, and Performance ratio. Experimental results obtained from MATLAB 2018a show that the proposed method performs better than other well-known edge detection methods.

**Index Terms:** Edge detection, Image processing, Divergence, Downsampling, Image Laplacian, Mean.

## **1. Introduction**

Edge of a digital image is a curvature that moves a route where an image intensity changes quickly. Edge detection is a procedure to detect the edge lines of an object [1]. Edge detection has the feature to classify an object with minimum information which needs less computation time and requires a small amount of computer memory for image storing. It requires a low bandwidth for online image data transferring. The application of edge detection [2] for the segmentation of image is in computer vision, machine vision, and digital image processing. An edge may be the consequence of variations in color, shadow, texture, and light. These changes can be utilized to enlighten the magnitude, direction, profoundness, and surface properties of a digital image. Edge detection feature supports filtering out redundant information to select the desired edge points. Image may have noise and this is subject to the pixel threshold of variation which expresses an edge. If an image gets affected by noise, then edge detection becomes difficult. Edge detection process is a fundamental and significant tool in the field of digital image processing. Edge detection can be used for image segmentation [2] to extract, and analysis of image objects with minimum information. A mathematical morphological operation *bwmorph* [4] filter is applied on a binary image to filter out the edge detection result.

Numerous edge detection approaches were suggested, though Sobel [5], Prewitt [6], Robert [7, 8], Laplacian of 1 Gaussian (Log) [9], and Canny [10] are considered due to the most prevalent edge detection feature. The Sobel edge detection algorithm applied a two-dimensional spatial gradient process on a grayscale image to find out the edges. Sobel,

Prewitt, and Robert's algorithm detect the edges by computing the gradient of the input image. Roberts edge detection method tracks out the image gradient of two orthogonal directions and computes the image gradients at degrees of 45 and 135, respectively. The Canny algorithm detects the edges by observing the local maxima of the input image gradient. The Gaussian filter is utilized to compute the image gradient to find out the edges. The zero-crossing [11] edge detector operates on the Laplacian of the Gaussian operator to filter out an image. Frei-Chen [12] edge detection algorithm has offered the eight-dimensional directions of Frei-Chen masks to perform a vector operation on the image to detect the edges. Acharya et al. describe a curve fitting-based picture segmentation approach employing Modified Vandermonde [3], which yields a higher quality segmented output in a short amount of time. Gautam et al. offer an edge detection algorithm based on ant colony optimization and adaptive thresholding to identify the target object's edge lines [13]. Dagar et al. conducted a comparative study on edge detection algorithms founded on Computational Intelligence. Various edge detection algorithms are explained, and their outcomes are contrasted using several illustrations [14]. Karanwa et al. present an edge detection approach based on different scale values. The study explains the influence of scale value when it increases and when it falls [15].

The major research objectives are proper detection of edge lines by reducing image noise and avoiding unwanted edge details. The introduction is supposed to introduce the problem to be solved in this article. Detection of the edge of a noisy image is a challenging task and, in this research, the downsampling method is applied to reduce the noise by reducing image size followed by thresholding by divergence operator. There are many existing solutions to find out the edges of image objects such as canny, Sobel, Roberts, Zero crossing, and Frei-Chen. Among them, Canny edge detection is the best. Canny edge detection produce is a popular traditional edge detection algorithm. The main downside of employing the Edge detection algorithm is that it takes a long time to compute due to its complexity. Achieving real-time response, is hard to accomplish.

Several image quality metrics like Entropy [2], Edge-based contrast measure (EBCM) [16, 17], Performance Ratio (PR) [18], and F-measure [18] have been calculated and it is observed from the simulation results that the proposed method finds the edges precisely and keep the optimum image quality in comparison to the other existing edge detection operators. In the present method its hoped to achieve a superior quality of edge lines taking less computation time.

## 2. Steps of Algorithm

Step 1: Conversion of a color image to a gray-scale image is done and computing the mean value of the grayscale image is implemented.

Step 2: Computing the divergence of vector fields of the image is processed and then the calculation of the Laplacian of the image is accomplished for further processing.

Step 3: Downsampling is done on the Laplacian of the image which reduces the image sampling rate by an integer factor. Maintaining the first sampling of an image and then every  $x^{th}$  sampling afterward the first is processed.

Step 4: Mean value is computed from the downsampling value. This mean value is considered a threshold value

Step 5: Pixel values are assigned based on the computed threshold value comparison with the Laplacian of the image. If the value returned by the Laplacian of image is less than the threshold value then one is assigned and zero is assigned if the Laplacian of image value is higher than the threshold value, processed in step 4.

Step 6: Morphological operations are performed on the Laplacian of the image obtained in step 5 to produce the final edge detected image.

## 3. Proposed Methodology

### A. Background

In 2008, Lam et al. proposed an image segmentation method using divergence of vector fields [19] to segment vessels in retina images. In the present study, a new method of edge detection-based image segmentation is proposed using image divergence and downsampled methods of images.

### B. Computing image divergence and Laplacian of image

The divergence of a vector field is a measurement to determine the amount of "flux" is moving over a surface adjacent point [20]. This approach can be used on a wide range of photos, not just medical images.

