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Smart Edge Detection Technique in X-ray Images for Improving PSNR using Sobel Edge Detection Algorithm with Gaussian Filter in Comparison with Laplacian Algorithm

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ABSTRACT

Aim: The aim of this study is to propose smart edge detection techniques in x-ray images for improving PSNR using the sobel edge detection algorithm and comparing it with the laplacian algorithm. **Materials and methods**: For the design of edge detection technique to improve PSNR Sobel edge detection algorithm is used along with the gaussian filter and it is compared with the laplacian algorithm. Sobel edge detection algorithm and laplacian algorithm are the two groups considered in this study. For each group, the sample size is 20 and the total sample size is 40. Sample size calculation was done using clinicalc.com by keeping g-power at 80%, confidence interval at 95%, and the threshold at 0.05%. **Result:** When comparing the two algorithms, it is clear that the Sobel edge detection algorithm has a higher mean PSNR value of 39.15db than the laplacian algorithm 36.79db. It is observed that the Sobel edge detection algorithm performed better than the laplacian algorithm by performing an independent sample t-test. The p value is 0.09 which is greater than the normal value($p>0.05$). **Conclusion:** Sobel edge detection has insignificantly greater PSNR when compared to the Laplacian algorithm

Keywords

Edge detection, Sobel Edge Detection, Laplacian Algorithm, PSNR, Image processing, Innovative edge detection technique.

Imprint

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INTRODUCTION

This work provides a method for edge identification on images with White Gaussian noises that combines the Sobel edge detection operator with soft-threshold wavelet de-noising. Many edge detection approaches have been proposed in recent years. The generally used approaches of combining mean de-noising with the Sobel operator, or median filtering and the Sobel operator, are ineffective at removing salt and pepper noise. In this study, we first reduce noise with a soft-threshold wavelet, then perform edge detection on the picture with the Sobel edge detection operator. This approach is most commonly used on photos with White Gaussian noises. We can observe from the results of the experiment that, when compared to typical edge detection approaches, the method suggested in this study has a more visible influence on edge detection. (Gao *et al.*, 2010)

Since 2015 there are 30 papers in IEEE and 47 papers in science direct have been published on the proposed edge detection algorithms. Image edge detection is a technique for locating an image's edge, which is useful for determining the approximate absolute gradient magnitude at each point I in an input grayscale image. The method used is the source of the challenge in obtaining an adequate absolute gradient magnitude for edges.In pictures, the Sobel operator measures the 2-D spatial gradient. The removal of redundant data is aided by converting a 2-D pixel array into a statistically uncorrelated data set, resulting in a reduction in the quantity of data necessary to depict a digital image. The Sobel edge detector employs a pair of 3 x 3 convolution masks, one of which estimates gradient in the x-direction and the other in the y-direction. Because the Sobel detector is so sensitive to image noise, it effectively highlights it as edges. As a result, the Sobel operator is recommended in data transfer for enormous data communication.(Vincent and Folorunso, 2009) Based on a k-means clustering approach, an enhanced edge detection algorithm has been developed. Edge detection, which is a key tool in image processing, tries to find the points in an image where the picture brightness varies sharply or

frequently. Edge detection is particularly valuable in medical science, such as in the segmentation of MRI images. By utilizing the natural magnetic properties of the bodily tissues, magnetic resonance imaging (MRI) creates a detailed image of any human body part. Because bodily tissues contain hydrogen atoms, they emit radio waves. A scanner then picks up on these radio frequencies. Magnetic resonance imaging (MRI) is a medical diagnostic that produces high-quality images that can be used to diagnose brain cancers. The location of a tumor is determined using paper edge detection in this experiment. The initial groups for the edge detection technique provided in this paper are generated using a k-means clustering strategy. The Mamdani fuzzy inference system is then used to construct alternative threshold parameters based on these categories. When these characteristics are fed into the traditional Sobel edge detector, the images acquired are enhanced and reveal the precise location of a brain tumor. ('A Novel Approach to Improve Sobel Edge Detector', 2016). Our team has extensive knowledge and research experience that has translate into high quality publications(Antink *et al.*, 2020; Chellapa *et al.*, 2020; Kaja *et al.*, 2020; Malaikolundhan *et al.*, 2020; Paul *et al.*, 2020; Raj R, D and S, 2020; Wu *et al.*, 2020; Kalidoss, Umapathy and Rani Thirunavukkarasu, 2021; Lavanya, Kannan and Arivalagan, 2021; Shilpa-Jain *et al.*, 2021; S, R and P, 2021; Ramadoss, Padmanaban and Subramanian, 2022)Our team has extensive knowledge and research experience that has translate into high quality publications(Antink *et al.*, 2020; Chellapa *et al.*, 2020; Kaja *et al.*, 2020; Malaikolundhan *et al.*, 2020; Paul *et al.*, 2020; Raj R, D and S, 2020; Wu *et al.*, 2020; Kalidoss, Umapathy and Rani Thirunavukkarasu, 2021; Lavanya, Kannan and Arivalagan, 2021; Shilpa-Jain *et al.*, 2021; S, R and P, 2021; Ramadoss, Padmanaban and Subramanian, 2022)

