Research on improved sharpening algorithm based on closed operation and binarization

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Abstract. In this paper, binarization and closed operation are used to improve traditional sharpening algorithms. Aiming at the problem that traditional sharpening algorithm tends to sharpen noise when processing pictures. First of all, this paper eliminates noise through binarization, and then uses morphological closed operation to fill the cavities generated by noise. Finally, the Sobel operator is used to detect the edge of the image, which is superimposed with the original image and simulated on matlab. The simulation result shows that the improved sharpening algorithm based on binarization and closed operation can not only sharpen the edges of the image, but also not sharpen the noise. The innovation of this paper is to make the image sharpening effect better than traditional phase algorithm.

1. Introduction

To enhance the edge of a gray-scale image containing Gaussian noise, it is necessary to suppress the noise, the purpose is to reduce the effect of noise on the edge of the extracted image. But the traditional sharpening algorithm has drawbacks. It is mainly reflected in the processing of grayscale images containing Gaussian noise. Because mean filtering suppresses the noise and also suppresses the edges of the image, resulting in blurring of the image edges, making it more difficult to extract image edges. Regarding the problem of image sharpening, some scholars at home and abroad conducted research and achieved certain results. Yang Xiuzhang and others had proposed an image edge extraction algorithm for images with low contrast through the research on the edge extraction of Hmong clothing images [1]. Li Lu and others had proposed Sobel weighted operators for image edge detection [2]. Yang Hong improved the Sobel algorithm for image sharpening and performed matlab simulation [3]. Wu Ting proposed a sharpening method based on non-uniform ordered histograms, mainly for infrared image enhancement [4]. Wu Wei and others adopted weighting Least squares filtering and fuzzy Gaussian histogram equalization method for image enhancement [5]. Mohammad Farhan Khan and others used normalized histogram equalization for image contrast enhancement [6]. Wang Xuewen and others improved the traditional histogram, used the improved histogram to sharpen the image [7]. However, what these methods do not consider is how to eliminate the influence of Gaussian noise on the extracted image edges during the sharpening process, so that only the edges of the image are sharpened.

In order to eliminate the influence of Gaussian noise in the sharpening effect, this paper uses two methods of binarization and closed operation to eliminate the influence of Gaussian noise on edge extraction, and performs edge detection on the black and white image through the Sobel operator, and finally adds it to the original image. Get a sharpened image that only sharpens the edges of the image.
2. Methodology

2.1. Traditional sharpening algorithm

Image sharpening refers to protecting the high-frequency information of the image, that is, the edge of the image, so that the edge details of the image are enhanced. For a noise-free image to sharpen its edges, it is important how to extract the edges. Sharpening algorithms based on edge detection operators have developed rapidly, such as Sobel operators and Canny operators. This article chooses the image sharpening algorithm based on Sobel operator.

For images containing Gaussian noise, the images need to be average filtered. However, noise still exists. Since noise also belongs to high-frequency information, the traditional image sharpening algorithm first detects the edge of the image and then adds it to the original image to obtain a sharpened image. This method is not practical. Traditional sharpening algorithms sharpen noise and image edges. To solve this problem, the previous solution is to first perform further denoising on the image to improve the signal-to-noise ratio of the image. However, this will reduce the gradient of the image edge, which will cause some edge information to be lost during edge detection, resulting in sharpness. The effect is not good.

2.2. Improved sharpening algorithm

First, use binarization. Binarization is a relatively simple method in image segmentation. To binarize the image is to divide all pixels in the image into two poles, namely 0 and 1. 0 represents black and 1 represents white, so that the original image is converted into a binary image with only two colors of black and white to achieve image segmentation.

Before performing the binarization process, a threshold \( T \) needs to be set. All pixel values in the image are compared with \( T \). Using Eq. 1, if the pixel value is less than \( T \), then set the pixel value of this pixel to 0.

\[
f(i, j) = 0 \quad (f(i, j) < T)
\]

Otherwise, using Eq. 2, set the pixel value of this pixel to 1.

\[
f(i, j) = 1 \quad (f(i, j) > T)
\]

In the formula, \( f(i,j) \) is the pixel value of the pixel with coordinates \((i,j)\) in the image. This paper uses the double peak method to select the threshold \( T \).

Second, use closed operation. Swelling and corrosion are concepts in morphology. It is a method that uses structural elements to perform logical operation on a binary image to generate a new image. Fig. 1 shows the structural elements.

![Figure 1. Structural elements.](image)

The closed operation process is the process of expanding the image first and then corroding it. The operation formula is shown in Eq. 3.

\[
B \bullet S = (B \oplus S) \Theta S
\]

"\( \oplus \)" stands for expansion treatment and "\( \Theta \)" stands for corrosion treatment. \( B \) stands for binary image and \( S \) stands for structural element. After the image is closed, it can fill in the small holes inside or connect adjacent objects, and also smooth the edges of the image.
As shown in Fig. 2, Gaussian noise causes many small holes in the grayscale image after binarization. The tiny holes appearing in the red round frame are the outline of the noise. These holes will affect the sharpening effect. As shown in Fig. 3, this paper uses closed operation to deal with these holes. As can be seen from the red circle in Fig. 3, the binary image after the closed operation can greatly reduce the impact of noise.