Vector function of an image I on image intensity  $I_x$  and  $I_y$  given as

$$\nabla I = (I_x, I_y) \quad (1)$$

The divergence operator of an image I expressed as

$$\text{div}(\nabla I) = \frac{pI_x}{p_x} + \frac{pI_y}{p_y} \quad (2)$$

Here  $p$  is a Laplacian of grayscale image  $I$ .

$\Delta I$  gives the Laplacian of the image  $I$  by the following equation

$$\Delta I = \frac{I - n}{N - n} \quad (3)$$

Where  $n = \mu - 100$  and  $N = \mu + 100$

Here, mean  $\mu$  is calculated from an image  $I$  as in (4)

$$\mu = \frac{1}{L} \sum_{i=1}^L I_i \quad (4)$$

Where minimum intensity is denoted by  $i$  which is 1 and  $L$  denotes maximum image intensity level which is 256.

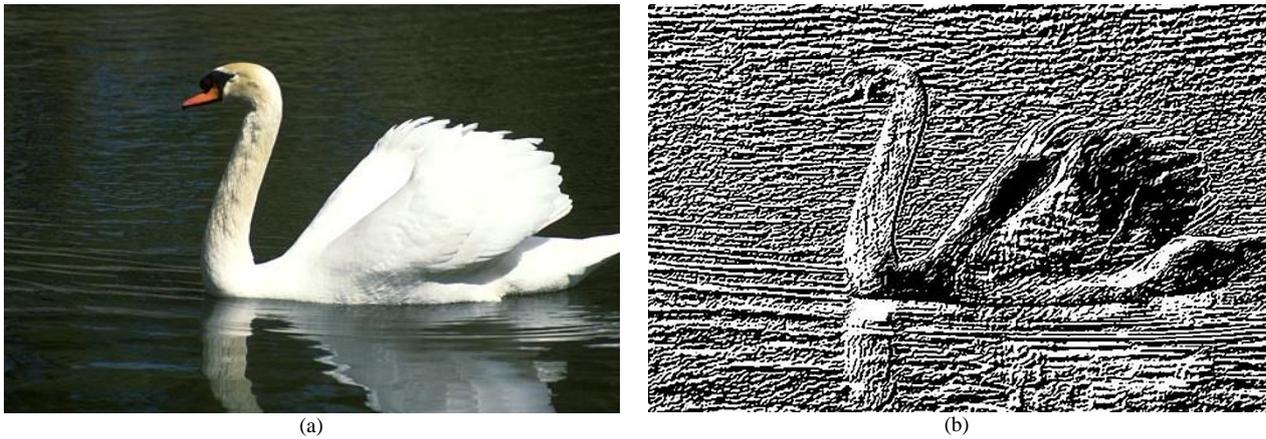


Fig. 1. Image flux passing on 'Duck' image using divergence operator

Fig. 1 shows the flux passing on the original BSD dataset 'Duck' image obtained by applying the divergence operator.

### B. Image downsampling computation

Downsampling [21] by an integer factor decreases the high-intensity values of an image at a lower rate. Image sample rate decreasing by an integer factor  $E$  is represented in the following steps:

- Decreasing the high-frequency of image signals through a lowpass filter to eliminate the high frequencies from an image.
- The filtered image signal is decimated by  $E$ , it is a rate of downsampling to retain only every  $E^{\text{th}}$  sample.

$$D[x] = \sum_{i=0}^{L-1} n[xE - L].r[L] \quad (5)$$

Decimation is a term allied with the resampling method in digital image processing [21]. It is correspondingly stated as downsampling. Decimating a finite impulse response (FIR) filter for the  $x^{\text{th}}$  output sample is a dot product.  $D[x]$  is the output signal of the processed image. Here,  $r$  denotes the sequence of impulse responses from an image and  $L$  denotes the maximum intensity level of an image. An image input signal is signified by  $n$ , which is downsampled. The dot product is the summation of the dot products of respective subsequences through the consistent sample of the  $n$  order.

Figure 2 (a) illustrates the original BSD image '71046' of Temple', Figure 2 (b) is showing the Laplacian of image which is obtained from an image divergence, Figure 2. (c) shows the downsampled of the image Laplacian, Figure 2 (d) is demonstrating the processed image which is obtained by comparing the threshold value and image Laplacian and Figure 2(e) illustrates the final edge detection image by the proposed algorithm.

