Image Inpainting Algorithm based on Improved Confidence Function

Wenjing Sun
Dianchi College of Yunnan University, Kunming, 650228, China

Abstract: With the rapid development of science and technology, more and more inpainting algorithms have appeared in the field of image inpainting, and the most representative one is the confidence inpainting algorithm. Confidence algorithm refers to after select the area that needs to be repaired in image, calculate the repair order of the damaged points in the image according to the confidence function algorithm, and then caryout the inpainting in sequence according to the repair order. However, because the confidence value has a great influence on the priority, the accuracy of the confidence algorithm is not stable. Therefore, the improvement of the confidence algorithm is the trend of the times. By analyzing the improved confidence function image inpainting algorithm based on confidence function and enumerating the examples, the positive effect of the improved confidence function algorithm on the image inpainting work is confirmed.

Keywords: Improved confidence function; Image inpainting; confidence value; Priority of filling

1. Introduction

In fact, the image repairing work is to fill in the damaged image. With the damaged point that needs to be repaired in the image as the core area, the structure information and texture information around the area are used as the base of the repair, which ensures that the restored image looks more natural, making the inpainting traces unobvious. However, the traditional confidence algorithm has obvious drawbacks and needs to be improved urgently. In this paper, based on the analysis of improved image inpainting algorithm, an example is made to complete the research of the beneficial help of the improved confidence function algorithm for image restoration.

2. Image Inpainting Algorithm based on Improved Confidence Function

2.1 Improved image inpainting algorithm

When using the confidence function to repair the damaged image, attention should be paid to the repair sequence of the damaged points in the damaged image, that is, the sequence of filling the damaged point, in the repair of the damaged image[1]. First, calculate the filling area of the damaged image, and then determine the priority of the damaged points in the area. After deciding the priority order, fill the damage point that has the first right to fill, get the updated image after the first filling. Likewise, fill the second, third and other filling points. Finally, the repair work of the damaged image is completed. Therefore, in the use of confidence algorithm, it is very important whether it can calculate the filling priority of damaged points or not. In the confidence algorithm, the filling point is represented by P. The formula for calculating the priority of P is:

$$P(p) = C(p) \times D(p) \tag{1}$$

In this formula, C (p) represents confidence level, and D (p) represents the corrupted data that needs to be filled. The formula for C (p) is as follows:

$$C(p) = \frac{\sum_{q \in \Psi p \cap \Phi} C(o)}{|\Psi p|} \tag{2}$$

The formula for D (p) is as follows:

$$D(p) = \frac{|\Delta Ip \times np|}{\tau} \tag{3}$$

In the above two formulas, Φ represents the whole area to be repaired of the damaged image. Ψ_P is the key filling area for p; np is the vector of the tangent perpendicular to the plane line in the damaged place of damage image; ΔIp is the curve of the upper level of the illuminant points on the damaged image connection surface; $|\Psi_P|$ is the area size of the focus filling region of P; and τ is the square root of the square sum of the coefficients[2].

The focus of the confidence algorithm is to repair images according to the filling order of damaged points. However, when the confidence degree algorithm is used, the values of the confidence C(P) will be reduced to 0, which will reduce the accuracy of filling priority size of the damage points calculated by the formula. The result of priority calculation decreases with the decrease of confidence level. That is, the change of priority size keeps pace with the change of confidence scale. The change of confidence value during damaged image inpainting process and the change of filling priority of damaged point are shown in Figure 1 and Figure 2.

