Comparison of edge detection operators in digital image processing

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Abstract. The Internet has been developed so far, computer has developed rapidly, and the use of computer for image processing has been widely used in all walks of life, the use of MATLAB for image processing has become a hot topic today. Image processing can find the information it wants in many images repeatedly compressed on the network, and restore information to a certain extent. Edge processing step is included in various digital image processing models. So Edge processing is particularly important for image processing. Common edge detection algorithms include Prewitt, Sobel, Canny, and so on. Choosing a more appropriate and effective operator becomes particularly important for processing the image. The three operators are processed by grayscale, binarization, edge detection of different operators, and the final results are compared. Gaussian white noise is added to compare the white noise interference ability of the three operators. Finally, the Canny operator works better.

Keywords: MATLAB, image processing, edge detection, canny

1. Introduction

With the development of Internet, there are thousands of the picture information, the number of people working with images is increasing rapidly, image processing has become more and more important. Computer technology develops at the fastest speed, processed by computers for digital image processing as an application based on human vision. Image processing can find the information it wants in many images that are repeatedly compressed and decompressed on the network, and restore the information to a certain extent. Before the emergence of computers, people relied on the naked eye to find the information they wanted, but due to human factors, poor objectivity was impossible to better judge the accuracy of information. Image processing refers to processing an image with a computer. Image acquisition, image-to-image conversion, image segmentation, encoding compression, image feature extraction, image enhancement and restoration, and image classification can all be realized through image processing.[1]There are countless people using MATLAB for various image processing in various fields at home and abroad. Some people use it to process [2] for oil film interference image, some people use it for video image processing [3], and some people use it to design an image and video quality evaluator [4].Because many people use MATLAB for image processing, image processing is a good topic worth studying. It means that a more accurate image processing tool needs to be found. Image processing contains many steps, the common steps are grayscale, median filtering, binarization, edge processing, labeled pictures, and so on. An important step of image processing is edge detection. Generally speaking, this step can be used with different methods. Common edge detection algorithms include Prewitt operator,

Sobel operator, Canny operator and so on. Finding a proper operator to image processing becomes significant.

This paper will compare the characteristics of three different operators and analyze their advantages and disadvantages, for better edge processing. In the past, it was found that Sobel is less computational, and the Prewitt operator is more convenient to implement. To some extent, the Canny algorithm is a further refinement and more accurate positioning of the effects of other operators.

The following structure of this paper will contain a short literature review of previous works. And then this paper will compare the three operators in the same image processing model. Then, in the next section, we will discuss the characteristics of each method. Finally, we will make a short conclusion.

2. Literature review

Edge processing step is included in various digital image processing models. Edge detection process is considered to be the basic operation implemented in the image processing. In general, this step can be done using the 3 operators in the Edge function. Around the world, the three operators have made a comparative analysis of their own advantages and disadvantages. Further improvements were also made to the operator.

Yue Di et al. [5] compare the effects of five edge detection operators in edge detection on the corneal surface: 'Sobel', 'Canny', 'Prewitt', 'Roberts', and 'Log'. The Canny return image is found to have a most smooth and complete curve. Guo et al [6] chose the canny operator to measure the parameters of straight cylindrical gear. After comparing different people in different test environments, most people use the Canny operator.

Further improvements were also made to the operator.