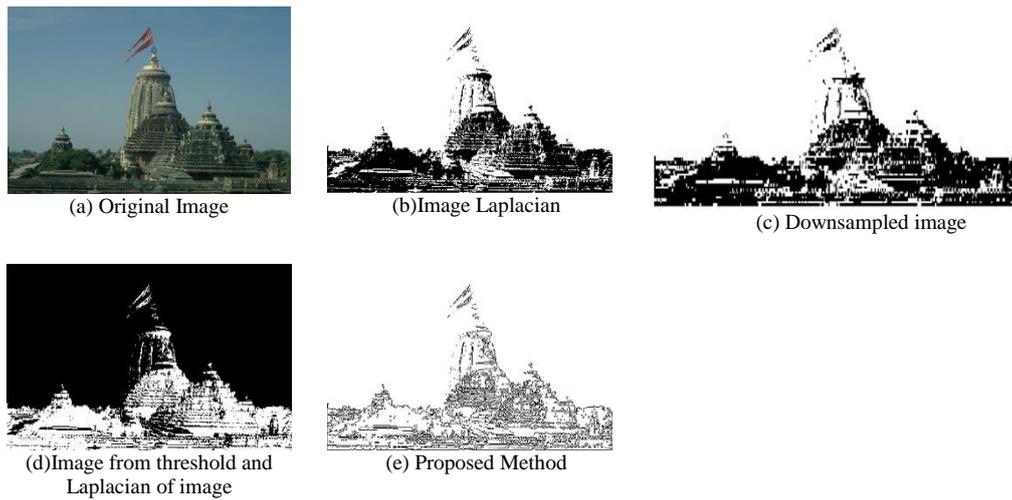


Fig.2. 2 (a) BSD image ‘71046’ of ‘Temple’ 2. (b) Laplacian of Image 2. (c) downsampled of image (d) Image obtained from the compared value between threshold and Laplacian of image (e) Proposed edge detection method

Table 1. Metrics Equations Description

Metrics	Equations	Description of metrics
Entropy [2]	$Entropy = -sum(HC.*log2(HC))$ (6)	HC contains the normalized histogram counts returned from image histogram. Entropy determines the detail information content of the image.
EBCM [13,14]	$EBCM(X) = \sum_{i=1}^H \sum_{j=1}^W (i, j) / HW$ (7)	$X = \{x(i, j)   1 \leq i \leq H, 1 \leq j \leq W\}$ of size $H \times W$ pixels, where $x(i, j) \in R$ . $H \times W$ pixels where $H$ indicates the height and $W$ indicate the width. Edge-based contrast measure (EBCM) measure the intensity of edge pixels in small windows of the image and more edge pixel indicates better the edge quality.
F-Measure [15]	$PR = TP / (TP + FP)$ (8)	PR is a ratio of true to false edges. TP is truly positive. FP is false positive.
	$RE = TP / (TP + FN)$ (9)	RE is the recall and F-measure is the harmonic mean of Precision and Recall. Higher value of F-Measure indicates the better quality of edges.
	$F = 2((PR * RE) / (PR + RE))$ (10)	
Performance Ratio (PR) [15]	$PR = \frac{TE}{FE + NEP} \times 100$ (11)	TE is true edges. FE is false edges i.e., non-edge pixels identified as edges and NEP is edge pixels identified as non-edge pixels. A high PR value signifies that the edge quality is better.

#### 4. Simulation Results and Analysis

The MATLAB [22] simulation is performed on 100 images of the publicly available Berkeley Segmentation Database (BSD) [23] for the performance evaluation of the proposed edge detection method. The configuration of hardware is the Intel Core i5 processor and 4GB random access memory on Windows 8 operating system. The methods are simulated in MATLAB [22] R2018a with the default constraints stated in the various operators. Finally, visual quality analysis and quantitative investigation are performed on the output images.

Table 2. ENTROPY

BSD Image	Original Entropy	Canny	Sobel	Robert	Zero cross	Frei-Chen	Proposed
"108041"	0.88502	0.32726	0.29317	0.17744	0.33774	0.21937	0.47648
"118020"	0.98313	0.40152	0.35124	0.22486	0.45475	0.40126	0.49568
"12074"	0.76673	0.25002	0.29114	0.18079	0.25805	0.17855	0.23328
"35058"	0.9383	0.0755	0.31925	0.14804	0.30942	0.12025	0.32798
"159029"	0.95912	0.46737	0.30951	0.19394	0.44239	0.36954	0.50766
"225017"	0.93683	0.36802	0.30005	0.22015	0.42691	0.3019	0.45818
<b>Average</b>	<b>0.91152</b>	<b>0.31494</b>	<b>0.31072</b>	<b>0.19087</b>	<b>0.37154</b>	<b>0.26514</b>	<b>0.41654</b>

Table 3. Edge-based contrast measure (EBCM)

BSD Image	Canny	Sobel	Roberts	Zero cross	Frei-Chen	Proposed
"108041"	32.474	18.486	15.459	34.719	15.142	81
"118020"	42.228	27.253	18.005	51.152	36.19	123
"12074"	24.358	15.716	16.407	25.568	12.821	50
"35058"	5.3877	15.276	12.723	32.561	8.3179	81
"159029"	54.857	24.834	15.713	54.374	34.386	80
"225017"	38.963	28.272	20.568	50.217	25.639	69
<b>Average</b>	<b>33.0446</b>	<b>21.6395</b>	<b>16.4791</b>	<b>41.4318</b>	<b>22.0826</b>	<b>80.6666</b>

Table 4. F-Measure

BSD Image	Canny	Sobel	Roberts	Zero cross	Frei-Chen	Proposed
108041"	0.0082596	0.005134	0.0047143	0.0082517	0.0035098	0.011816
"118020"	0.017944	0.012202	0.0072005	0.017891	0.016293	0.023686
"12074"	0.0082604	0.0058496	0.0044125	0.0082523	0.0041348	0.006191
"35058"	0.0018651	0.0031386	0.0033435	0.0018577	0.003036	0.011883
"159029"	0.012053	0.0056871	0.0026613	0.012061	0.0076362	0.011666
"225017"	0.0066764	0.0056785	0.004595	0.0066634	0.0052502	0.00937
<b>Average</b>	<b>0.00917642</b>	<b>0.006282</b>	<b>0.004488</b>	<b>0.00916285</b>	<b>0.006643</b>	<b>0.012435</b>

It is observed from the quantitative results obtained in Table 2. that the average outcome of entropy of the proposed method is 0.416543 which is higher than all other compared edge detection operators i.e., Canny, Sobel, Robert, Zero crossing, and Frei-Chen.

