Image Denoising Algorithm Based on Neighborhood Clustering

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Abstract --- In image processing, noise in the image has become an important factor affecting image quality. The appearance of noise will cause important information in the image to be lost, and blurring will occur, affecting the image quality.
The neighborhoods used in traditional spatial domain image processing algorithms are mostly squares, but the neighborhoods of pixel points in real images have various shapes. Traditional algorithms cannot adapt to the characteristics of neighborhood diversity. This paper first proposes an image denoising algorithm based on neighborhood clustering. The algorithm focuses on generating a dynamic neighborhood, then integrating the pixel information in the neighborhood and completing the denoising. This algorithm has achieved good denoising effect. Compared with the traditional spatial domain denoising algorithm, the peak noise ratio is significantly improved.

Image Denoising ; Clustering Algorithm ; Image Processing

I. INTRODUCTION

The improvement of image quality depends on image processing. In image processing, removing noise is an important part of image processing. The image contains noise signal interference, and the transmitted information will be lost or redundant, which will affect our acquisition of image information. For example, a picture loses its recognition due to the reduced clarity of the noise, and cannot obtain the detailed information of the place, person, etc. that it wants. In medical images, the presence of noise will prevent doctors from judging the condition; on the surveillance images, the presence of noise will prevent police officers from identifying suspects; on the images returned by satellites, the presence of noise will prevent scientists from quickly and correctly understanding the planet. Therefore, it is particularly important to improve image quality and remove noise.

Algorithm introduction

Image denoising algorithms are mainly divided into spatial domain[1] denoising algorithms and transform domain[2] denoising algorithms. The denoising algorithm in space domain was proposed and used earlier. The spatial domain denoising algorithm refers to the algorithm that performs denoising processing on the gray level of the image. It is divided into two types: linear denoising algorithms and non-linear denoising algorithms. The difference between the two is to satisfy the superposition principle. The main representatives of spatial domain algorithms are: mean filtering[3] algorithm, median filtering[4] algorithm, Gaussian filtering[5] algorithm, and so on. Regarding the improvement of the spatial domain algorithm, some people determine the edges and noise points of image pixels and set the weights according to the results of the discrimination. Later, some people introduced the image information in the method noise into the weight design, and achieved good denoising effects. These are the changes made to the spatial domain algorithm this year.

The transform domain denoising algorithm performs the denoising algorithm in the noise frequency domain by transforming the frequency domain. The signal carrying the image information and the signal containing noise are not in the same frequency domain. By Fourier transform, the energy of the noise signal is suppressed for the frequency domain containing noise to achieve the effect of denoising. There are many such denoising algorithms based on the frequency domain. Johnstone [6] et al. Proposed a shrinking algorithm based on the study of thresholds. Gupta[7] et al. Made the threshold processing adaptive, and Yu in On this basis, Bayesian principle is added. Do et al. Performed Contourlet transform [8] on microscopic images to achieve the effect of image denoising. The core of the wavelet denoising algorithm is to set the wavelet coefficient. This algorithm needs to set a threshold value in advance, and compare the wavelet coefficient with it. If it is larger than the threshold function, the wavelet coefficient is corrected. If it is smaller, the coefficient is set to zero. The above is the improvement of transform domain algorithm in recent years.

This paper proposes an image denoising algorithm[9] based on neighborhood clustering[10]. Although some traditional denoising algorithms also use the information of the neighborhood pixels, the neighborhoods used by these algorithms are fixed shape or fixed size. For example, the neighborhood used by the median denoising algorithm is a fixed-size square. The neighborhood of a square can cause passivation or distortion of the edges or sharp points of objects in the image. The algorithm proposed in this paper generates a dynamic neighborhood for each pixel, that is, each pixel has a neighborhood with a different shape and a different size. The dynamic neighborhood can ensure that the pixels in the neighborhood are similar to the processed pixels, thereby improving the consistency of the pixels in the neighborhood.

The core of image denoising algorithm based on neighborhood clustering is to generate a dynamic neighborhood, and then integrate the information of pixels in the neighborhood to complete the denoising. The specific algorithm is as follows:

1. Input an image containing noise, and the image is represented by image [m] [n] [3]. Where m is the

Manuscript received December 30, 2019
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length of the image, n is the width of the image, and 3 is the R, G, and B channels of the image;

2. Iterate through each pixel of the image, and perform the operations in steps 3 to 5 for each pixel;
3. Start generating neighborhoods for each pixel. This step involves two queues, one of which is called a waiting queue (where the element is a pixel) and the other is a result queue, and the target pixel is represented by pixel_target. These two queues are represented by waiting list and result list, respectively. First we add the four pixels above, below, left and right of the target pixel to the waiting list. In addition, we initialize the result list to an empty set.
4. Complete the neighborhood generation. If the number of elements in the result list is less than the size of the neighborhood we set (the number of pixels k, a parameter of the algorithm), the loop does the following: selects the pixels in the waiting list that are most similar to pixel_target (represented as pixel_select) , Add pixel_select to the result list, and add the top, bottom, left, and right four pixels of pixel_select to the waiting list. After this step, the result list contains k pixels.
5. Calculate the median of the neighborhood of pixel_target. In steps 3 and 4, the algorithm generates the neighborhood of pixel_target, which is the result list of the result queue. In this step, the median is calculated based on the pixels in the neighborhood, and the median is stored in the denoised image. In the denoised image, the generated median value will replace the pixel value at the corresponding position of pixel_target.

In the above algorithm, in order to reflect the overall logic and flow of the algorithm, we have omitted some details. These details are as follows:

In steps 3 and 4, the upper, lower, left, and right pixels of a pixel may exceed the boundary of the image. At this time, the pixels beyond the boundary are not added to the waiting list;

In step 4, the distance between two pixels is calculated according to formula 1-1 :

$$d = |r_1 - r_2| + |g_1 - g_2| + |b_1 - b_2| \quad (1)$$

Where $r_1, g_1, b_1$are the three-channel values of the first pixel, and r_2, g_2, b_2 are the three-channel values of the second pixel.

In step 5, the median is calculated as follows: For each pixel pixel (i) in the result list, the distance between the pixel and all other pixels in the result list is calculated and summed, and the sum of the distances is expressed asD_i. If the distance and minimum of the j pixel are $D_j = \min\{D_i\}$ then pixel (j) is the median value of the result list.

We can see that the image denoising algorithm based on neighborhood clustering generates a dynamic neighborhood for each pixel, which is composed of several connected pixels. However, the shape of the neighborhood of each pixel is not fixed, which depends on the content of each image and the image content around each pixel. The flexibility and dynamics of this neighborhood ensure the neighborhood and target pixels Similarity of points.

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According to the algorithm principle, the algorithm is designed. This article uses Opencv[11] for development and implementation. Under Windows 10 system, visual studio 2010 is used as the development environment. Use a C ++ language that is more suitable for image processing.

According to the algorithm design, an algorithm can be obtained. The algorithm has a good denoising effect and can complete the image denoising task.

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