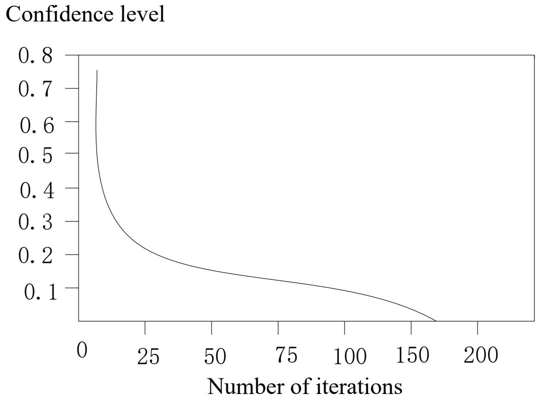

Figure 1. Changes of confidence level

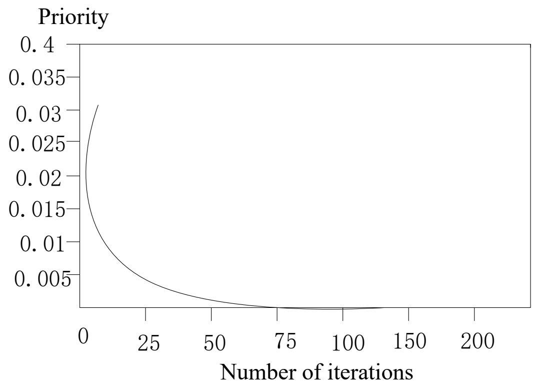

Figure 2. Changes of filling priority

As can be seen from Figure 1 and Figure 2, the calculated result of filling priority is inaccurate because the damaged point is changing with the confidence, which has an adverse effect on the restoration work of the image, and even leads to the phenomenon that the computer randomly arranged the order of filling the damaged points in the later work of the image restoration, which greatly reduces the quality and efficiency of image inpainting work. During using confidence algorithm, in addition to the influence of the change of the confidence value on the priority, the curve direction of the upper illumination point of the damaged image connection surface and the normal vector direction of the damaged image will also affect the priority [3]. When the two directions are in a vertical state, the value of the confidence C(p) increases, causing the damaged points that should be first filled not to be filled in time, which leads to the reduction of the quality of the image restoration work.

Therefore, in order to make up for the shortcomings of the confidence algorithm, it can be used in combination with the two matching criteria to achieve the goal of improving the accuracy of the confidence algorithm. Collate and merge the Census matching criterion and the SSD matching criterion, and then introduce the combined results into the confidence algorithm, thus realizing the improvement of the confidence algorithm. The calculation of confidence before improvement is the formula, which is updated with the function f (P) =p, 0≤p≤1[4];in the process of repeated calculation, the confidence level will gradually reduce to 0, resulting in the deviation of priority calculation results. After improving the confidence algorithm, the function formula also changes. The function formula after the change can ensure the accuracy of the calculation results of the priority, and then ensure the smooth completion of the image restoration work. The calculate formula of confidence function h (p) is:

$$h(p) = \alpha p^{n-1} \times e^{-\beta p} \tag{4}$$

In this formula, 0<α; n-1≤β; 0≤P≤1.

When the improved confidence function H(P) is analyzed for the derivative function H(P), it can be seen that the confidence function H(P) changes in two different numerical intervals. When the confidence function is increased monotonously, H(P) is in [0, (n-1)÷β] beta interval; when the confidence function is monotonically decreasing, H(P) is in [(n-1)÷β, 1] interval, and the maximum of confidence function is:

$$H(p) = h(\frac{n-1}{\beta}) = \alpha(\frac{n-1}{\beta e})^{n-1} \tag{5}$$

When Pn+1=h (Pn), in order to ensure that the confidence function value is between 0 and 1 during each iteration of the calculation, the maximum value of the confidence function is also between 0 and 1, that is:

$$0 \le H(p) = \alpha(\frac{n-1}{\beta})^{n-1} \le 1 \tag{6}$$

The change of the improved confidence function value is shown in Figure 3.

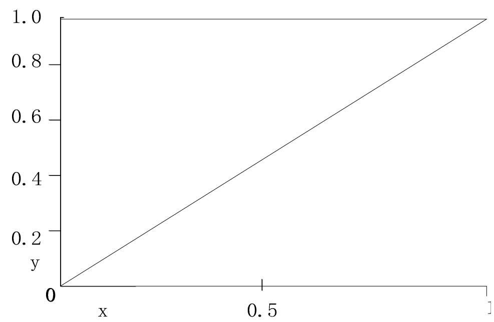

Figure 3. Change of confidence function

After determining the value of n, the direction of h (p) changes with the maximum confidence function H (p), and when H(p) moves towards the direction of x=1, h(p) moves to the right; when H(p) moves in the direction of y=1, h(p) moves up. From the Figure 3 which shows the change of confidence function, it can be seen that the confidence function h(p) change is represented as a straight line during the change process, but the confidence function change before the improvement is represented as a sharp curve. In fact, the reduction rate of the confidence data of the linear type is slower than that of the curve type, thus the improved formula for calculating confidence is [5]:

$$C(q) = h(C(p)) = \alpha(C(p))^{n-1} \times e^{-\beta C(p)} \qquad (7)$$

Due to the different damaged situation of different damaged images, the repair points that should be paid attention to in repair work are slightly different. Because the damage information distribution of different types of damaged images is different, some images need to be repaired with a large proportion of texture information, and some images need to be repaired with a larger proportion of structural information. So in the process of restoring the image, we should judge the importance of the confidence value C(p) and the damage point data D(p) that needs to be filled in according to the actual situation[6].When a uncomplicated image is restored, different α values and β values will have different effects on image restoration results. When the area that needs to be repaired is at the edge of the image, the structure information of the area needing to be repaired is more obvious, while the texture information is fuzzier; when the values of α and β are the same, image restoration may fail, resulting in repair errors at the junction of filled regions; when the value of α is close to 0 and β is close to 1, the structure information of the repaired area is increased, and the texture information is reduced, which makes the image restoration effect be improved; when α is 0 and β is 1, only the structure information of the repair area needs to be taken into consideration in calculating the sequence of the damaged points, while there is no need to consider the texture information, which can make a satisfactory image inpainting results. Therefore, it can be seen that when using the improved confidence function to carry out image restoration calculation, attention should be paid to the proportion of structural information in the confidence function.