The quantitative results found in Table 3. demonstrate that the average EBCM of the proposed method is 80.66667 which is higher than all other compared edge detection operators. The second-best result is given by the Zero-cross edge detector which is 41. 4318.

The quantitative results obtained in Table 4. show that the average F-Measure value of the proposed method is 0.012435 which is higher than all other compared state-of-art edge detection operators. The second-best average F-Measure is given by the Canny operator, which average value is 0.00917642.

Table 5. Performance Ratio (PR)

BSD Image	Canny	Sobel	Roberts	Zero cross	Frei-Chen	Proposed
"108041"	7.6445	4.571	3.6657	6.9287	3.9539	7.8352
"118020"	11.913	7.106	5.4713	12.047	10.331	13.073
"12074"	8.9997	6.736	8.0094	7.5988	9.2688	7.4297
"35058"	2.2213	4.496	4.2608	7.6766	3.2277	9.3304
"159029"	9.1432	4.244	3.0593	7.195	6.9385	8.1259
"225017"	10.929	8.944	8.9684	9.4756	14.133	11.343
<b>Average</b>	<b>8.4751</b>	<b>6.0161</b>	<b>5.5724</b>	<b>8.4869</b>	<b>7.9754</b>	<b>9.5228</b>

The quantitative results of performance ratio (PR) are demonstrated in Table 5 and it is observed that the average PR value of the proposed method is **9.5228** which is the highest among all other compared edge detection operators. The second-best average PR is returned by the Zero cross operator whose average value is 8.4869.

#### 4.1. Visual quality analysis

Fig.3 illustrates the BSD image “118020” of the ‘sea boat’ and the results of different edge detection operators. The canny operator is showing satisfactory results with a few missing edges of background objects. The result shows that the canny operator is unable to display the edges of sea waves. Sobel operator is showing the broken edges of sea boats. It shows that a few edge details of background buildings are missing. It is also observed that the edges of sea waves have been lost. Robert cross operator is producing a lot of missing information of edges and the background building is not displaying properly and sea waves are not visible. Zero crossing edge detector displays a lot of edge details of the ‘sea boat’ image but still its missing edges of sea waves. Frei-Chen edge detection method shows edges but the continuity of edges pixels is missing. The edges of sea waves are invisible. The proposed method shows all the detailed information about sea boats, background buildings, and sea waves to a large extent compared to other edge detection operators. Overall, the proposed method illustrates the best visual quality.

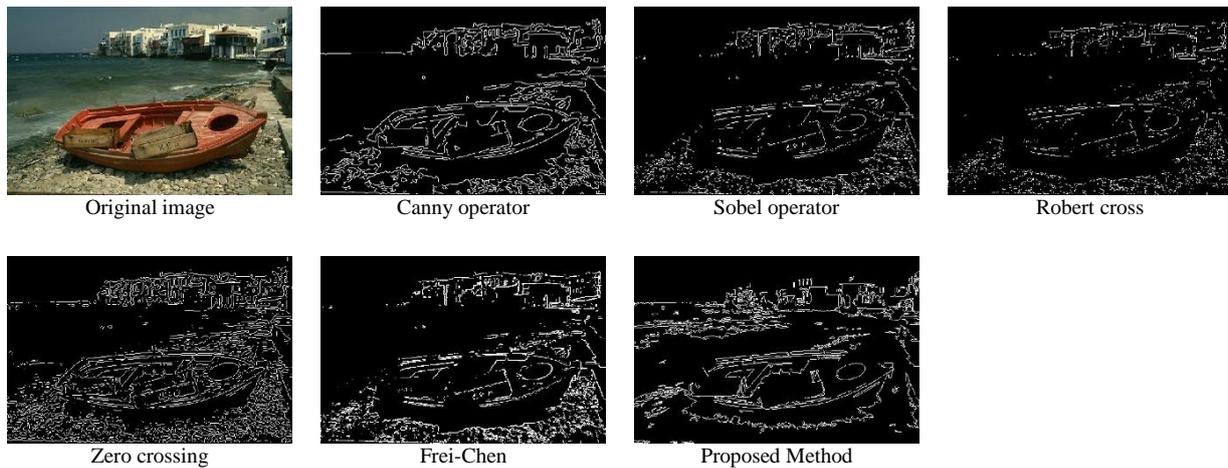


Fig. 3. BSD image 118020 of ‘sea boat’ and its different edge detection results

Fig.4 illustrates the BSD image “159029” of the ‘cat’ and the results of various edge detection operators. The canny operator has fair quality edge detection result but few edges of cat objects are broken and missing. Sobel operator shows the edges of a cat but many edges are broken and few edges have been lost. The overall result is not satisfactory. Robert cross operator displays the edges of a cat but much edge information is lost and the overall performance of the Robert method is poor than the Sobel operator. Zero crossing edge detector illustrates the edges of a cat but the continuity of edge pixels is lost at some part of the object and few extra details of edges make the overall result a little unclear. Frei-Chen edge detection method shows edges of cat image but from the results, it is observed that many details of edges are lost and unable to produce the desired output. The proposed method illustrates the detailed information about the cat and shows all the vital information of the edges. Visual performance shows the proposed method produced superior edge quality to other state-of-art methods.

