An improved Sobel edge detection using median filter

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***Abstract*—This paper offers a sophisticated algorithm for edge detection that is based on the traditional Sobel operator, whose flaw is that it is highly noise-sensitive and has a rough effect. An enhanced technique that combines the median filtering method with an improved Sobel operator is presented in this paper. The Sobel operator's limited sensitivity to vertical and horizontal directions is well addressed by this technique, which generates edge detection for the images with salt and pepper noise. In order to eliminate salt-pepper noise, it combines the benefits of the median filter. The experiment's results outperform the traditional edge detection technique.**

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I. Introduction

The introduction section of the paper provides a comprehensive overview of the importance of edge detection in image processing and its applications in various fields. E dge is a crucial feature of the image that contains a wealth of information and is essential for extracting image characteristics in image segmentation, identification, and analysis. The section also highlights the two characteristics of the edge, direction, and magnitude, and explains how the edges can be divided into two kinds: step-like edge and roof-like edge.

Furthermore, the need for a detection algorithm that is strong against noise, can accurately position edges, and does not produce false detections is implemented. The proposed improved Sobel algorithm based on median filtering that overcomes the limitations of the classical Sobel operator and provides better edge detection accuracy. The algorithm uses a weighted mean to calculate the coefficients of the Sobel operator and different values for the coefficients in different locations to ensure that the pixel near the center of the template contributes more to the filter results.

Individuals anticipate a detection method that is robust against noise, prospectively positioned, undetectable, and does not produce false positives. The gradient operator is primarily utilized in classical algorithms; Prewitt and Sobel operators are more frequently used; while the Sobel operator has a superior result, the classical Sobel operator also has a number of drawbacks. Some edges cannot be directed due to its strong directional nature, which is only sensitive to vertical and horizontal directions. This has a significant impact on the processing of subsequent images.

II. Classical Sobel operator

The Sobel operator is a gradient-based edge detection algorithm that is commonly used in image processing. It works by calculating the gradient of the image intensity at each pixel and then using this information to identify edges.
Sobel edge operator uses two convolution kernels that are

$$k1 :- \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix}$$

$$k2 :- \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix}$$

These two kernels are used to perform convolution at each point in the image. The Sobel operator is sensitive to edges in the vertical and horizontal directions. The typical vertical edges cause one kernel to respond to its maximum, while the horizontal edge causes the other kernel to respond to its maximum. This point's output value is the maximum of the two convolutions.

s(i,j) :- $|\Delta_x f| + |\Delta_y f|$
$\Delta_x f : -(f(i-1,j-1) + 2f(i-1,j) + f(i-1,j+1))$
$-(f(i+1,j-1) + 2f(i+1,j) + f(i+1,j+1)))$
$\Delta_y f : -(f(i-1,j-1) + 2f(i,j-1) + f(i+1,j-1))$
$-(f(i-1,j+1) + 2f(i,j+1) + f(i+1,j+1)))$

We can see the weighted difference of the gray of the points surrounding each pixel in the digital image U(x,y), and the weights of the nearby bordering points are large.

It is not as effective at detecting edges in other directions. Sobel operator has a smoothing effect on noise but it cannot remove salt and pepper noise completely. Hence improved methods are to be developed to effectively detect edge by efficiently removing salt and pepper noise.

III. MEAN

In image processing, a mean filter is a linear digital filtering method that is frequently used to eliminate noise from images. The way it operates is by substituting the average value of each nearby pixel for each pixel in the image. This method works well for mitigating Gaussian noise, a kind of noise that manifests as erratic brightness variations in an image. The size of the neighborhood used for the computation and the total number of pixels included in the calculation determine how effective the mean filter is. For example. the template can be

$$k2 : -(1/10) \begin{bmatrix} 1 & 1 & 1 \\ 1 & 2 & 1 \\ 1 & 1 & 1 \end{bmatrix}$$

Mean filtering is combined with Sobel operator to remove noise and detect edge of an image.
Mean filter is faster than nonlinear filters. Although the mean filter reduces noise and blurs edges and details in an image, it cannot completely remove salt and pepper noise.

IV. MEDIAN

A median filter is a nonlinear digital filtering technique which is frequently used in image processing to eliminate noise from images. The way it operates is that the median value of each pixel in the image is substituted for the original one. This method works well for eliminating "salt-and-pepper" noise, a kind of noise that makes sporadic white and black pixels appear in an image. The size of the neighborhood used for the computation and the total number of pixels included in the calculation determine how effective the median filter is. Although the median filter is slower than linear filters, it can reduce noise in an image while maintaining edges and boundaries.

V. IMPROVED SOBEL ALGORITHM

The improved Sobel algorithm based on median filter is
Step 1: Select a right median filter template according to consistency of noise
Step 2: Use median filter on the image and filter out salt and pepper noise
Step 3: By the template of Sobel operator, define the edge template coefficient
Step 4: Convolute every pixel of the image with the template and get the gradient of the point. The amplitude of gradient is output of this point.

VI. RESULTS

The classical Sobel algorithm can detect edges well but sensitive to salt and pepper noise as shown in figure 3. Mean filtering along with Sobel operator can improved edge detection by reducing salt and pepper noise to a small extent but it cannot remove the noise totally. The result of Sobel edge detection with mean filtering is shown in figure 4. The improved Sobel algorithm combined with median filter effectively reduces salt and pepper noise and performs edge detection very well The result of Sobel edge detection with mean filtering is shown in figure 4. The experiment demonstrates that this algorithm's performance outperforms that of the traditional edge detection technique.

Figure 1. Input image

Figure 2. Noisy image

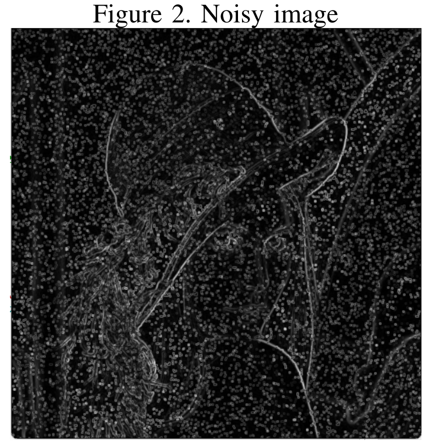

Figure 3. Sobel edge detected image

Figure 4.]Sobel operator based on mean filtered image

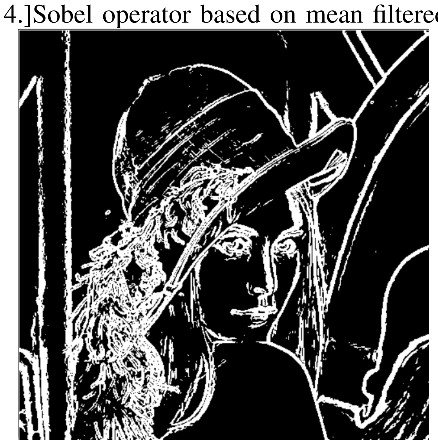

Figure 5. Sobel operator based on median filtered image

VII. Conclusion

Improved Sobel algorithm based on median filter overcomes the limitations of the classical Sobel operator for edge detection. It can eliminate peak pulse and high frequency noise signal and effectively suppress salt pepper noise. More importantly ir can effectively detect edges in noisy images.

VIII. References

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