The initial stage in covering information in an image is edge detection. Edges define the borders of objects, making them important for image segmentation and identification. The goal of edge detection is to make the object's borderline appear more prominent in the image. The Sobel method uses two 3x3 pixel kernels for gradient calculations, resulting in an estimated gradient that is exactly in the middle of the window. The goal of digital image processing is to use a computer to alter picture data and interpret an image. Because each input image has a varied pixel value, the experimental results from the input image research, namely the floral image, have different MSE values. (Asmaidi *et al.*, 2019). This work focuses on digital image processing, salt, and pepper noise system research, digital morphological preprocessing, image filtering noise reduction using MM-Sobel edge detection, and region growth for edge detection. The four finished pairs of grey image edge detection is a reasonably comprehensive method, as shown by the simulation experiment, the algorithm for edge detection effect is outstanding, in the case that it can maintain more edge features. (Yao, 2016). Partially segmented images, which are sections of the same image, are one of the most recent directions in digital imaging research. The algorithms now in use are uncommon and far from perfect. Algorithms behave differently depending on the situation, making it nearly impossible to come to a single conclusion. This work proposes new digital picture segmentation approaches using an auxiliary Sobel edge detection algorithm and, in particular, a set detection threshold. Matlab software is used to create a specific conceptual design for a partial visual display and to correlate appropriate numerical methods of digital processing. The study's findings validate the suggested algorithm's quality and position it for practical application, as well as provide recommendations for further enhancements (Ivković *et al.*, 2018). In image processing and computer vision, image edge detection is crucial. The edges are the most essential parameter in an image, and they are employed extensively in image analysis and processing. The hardware version of the Sobel edge detection technique was chosen since it can work with less noise decline at high levels. The Sobel operator is a derivative mask that is used to detect edges. Two types of image edges can be recognized here. Thick limits and fractured edges characterise the edge detected image. The edge detected image cannot be obtained completely, and the time and space complexity are both high.. To address these flaws, the suggested approach includes the addition of additional masks as well as adjustments to the coefficients of each mask in the picture filter. For the best results, the proposed system is implemented using both MATLAB and SIMULINK. (Ravivarma *et al.*, 2021)

MATERIALS AND METHODS

In the study which was carried out at Saveetha School of Engineering college in the simulation lab, we are using an image enhancement technique for im-

proving PSNR of x-ray images using MATLAB simulation software. The sample size calculation was done using clinical.com by keeping alpha error threshold 0.05and power at 80% and the value for enrollment ratio is 0.1.95% confidence interval. The sample size is 40. In sample preparation for group 1 the image samples were collected from kaggle.com.In group 2 sample preparation 20 samples were collected from kaggle.com.Working station in designing the image processing filter is mostly in a personal computer in software named MATLAB R2014a with all the required addons installed. Both the algorithms have been simulated using the software MATLAB for optimization. The resultant graph shows that the Sobel edge detection technique along with the Gaussian filter produces better PSNR values

Statistical Analysis

By using the software IBM SPSS statistics 26 the statistical analysis is done. It helps to find the significant variance between the two. In our study an independent variable is PSNR and there are no dependent variables used in the study(McCormick *et al.*, 2017)

RESULT

The proposed algorithm shows better results when compared to the Laplacian algorithm. The proposed algorithm shows better PSNR values when compared to PSNR values produced by the laplacian algorithm. Table 1 shows PSNR for both algorithms.

Group statistics providing mean, standard deviation and standard error mean for a total of 40 samples is determined and shown in Table 2. The mean PSNR value is 39.15 for the sobel algorithm and 36.79 for the laplacian algorithm. Sobel algorithm provides a better PSNR than the laplacian algorithm.

Table 3 shows the independent sample test obtained from statistical analysis using algorithms like the sobel edge detector and laplacian with the IBM spss tool.

In Fig.1. The various images are depicted. Figure 1(a) shows the input original sample image.This image is given as input image to the sobel and laplacian algorithm. In Fig. 1(b) the original image is converted into a binary image. By changing the pixel values the binary image is converted into a segmented image which is depicted in Fig. 1(c). The output image using the innovative edge detection algorithm which is the sobel edge method is depicted in Fig. 1(d).