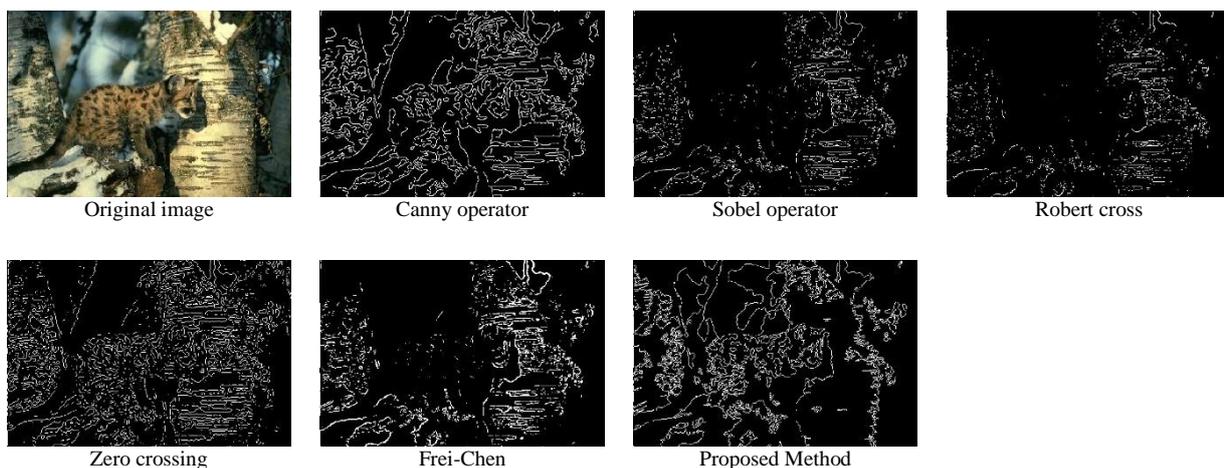


Fig. 4. BSD image 159029 of ‘cat’ and its different edge detected results

Fig.5 illustrates the BSD image ‘35058’ of insects on leaves and edge detection results of existing operators and the proposed method. Canny operator unable to produce detailed edge information of leaves and insects and lost many details. Sobel operator illustrates slightly better edge information than the Canny operator but few edges of leaf objects are broken and not able to display the details of leaves. Robert cross operator lost many edges information of leaf and the overall visual performance is poor than Sobel and Canny operator. Zero crossing edge detector shows the details of edges but a few extra details in leaves make it a little bit unclear and hazy. Frei-Chen edge detection method displays edges but could not maintain the continuity of edge pixels which causes an unsatisfactory visual appearance of Canny, Sobel, Robert, and Zero cross operators. The proposed method is overcome all these problems and illustrates the detailed edge information of the ‘inset on leaves’ image and avoids any unwanted information. Overall, the proposed method is superior to other compared edge detection methods.

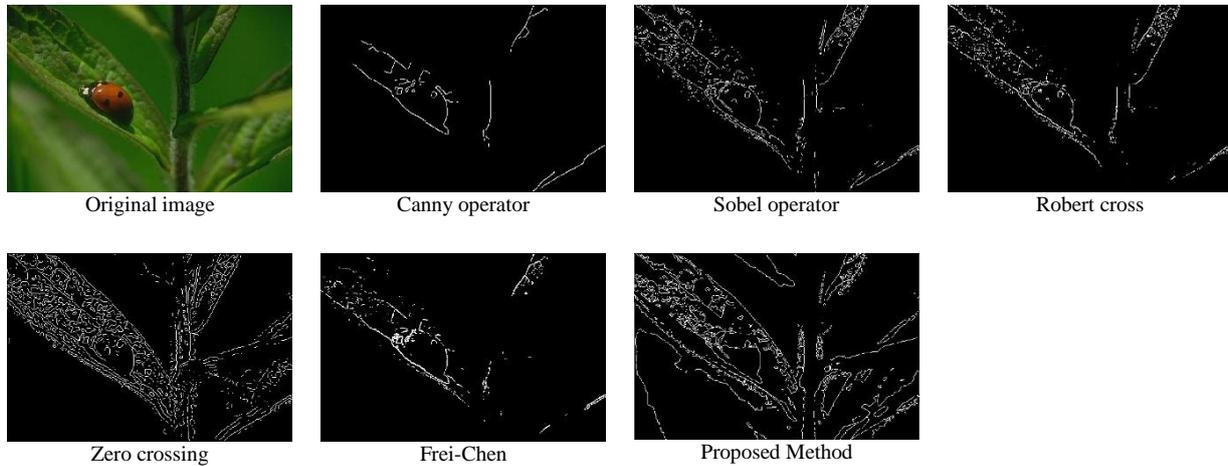


Fig. 5. BSD image ‘35058’ of ‘insect on leaves’ and its different edge detected results

Fig.6 shows the BSD image ‘12074’ of ‘Underwater tree’ and the results of various edge detection methods. The canny operator clearly displays the edges of the ‘underwater tree’. But the result shows less information on edges is lost in the left area of the ‘Underwater tree’ image. Sobel operator shows the edges of sea ‘underwater tree’ almost close to Canny method. Sobel edge operator is unable to display the detailed information on the left area of the ‘Underwater tree’ image. Robert cross operator is showing the edges of the ‘Underwater tree’ image but with few broken edges due to the discontinuity of edge pixels. It has lost a few edges information about the image background. Zero crossing edge detector exhibit edge details but still few edges information is missing in the left portion of an image. Frei-Chen method demonstrates edges but the continuousness of edge pixels is lost and this makes the edges of ‘Underwater tree’ a little bit broken.