**Figure 2.** Binary image.  
**Figure 3.** Close operation result.

Third, use Sobel operator. For binary images, since there are only two pixel values, 0 and 1, the color gradient is obvious. So using Sobel operator is enough to detect edges. The template corresponding to the Sobel operator is shown in Eq. 4.

\[
S_x = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix}, \quad S_y = \begin{bmatrix} -1 & -2 & -1 \\ 1 & 2 & 1 \end{bmatrix}
\]  

(4)

Among them, \( S_x \) represents the template in the horizontal direction, and \( S_y \) represents the template in the vertical direction.

Finally, use Eq. 5 to calculate the sharpened image. Use the Sobel operator to perform edge detection on the enclosed binary image. Obtain the edge contour of the original image. Then, using Eq. 5, the original image and the sharpened edge image are added. An image sharpened only for edge pixels can be obtained.

\[
F'(i, j) = k * f(i, j) + F(i, j) \quad (k > 0)
\]  

(5)

\( F'(i,j) \) represents the final sharpened image, \( F(i,j) \) represents the original image, \( k \) represents the gain of edge sharpening, and \( f(i,j) \) represents the image after edge detection.

### 2.3. Algorithm flow

The mean filtering is applied to the image containing Gaussian noise, which makes the edge of the image blurred. In order to sharpen the edges of the image without enhancing the noise, it is necessary to suppress the influence of noise on the sharpening process to a maximum extent. Therefore, this paper adopts the binarization processing, closed operation processing, and image sharpening process.

This article is based on matlab software for simulation test. Fig. 4 shows the specific flow of the algorithm. First, the grayscale image is binarized to obtain a black and white image, and then the binary image is processed by closed operation, and then the image is sharpened, and the edge image of the binary image is detected by the Sobel operator to obtain the edge contour of the original image. Finally, the edge contour of the original image obtained is added to the original image to obtain a sharpened image.
3. Experiment and discussion
In order to more intuitively see the sharpening effect of the improved sharpening algorithm, this paper takes \( k = 100 \) for the experiment. The simulation results are shown in Fig. 5, Fig. 6, Fig. 7 and Fig. 8.

![Algorithm flow chart](image-url)

**Figure 4. Algorithm flow chart.**

**Figure 5. Original image.**

**Figure 6. Sharpen (Sobel).**

After experimental comparison and analysis of the simulation results of the traditional sharpening algorithm and the improved sharpening algorithm, it can be clearly seen that the improved sharpening algorithm proposed in this paper can effectively eliminate the influence of Gaussian noise on image sharpening. For the traditional sharpening algorithm, the edge detection result based on the Sobel operator is shown in Fig. 6, and some edges in the original image are enhanced. This is due to the fact that the Sobel operator's positioning of the image edge is prone to deviation. While sharpening the edges, it also sharpens the noise. The results of edge detection based on the Canny operator are shown in Fig. 7. Although the image edges in the original image have been enhanced, due to the presence of noise, the edges of the noise are also extracted by the Canny operator, so the edge of the enhanced image At the same time, it is also enhancing noise, which is not allowed. Fig. 8 is the result of processing the original image through the improved sharpening algorithm proposed in this paper. It can be clearly seen that the algorithm proposed in this paper can completely eliminate the effect of noise on image sharpening. In
the process of image sharpening, the Gaussian noise inside the image is not enhanced, and only the edge portion of the image is sharpened. Meet the test requirements.

![Figure 7. Sharpen (Canny).](image1.png) ![Figure 8. Improved sharpening.](image2.png)

However, as can be seen from Fig. 8, the algorithm proposed in this paper can only sharpen the outermost edge contour in the original image. For the object information where the cross phenomenon occurs in the original image, due to the effect of binarization, the information of the cross part image is merged into one. When edge detection is performed at this time, the outline of the cross part cannot be recognized. This makes it impossible to sharpen the image edges of the intersection during the final sharpening process. In Fig. 8, the part where the orchid leaves intersect and the rock part of the orchid root illustrates this problem. For this problem, further research is needed. For this problem, in this article, the reason for the analysis is that the selection of the threshold T fails to separate the overlapping parts of the original image. As a result, after binarization, the overlapping part of the image is integrated, so the outline of the overlapping part cannot be sharpened. For the selection of the threshold T, this article only introduces one of them. For other methods, such as Otsu, iterative method, gray-scale stretching method and other algorithms have not been tested in this article. Therefore, it is necessary to continue to study and analyze whether these algorithms are feasible, and to achieve the goal by combining and improving these algorithms.

4. Conclusions
In this paper, the image is firstly binarized to eliminate noise. Secondly, the noise bubbles are eliminated by the closed arithmetic algorithm. Then the closed binarized image is edge detected by the Sobel operator. Finally, the edge image and the original image are added to obtain the final Sharpen image. Experimental results show that the improved sharpening algorithm proposed in this paper can achieve the preset goal, but the improved algorithm still has the defect that it cannot sharpen the contours of the overlapping parts of the image. In view of this problem, further research is needed.

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