P.Arunkumar et al. [7] proposed a modified CANNY algorithm for edge processing, using an adaptive watershed segmentation algorithm and a modified canny algorithm to segment text content in document images. MAMTA MITTAL et al. [8] proposed an edge detection method based on the multiple threshold method (B-Edge), using the choice of two thresholds in the canny operator set. The proposed method can effectively solve the detection threshold of the effective edges. Ri-Gui Zhou et al. [9] proposed a quantum edge extraction algorithm based on the NEQR model, combining non-maximal inhibition and adaptive threshold determination, by improving the Prewitt operator. Xiangyu Sun and jijiang Ge [10] used the CANNY operator edge to detect the prominent residual oil droplets to discover the residual oil inside the displacement route. R.Chetia et al. [11] implemented quantum circuits, simulation results, circuit complexity, and the number of edge pixels by improving the Sobel operator. The operator has the characteristic of non-maximal suppression and can be used in new enhanced quantum representation methods. An adaptive smart edge detection algorithm based on iterative algorithm was proposed by Deng Dongwei, [12] master from Hunan Normal University. The improved Canny operator has the following characteristics: high sensitivity, specificity and accuracy, which is estimated to have better performance results than traditional methods.
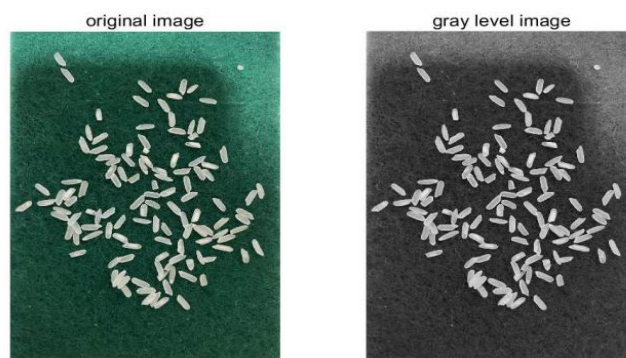

Figure 1. Comparison of original image and grayscale and after image denoising.

3. The three operators were compared using the MATLAB

A more precise conclusion requires a comparison under the same experimental conditions, which will analyze the results of the three operators processed in the same scattered photo of rice. This paper will be divided into two parts: pre-processing and edge detection and its feature processing, and the final processing results will be obtained through the corresponding operation. And the three operators are compared against noise in the edge detection environment.

3.1. Image preprocessing

Image preprocessing includes grayscale, image denoising, image binarization processing, etc. This step is mainly designed to enhance the contrast of the picture and improve the success rate of the subsequent steps. In this paper, scattered rice grains were used as experimental samples.

3.1.1. Graycalization and image denoising. Images taken by the camera are RGB images. The RGB refers to the colors of the red, green, and blue channels, and almost all the colors visible to the naked eye are included by this standard. But for faster computing speed on computers, they need to be converted to grayscale images. The principle of median filtering is that the rgb2gray function in MATLAB is used for gray-scale processing and the medfilt2 function for used. The results after gray-scale and image denoising are shown in Figure 1.
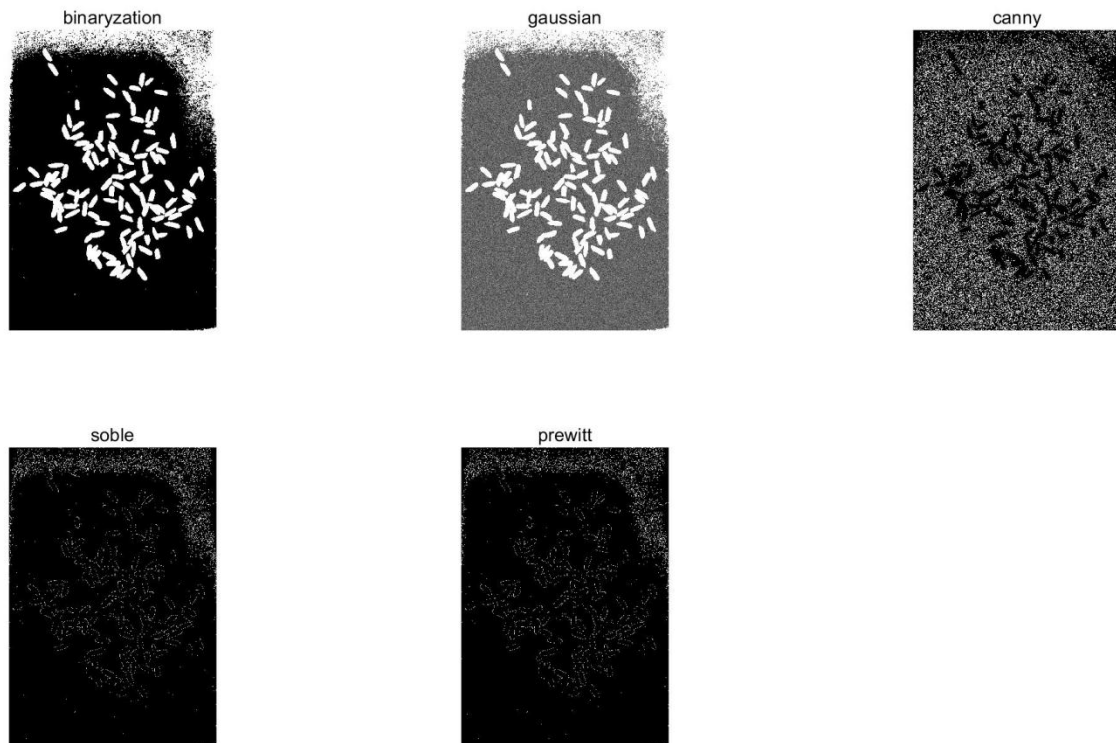