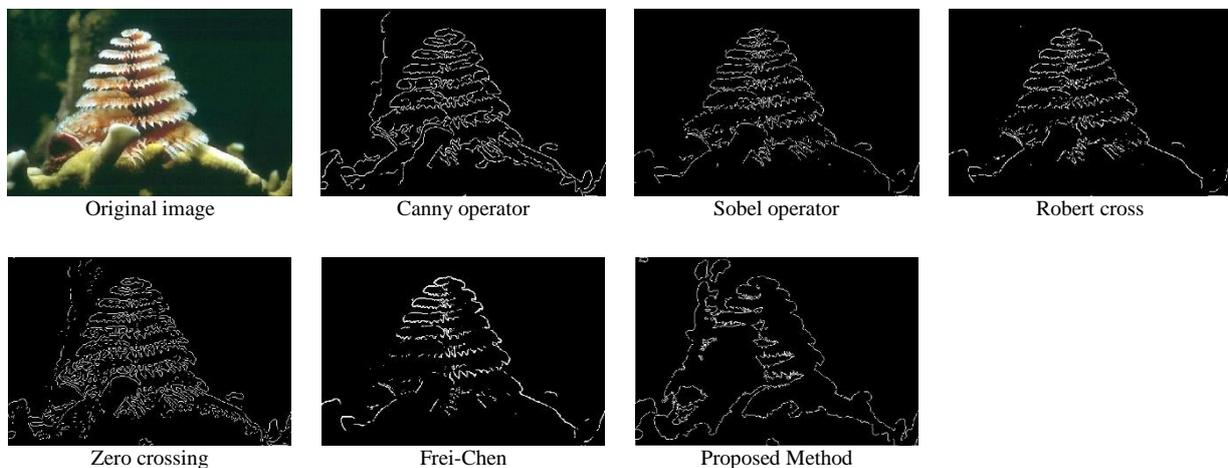


Fig. 6. BSD image ‘12074’ of ‘Underwater tree’ and its different edge detected results

The proposed method overcomes this problem and illustrates all the vibrant features of the ‘Underwater tree’ and avoids any unwanted edge information. It shows all the vital information of the ‘Underwater tree’ along with the edge of the branch located in the left area of the image which has not been shown by the other compared edge detection methods. It is also observed that the proposed method misses some inner details of the edge of the ‘Underwater tree’ but the overall visual quality of the proposed method is the best.