Table 1

PSNR values for Sobel edge detection algorithm and laplacian algorithm for different iterations. the improved Sobel edge detection algorithm produces higher PSNR values than the laplacian algorithm

Iterations	Sobel Edge Detection Algorithm PSNR(db)	Laplacian Algorithm PSNR(db)
1	38.5	36
2	38.6	36.2
3	38.7	36.3
4	38.7	36.4
5	38.8	36.5
6	38.8	36.6
7	38.8	36.7
8	38.8	36.7
9	38.9	36.7
10	39	36.9
11	39.2	36.9
12	39.3	37
13	39.4	37
14	39.5	37
15	39.5	37
16	39.6	37.1
17	39.6	37.1
18	39.7	37.1
19	39.8	37.2
20	39.8	37.2

Table 2

SPSS analysis of two groups – Group statistics providing means, standard deviation, and standard deviation, and standard error mean of the PSNR for the total samples of 40. The Sobel edge detection algorithm has better PSNR than the laplacian algorithm

Group Statistics					
	Group	N	Mean	Std. deviation	Std. error mean
PSNR	Sobel Edge Detection Algorithm	20	39.1535	.43960	.09830
	Laplacian Algorithm	20	36.7950	.35314	.07897

The graphical representation of PSNR values for both algorithms simulated for different iterations is shown in Figure 2. From the graph, it is evident that for most of the iterations the Sobel algorithm provides better PSNR.

Figure 3 gives the comparison of both algorithms. An Independent t-test is used for comparing both the algorithms and a statistically significant difference is

Table 3

Independent Sample Test: The Mean Standard deviation and significant difference of the sobel edge detection algorithm have better PSNR consistent with the Laplacian algorithm. There is a Significance difference between the two groups since (independent T test)

Parameters		Leven's Test for Equality of Variances					T-Test for Equality of Means		95% Confidence interval of the difference	
		F	Sig	t	df	sig(2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
PSNR	Equal Variances assumed	3.031	.090	18.705	38	.000	2.35850	.12609	2.10325	2.61375
	Equal variances not assumed				36.313	.000	2.35850	.12609	2.10286	2.61414

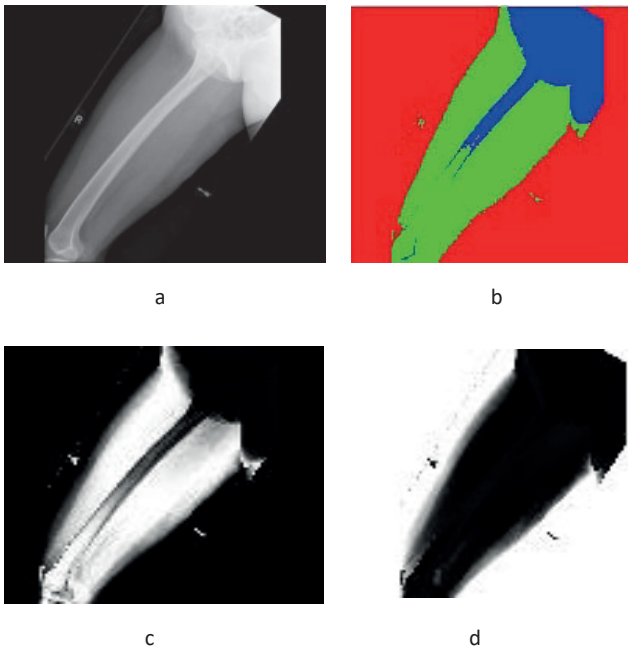

Fig.1. Simulation result using Sobel edge detection algorithm. (a).Input image (b)binary image.(c) segmented image.(d)simulated image with filter

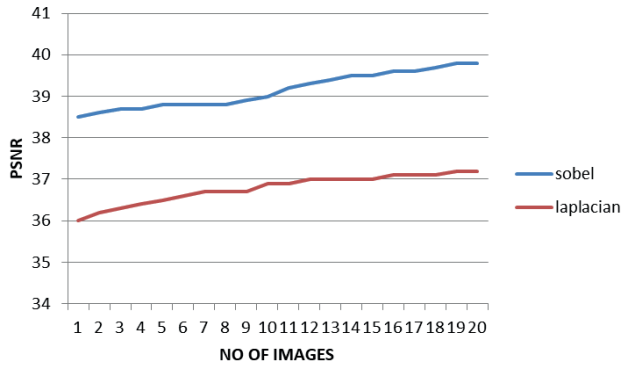

Fig. 2. The difference in PSNR values produced by the sobel edge detection algorithm and the laplacian algorithm.20 iterations are performed and the sobel edge detection algorithm produces more PSNR values than the laplacian algorithm