Figure 2. Add a Gaussian noise, a comparison of the three operators.

3.1.2. Image binarization processing. After the gray scale and image denoising, binarization is an important operation to perform image segmentation to distinguish the target and the background, making the image simple and reducing the data amount, which can highlight the outline of the target of interest. Binarization changes a portion of the data in a grayscale image to only 0 (black) and 1 (white).To make the binarization results more appropriate, the graythresh function is utilized here to automate the determination of the binarization threshold. Automated determination of the binarization threshold can make the binarization results more accurate, without resulting in the fuzzy error phenomenon caused by arbitrary selection.

3.2. Image edge processing and feature extraction

3.2.1. Edge detection. Edge processing is an important step in image processing, and the object edges can be detected by the gray scale changes in the image, so that the object outline in the image becomes clearer, thus realizing the purpose of image segmentation. The edge detection implementation based on MATLAB is more sensitive than FFT[13].Therefore, there are three kinds of edge detection methods more commonly used in this paper: Canny operator, Prewitt operator and Sobel operator. The derivative of the Prewitt operator in the x direction is approximated by the difference between the two gray lines and the difference in the y direction. The principle is that edge detection can be realized by the difference generated by the gray value of pixels in a specific region. For the Sobel operator, the weighted difference of the neighboring point, the closer it, is used to compare each pixel in the image. Canny is different from the other two operators. The first step is to select a suitable Gaussian filter, and use the non-extremal suppression technique to achieve the edge detection effect. In this paper, a Gaussian white noise with a mean of 0.4 and a variance of 0.01 is added to compare the noise resistance of the three operators. A Gaussian distribution in Gaussian white noise indicates that the probability distribution presents a normal function, while a white noise representation shows that the second moment is not correlated. Among them, the power spectral density is uniformly distributed, and its amplitude distribution is Gaussian. One of the ideal models for analyzing channel additive noise is Gaussian white noise, which "random" signal can better analyze experiments. The noise resistance of the three operators can be compared by the resulting alignment of the added Gaussian noise. The result of the edge processing after adding the noise is shown in Figure 2.
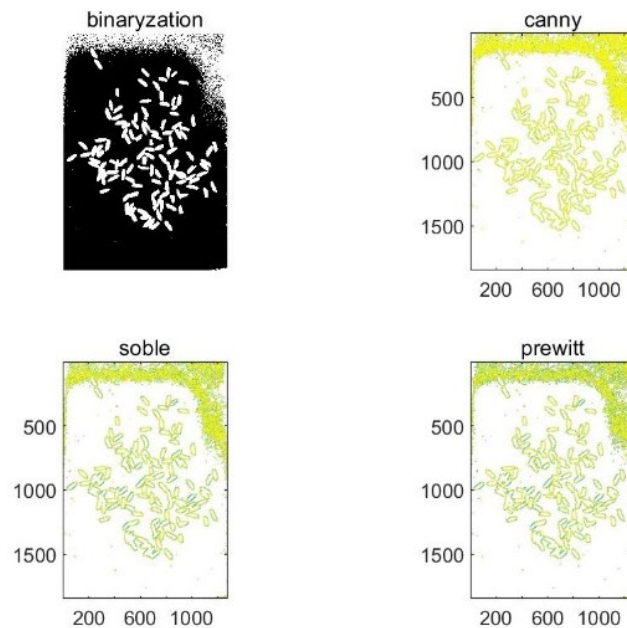

Figure 3. After the noise-free edge processing.

For subsequent processing, edge detection without noise was also performed with the following procedure. The results after the edge processing are shown in Figure 3.