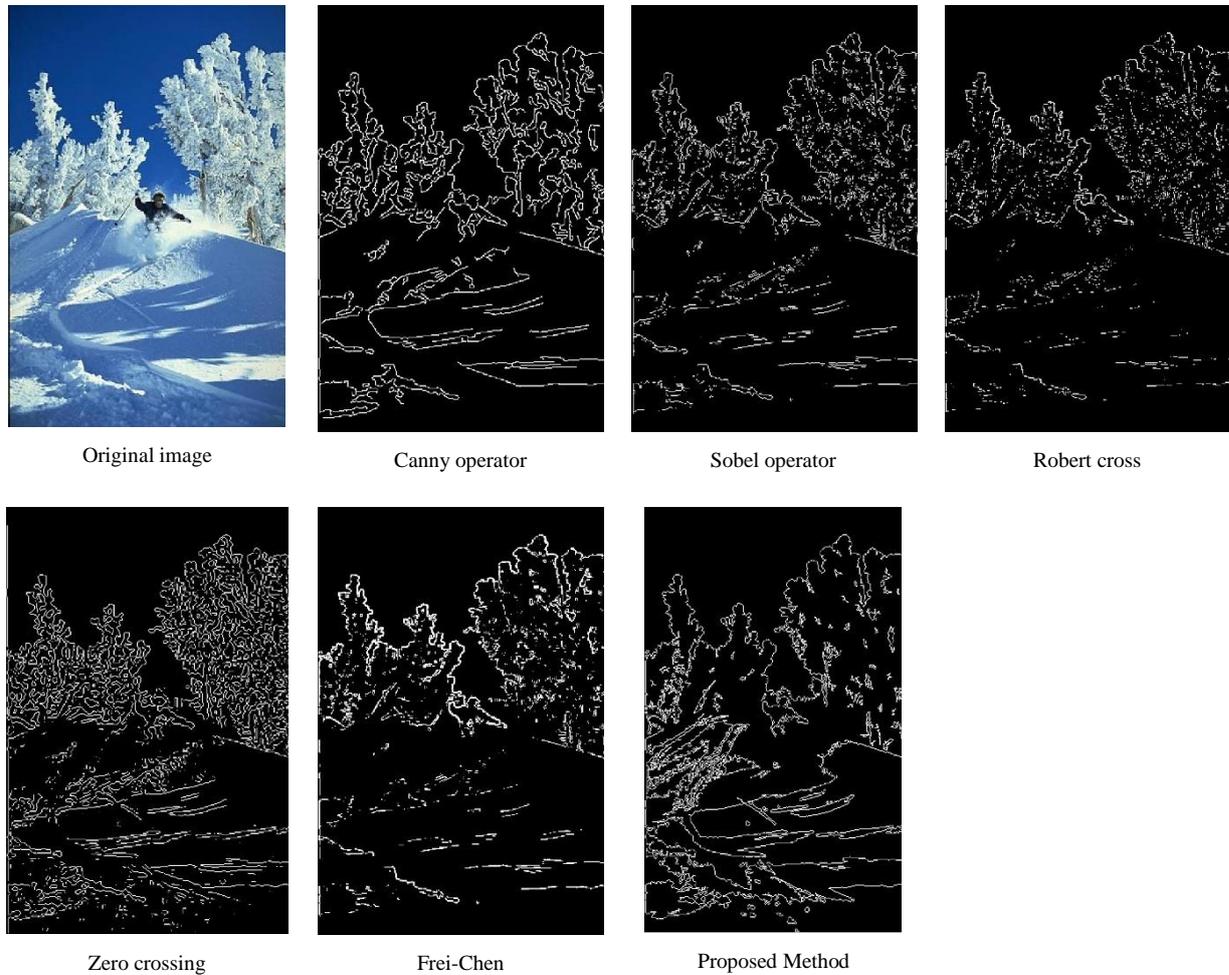


Fig. 7. BSD image ‘35058’ of ‘skating on the snow mountain’ and its different edge detected results

Fig. 7 demonstrates the BSD image ‘35058’ of ‘skating on the snow mountain’ and the outcomes of numerous edge detection operators. Canny operator displays details of edges but a few edge details are missing on the bottom side of the image. Overall performance of the Canny operator is satisfactory. Sobel operator displays edges of ‘skating on the snow mountain’ but it is observed that many edge details of snow mountain are lost. The overall performance is not satisfactory compared to Canny. Robert cross operator is illustrating the edge of ‘skating on the snow mountain’ but various edge information of the snow mountain is missing. The overall performance of the Robert operator is poor than Sobel and Canny operator. Zero crossing edge detector demonstrates detailed edges of ‘skating on the snow mountain’ but a few additional details of edges make the overall result a little bit hazy which makes the overall result unclear. Frei-Chen edge detection method displays edges of the ‘skating on the snow mountain’ image. It is observed from the visual results that many vital edge details of snow mountains have been lost. The overall result of the Frei-Chen method is poor than the Canny, Sobel, Robert, and Zero cross methods. The proposed method demonstrates the detailed edge information of the ‘skating on snow mountain’ image and displays all the significant information on the edges. It shows the detailed edges of snow mountains to a large extent which is absent in other compared methods. Visual the presentation demonstrates the proposed method produced a superior quality of edge to other state-of-art methods.

Fig. 8 illustrates the BSD image ‘108041’ of ‘Tiger’ and the results of edge detection of several edge detection methods. Canny operator shows the edges of a tiger but it is not able to show details of edge information on the top and bottom part of the ‘Tiger’ image. Sobel operator illustrates the edges of a tiger but a few edges of tiger objects are missing and broken. Sobel operator is unable to show the edges of the top and bottom areas of the image. Robert cross operator lost several edge details of the ‘Tiger’ image. The overall visual quality is poor than Sobel and Canny operator.

Zero crossing edge detector illustrates details of edges but less information about water edges is still missing which is exist at the bottom side of the tiger image. Frei-Chen method shows edges of the ‘Tiger’ image but much edge information is not available to show which makes the overall visual performance unsatisfactory to Canny, Sobel, Robert, and Zero cross operators. The proposed method is overcome all these problems and displays detailed information on the edges of the ‘Tiger’ image. It illustrates the edge detail of the tiger objects as well as the edges of the water areas. The overall visual quality of the proposed method demonstrates the best visual presentation compared to other existing edge detection methods.

So, it is observed that the proposed method is superior to other compared methods from both quantitative and qualitative points of view



Fig. 8. BSD image ‘108041’ of ‘Tiger’ and its different edge detected results

## 5. Conclusion

In this paper Laplacian of grayscale image is computed through divergence operator followed by downsampling on the image Laplacian. The mean value of the computed downsampling of image Laplacian is considered a threshold value. Finally, the threshold value is compared with the image Laplacian to produce the final edge detection image. the proposed work advances the present state of knowledge in edge detection by producing better quantitative and qualitative results compared to other methods. The application of edge detection is to find the shape, and feature of desired objects in sports, medical, astronomy, agriculture, traffic monitoring, tracking, and so forth with less information. MATLAB simulation results obtained through the metrics i.e., Entropy, EBCM, F-Measure, and PR show that the proposed method outperforms the compared state-of-art methods. In the future, other mathematical and statistical operations can be applied to the proposed edge detection method for better performance. In the future study, the present method can be extended by making it more adaptive and introducing live edge detection technique in both windows and android versions to track and caught the criminals before the crime incident.