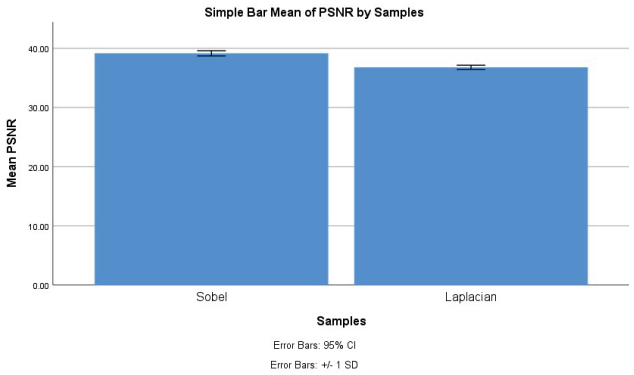

Fig. 3. Comparison of Sobel edge detection algorithm and laplacian algorithm using standard deviation values. The mean PSNR of the sobel edge detection algorithm is better than the laplacian algorithm. X-axis: Sobel edge detection algorithm vs laplacian algorithm Y-axis: Mean PSNR with +/_ 1 SD

noted in the mean PSNR value. The Sobel algorithm produces a insignificant difference from the laplacian algorithm with a value of 0.09 ($p > 0.05$)

DISCUSSION

The challenge of image edge detection is a well-known one in computer vision and image processing. The choice of threshold is crucial in edge detection; the outcomes of edge detection are directly determined by the threshold. One of the most difficult aspects of edge detection is determining an optimal threshold automatically. In this study, we first look at the Sobel edge detection operator and its enhanced algorithm in terms of optimal thresholding. After that, a new automatic threshold approach for image processing is proposed, which is based on evolutionary algorithms and an enhanced Sobel operator. Finally, two algorithms are used to perform edge detection experiments on two real photos. (Jin-Yu, Yan and Xian-Xiang, 2009). The Sobel edge detector's magnitude and angle accuracy are investigated. It is demonstrated that the iterative Sobel edge detector's error-free angle output can only be obtained at the expense of edge magnitude accuracy. The equations for adjusting edge angle and edge magnitude

are derived. (Kittler, 1983). Edge detection is one of the most widely utilized processes in computer vision. The key to edge detection is the threshold selection; the threshold selection directly influences the edge detection results. One of the most difficult aspects of edge detection is determining an optimal threshold automatically. In this study, we first look at the Sobel edge detection operator and its enhanced algorithm in terms of optimal thresholding. We include color information into a principal component analysis-based color edge detection method (PCA). Finally, two methods are used to undertake edge detection studies on synthetic and real color images. The findings of the comparative experiment reveal that the new algorithm is extremely successful. The results are also superior to those obtained using traditional approaches. (Rami, Hamri and Masmoudi, 2013). The SIFT algorithm (Scale Invariant Feature Transform) is a method for extracting invariant characteristics from photographs. Because the SIFT detector searches the entire scale space for extreme points, it frequently finds key points that have no value, reducing the algorithm's efficiency. The Sobel edge detector is used in this research to develop a fast SIFT technique. The Sobel edge detector is used to construct an edge group scale space, and the SIFT detector is used to identify the extreme point inside the edge group scale-space restriction. The experimental findings show that the suggested technique reduces keypoint redundancy and speeds up implementation while maintaining a high matching rate between diverse images. The number of key points decreases as the Sobel detector's threshold rises. (Li *et al.*, 2012). The Quality of Edge Detected at Different Threshold Values will be discussed in this study. We shall compare Bacterial Foraging Algorithm, Canny Edge Detector, and Sobel Edge Detector for this purpose. The Methodology Bacterial Foraging likewise employs a thickness limitation and follows the Swarm intelligence characteristic, and operates similarly to how bacteria look for food. Canny reduces noise before applying a Gaussian Filter, whereas Sobel uses the notion of Image Gradient for Edge detection. We will look at a common image with multiple thresholds and different methodologies in this study. Finally, we'll determine the best threshold values for each technique. (Goel, Sehrawat and Agarwal, 2017). Edge detection is frequently utilized in image processing and analysis applications. It's an old idea that uses numerical derivatives to detect image edges, usually of the first (gradient) or second (Laplacian) order. Edge detection is addressed with non-integer order derivatives with the advent of fractional calculus. The design of a fractional-order Sobel edge detector is proposed in this study. For the first-order derivative, Sobel gradient operators are used, and fractional calculus is used for non-integer orders beyond unity. In the context of road obstacle identification, the proposed method is developed and evaluated, and it is compared to the traditional Sobel edge detector. (Yaacoub and Daou, 2019).

CONCLUSION

The Sobel edge detection algorithm has significantly greater PSNR than the laplacian algorithm. Sobel edge detection gives a better PSNR of about 28.98 when compared to the Laplacian algorithm which gives 27.08

DECLARATIONS

Conflict of interest

No Conflict of interest in the manuscript

Author Contribution

Author NK was involved in data collection, data analysis, and manuscript writing. Author PN was involved in the Conceptualization, Data Validation, and critical review of the manuscript

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