3.2.2. Outline extraction. The aim of contour extraction is to better perform the detection of the object edges in the image. This paper again uses the imcontour function to perform contour extraction to reduce unnecessary noise in the image. The three operators and then contour extraction processing obtained the results in Figure 4.
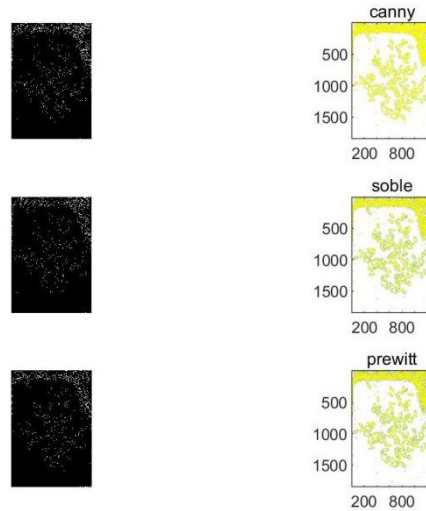

Figure 4. Results of the contour extraction.

3.2.3. Label images. Image labeling is assigning the same label to all pixels that are connected in the image. Labeling processing can separate each link component in order to study characteristics. Through this step, the specific results of the three operators can be analyzed. From left in Figure 5 to right in Figure 5 is the last presented images using the Canny operator, the Sobel operator and the Prewitt operator.
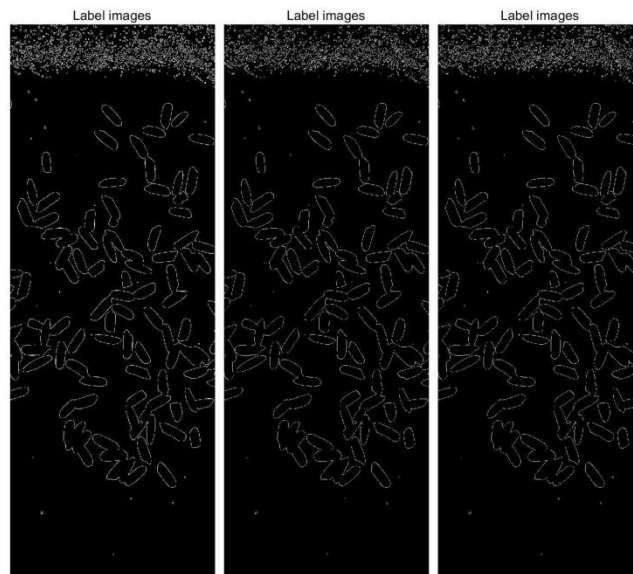

Figure 5. The effect of the final image processing presentation.

4. Results and discussion

In step 3.2.1, after the addition of a Gaussian white noise with a mean of 0.4 and a variance of 0.01.As can be seen from the comparison results of the three operators, the Canny operator presents the best anti-noise results, with the best edge detection effect, and the obtained results can see the clear rice grains. Compared with the Canny operator, the Sobel operator is relatively fuzzy and has a poor resistance ability. This is because the Canny operator is used to use a Gaussian filter, and high and low thresholds are better traced to the edges. That is why the Canny operator gets the best results.

The Prewitt operator has the highest ambiguity without noise. And the Canny operator still performs the best, with not much difference between the Prewitt operator and the Sobel operator. The Canny operator smoothly filters some Gauss filter, with better anti-interference effect than the other two operators, and the result has better image processing results, but a long time. The Prewitt operator is simpler and processed faster than the Sobel operator, but the Sobel operator is better in terms of noise printing characteristics.

The Sobel is less computational, and the Prewitt operator is more convenient to implement. To a certain extent, the Canny algorithm is a further refinement and more accurate positioning of the effects of other operators.

5. Summary

This paper analyzes and studies the image processing of scattered rice grains. Image processing was performed through grayscale, median filtering, binarization, edge detection, contour extraction, and labeling image steps. By adding noise to edge detection, we found that Canny had better edge detection after adding noise, and the final image results were of better quality and more obvious. As with most studies, limitations to the design of the current study. This paper is only a rough comparison of the three operators, and the developed criteria have limitations. Improving these shortcomings is one of our future work.

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