2.2. Examples

In order to verify the validity of the improved confidence function calculation method, three examples are listed in this paper. There are different problems in the three examples, and the areas that need to be repaired are also different. Figure 4, Figure 5, and Figure 6 are the damaged images that need to be repaired and the restored images. The parameters of these three samples {α, β, ʎ, n} are set in the values of 0, 1, 2, and e.

There are two images in Figure 4. The previous one is a damage image of a moon, and the latter is a restored image after being restored by using improved confidence function method. First, the moon's halo is reduced, so that the moon is concentrated in the core area that needs to be repaired; then, by using the confidence function algorithm introduced above, the confidence value is controlled within a certain range to avoid its rapid reduction; then, in the improved confidence algorithm, the matching criterions both of Censes and SSD are used simultaneously, so that the computer can match data of the damaged point that has filling priority, which makes the texture information of the damaged point in the picture increased, the texture restoration is obvious, and the restoration effect of the Moon Halo area is better and more obvious and natural, avoiding the diffusion after the restoration.

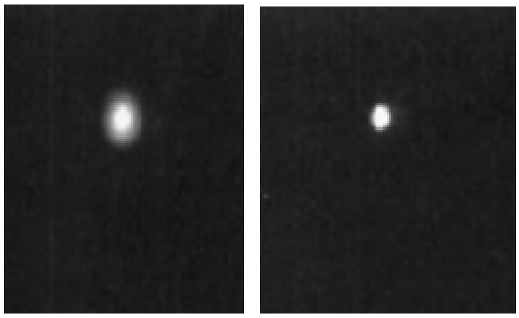

Figure 4. Comparison of moons before and after restoration

The two pictures in Figure 5 are: the damaged image of an arm and the restored image by using the improved confidence function calculation method. First, determine the repair area of the image which refers to the area around the arm; then use the confidence function algorithm introduced above to count the confidence level. Control the value of confidence is in a certain range, so as to avoid the problems of image restoration because of rapid reduction of the confidence value, such as the unsatisfactory restoration of gray and white areas around the arm, the low continuity of the restored image, and the diffusion of image after the restoration. Then, according to the calculated priority, the computer will automatically carry out the matching work, increase the structure information of the image, reduce the texture information of the image, and improve the image quality after the restoration.

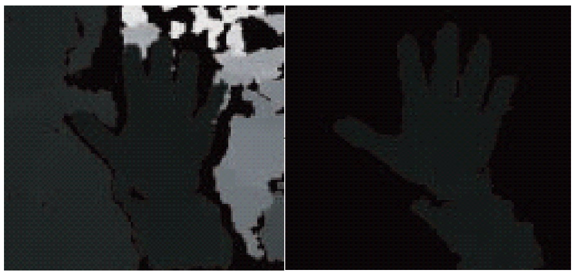

Figure 5. Comparison of arms before and after restoration

The image restored in Figure 6 is a snowflake image with complex structural information. When the snowflake image is restored, the structure information of the image will change correspondingly in the process of restoration because of the rapid reduction of the confidence value, and the snowflake image will appear obvious protruding phenomenon. After using the improved confidence function algorithm, the structure features of the snowflake are kept well, and the protruding phenomenon caused by the reduction of the confidence value does not appear. It ensures that the structure information of the repair area will not change obviously during the repair process, and then the computer can carry out the image restoration word in the correct order, which makes the restored snowflake image look more natural.

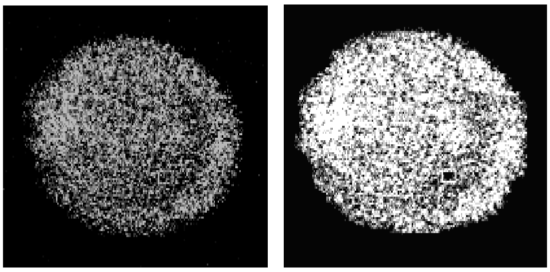

Figure 6. Comparison of snowflakes before and after restoration

3. Conclusion

Although the confidence function algorithm has disadvantages, with the continuous improvement of the confidence function algorithm, the influence of the confidence value on the priority is becoming smaller and smaller, and the quality of the image inpainting results becomes higher and higher. After using the improved confidence function algorithm, the restored image looks more natural. In this paper, based on the analysis of improved confidence function algorithm, examples are given to prove the effectiveness of the improved confidence function algorithm for image restoration which completes the research in this paper. It is expected that the research in this paper can provide a way for the research of image restoration.

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