## References

- [1] Edge detection methods for finding object boundaries in images, <https://in.mathworks.com/discovery/edge-detection.html> (accessed January 2022).
- [2] Gonzalez, R.C., R.E. Woods, S.L. Eddins, Digital Image Processing Using MATLAB, New Jersey, Prentice Hall, 2003, Chapter 11.
- [3] Acharya, K., Ghoshal, D., & Bhattacharyya, B. K. (2021). Segmentation of images through curve fitting analysis by modified Vandermonde matrix and modified Gram-Schmidt method. IET Image Processing, 14(17), 4588-4598.
- [4] B. Meihua, G. Siyu, T. Qiu, and Z. Fan, "Optimization of the bwmmorph Function in the MATLAB image processing toolbox for binary skeleton computation," in Proc. Int. Conf. Comput. Intell. Nat. Comput., Wuhan, China, 2009, pp. 273-276.
- [5] Sobel, I., Feldman, G.: A 3x3 isotropic gradient operator for image processing. Presented at the Stanford artificial intelligence project (SAIL), 1968.
- [6] Prewitt, J.M.: Object enhancement and extraction. Pict. Process. Psychopict. 10(1), 15-19 (1970).
- [7] G. Roberts, Machine perception of three-dimensional solids, in Optical and Electrooptical Information Processing (J. T. Tippett et al., Eds), pp. 159-197, MIT Press, Cambridge, Mass., 1965.
- [8] Edge Detector, [https://in.mathworks.com/help/visionhdl/ref/visionhdl.edgedetector-system-object.html?searchHighlight=Roberts%20methods&s\\_tid=doc\\_srchtile](https://in.mathworks.com/help/visionhdl/ref/visionhdl.edgedetector-system-object.html?searchHighlight=Roberts%20methods&s_tid=doc_srchtile), MATLAB Central File Exchange. [Accessed Jan. 2022].
- [9] Laplacian of Gaussian, [https://in.mathworks.com/help/images/ref/edge.html?searchHighlight=Log%20edge&s\\_tid=doc\\_srchtile](https://in.mathworks.com/help/images/ref/edge.html?searchHighlight=Log%20edge&s_tid=doc_srchtile) MATLAB Central File Exchange. [Accessed Jan. 2022].
- [10] Canny, J.: A computational approach to edge detection. IEEE Trans. Pattern Anal. Mach. Intell.6, 679-698 (1986)
- [11] Haralick, R.M. 1984. Digital step edges from zero crossing of second directional derivatives. IEEE Trans. on Pattern Analysis and Machine Intelligence, 6(1):58-68.
- [12] W. Frei and C. Chen, "Fast Boundary Detection: A Generalization and New Algorithm," IEEE Trans. Computers, vol. C-26, no. 10, pp. 988-998, Oct. 1977.
- [13] Pragya Gautam, Krishna Raj, " Edge Detection based on Ant Colony Optimization Using Adaptive Thresholding Technique ", International Journal of Image, Graphics and Signal Processing (IJIGSP), Vol.10, No.7, pp. 60-68, 2018.DOI: 10.5815/ijigsp.2018.07.07
- [14] Naveen Singh Dagar, Pawan Kumar Dahiya, "A Comparative Investigation into Edge Detection Techniques Based on Computational Intelligence", International Journal of Image, Graphics and Signal Processing (IJIGSP), Vol.11, No.7, pp. 58-68, 2019.DOI: 10.5815/ijigsp.2019.07.05
- [15] Shekhar Karanwal, "Implementation of Edge Detection at Multiple Scales ", International Journal of Engineering and Manufacturing (IJEM), Vol.11, No.1, pp.1-10, 2021. DOI: 10.5815/ijem.2021.01.01
- [16] A. Beghdadi and A. L. Negrata, "Contrast enhancement technique based on local detection of edges," Comput. Vis. Graph. Image Process., vol. 46, no. 2, pp. 162-174, May 1989.
- [17] Shashi (2020). Edge based contrast measure for Image enhancement quality assessment (<https://www.mathworks.com/MATLABcentral/fileexchange/35365-edge-based-contrast-measure-for-image-enhancement-quality-assessment>), MATLAB Central File Exchange. Retrieved January, 2022.
- [18] Intawong K., Scuturici M., Miguet S. (2013) A New Pixel-Based Quality Measure for Segmentation Algorithms Integrating Precision, Recall and Specificity. In: Wilson R., Hancock E., Bors A., Smith W. (eds) Computer Analysis of Images and Patterns. CAIP 2013. Lecture Notes in Computer Science, vol 8047. Springer, Berlin, Heidelberg.
- [19] Lam, Benson Shu Yan, and Hong Yan. "A novel vessel segmentation algorithm for pathological retina images based on the divergence of vector fields." IEEE Transactions on Medical Imaging 27.2 (2008): 237-246.
- [20] Divergence in image processing, <https://math.stackexchange.com/questions/690493/what-is-divergence-in-image-processing>, accessed: April, 2022
- [21] Tan, Li (2008-04-21). "Upsampling and downsampling". [www.eetimes.com/multirate-dsp-part-1-upsampling-and-downsampling](http://www.eetimes.com/multirate-dsp-part-1-upsampling-and-downsampling). [Accessed Jan. 2022].
- [22] MATLAB 2018a. A Natick ed. Massachusetts, United States: The MathWorks, Inc.; 2018.
- [23] Arbelaez, P., Maire, M., Fowlkes, C., et al.: 'Contour Detection and Hierarchical Image Segmentation', IEEE Transactions on Pattern Analysis and Machine Intelligence., 2011, 33, (5), pp. 898-916.

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