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Image Restoration Algorithm Based on Artificial Fish Swarm Micro Decomposition of Unknown Priori Pixel

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Abstract

In this paper, we put forward a new method to holographic reconstruct image that prior information, module matching and edge structure information is unknown. The proposed image holographic restoration algorithm combines artificial fish swarm micro decomposition and brightness compensation. The traditional method uses subspace feature information of multidimensional search method, it is failed to achieve the fine structure information of image texture template matching and the effect is not well. Therefore, it is difficult to holographic reconstruct the unknown pixels. This weakness obstructs the application of image restoration to many fields. Therefore, we builds a structure texture conduction model for the priority determination of the block that to be repaired, then we use subspace feature information multidimensional search method to the confidence updates of unknown pixel. In order to maintain the continuity of damaged region in image, the artificial fish swarm algorithm decomposition model is combined with the image brightness compensation strategy of edge feature. The simulation result shows that it has a good visual effect in image restoration of a priori unknown pixel, recovery time and computation costs are less, the stability and convergence performance is improved.

***Keywords**: artificial fish swarm, image restoration, subspace, brightness compensation*

1. Introduction

Image restoration plays an important role in the field of digital image processing. The objective of recovery is that can be achieved for the restoration and present of loss of image information and valuable information. Evidently, a priori unknown pixel image restoration is of great significance in image reproduction and information recovery. Image restoration, which accords in a certain criteria and algorithm, fills and shows image information that is lost and removed through the vision principles of human. In real life, age-old image need restoration. In the field of target detection, fuzzy remote sensing image information and lacking in a certain angle characteristics also need image restoration. Therefore, the image restoration technology have important applications in the protection of cultural relics paintings, medical image information perception, video effect design, image object recognition and remote areas. In the study of image restoration, it is difficult to repair image pixel with unknown texture feature. Therefore, the priori unknown pixel restoration algorithm with some cutting-edge and practical significance is the focus of scholars [1].

Currently, research on image restoration is still in its infancy, the key technologies related algorithm are not perfect, many of them are used in image restoration focusing on the establishment of a non-technical texture image restoration model by enhancing the contrast of the image, and then extracting highlights model and texture characteristics of the image for image restoration. Among them, the literature [2] proposes a classic restoration algorithm based on texture highlights, this algorithm selects a pixel on the edge of the damaged area at first, and then using the template matching size and fast matching method to repair the damaged area. It is simple and practical, but the accuracy is not high. The literature [3] proposes a restoration method based on image characteristics preprocessing prior model for an image of the damaged area and it does not choose the most similar block matching to complete the repair. This algorithm enhanced the visual better gains, but huge computation and complex algorithm are the limitations of the method. The literature [4] uses affine Markov random pixel-level to fill image restoration, the repair is feasible on a single object, but algorithms consume a lot of

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memory space in the model and complex. The literature [5] proposes an image completion algorithm based on fragments, known as a part of the image training set to infer the unknown parts of the iterative approximation of an unknown region and adaptive composite image of debris. However, this algorithm is similar when looking for debris with a full search method, resulting in slow restoration speed, and greatly limits its practical application. The literature [6] gives a fast restoration algorithm, although to some extent, accelerating the restoration rate, but it affects restorative effects. The literature [7] proposes a linear additive of gradient and the gradient of the logarithmic function to decide to repair the block, introducing the sparse degree of large amount of calculation, thus leading to low efficiency. The literature [8] uses subspace feature information multidimensional search method for image restoration. But it has failed to template matching and joint decomposition, image restoration result is bad.

To solve these problems, this paper proposes a restoration algorithm based on artificial fish decompose and priori of unknown holographic pixels, and it extract weak information by decomposing the image to obtain a priori. This algorithm update the priori of unknown pixel confidence by the block priority grade determination, building artificial fish decompose fine image restoration model to achieve restoration of the details of the image analysis and the position of the pixel points. Finally, the simulation results show the superior performance of the algorithm.

2. Conduction Model and Priority Determination

2.1. Image Texture Information Transmission Model Based on Intuitionistic Fuzzy Sets

Before we design an image restoration algorithm with a priori unknown pixel, we give a model structure design about the image texture information conduction. We propose a mage texture information transfer model in this paper [9], and choose a block to repair from many blocks around the edge pixels and determine its priority. Let $G(x, y; t)$ denote the image texture information per unit time, and assume the image texture subspace of fuzzy sets as a conduction function:

$$p(x,t) = \lim_{\Delta x \to 0}[\sigma \frac{u-(u+\Delta u)}{\Delta x}] = -\sigma \frac{\partial u(x,t)}{\partial x} \tag{1}$$

Among them, σ is the heat flux of fuzzy set per unit time in image texture, showing poor visual image edge information indicates conductivity. Assuming the gradient direction along the edge of the image information is:

$$G_x(x, y; t) = \partial u(x, y; t)/\partial x \tag{2}$$

Utilization the objective function to zero uniformly ergodic properties, and get image texture information flow density vector is:

$$\begin{aligned} p(x,y;t) &= -\sigma \nabla u(x,y;t) = -\sigma G(x,y;t) \\ &= -\sigma[G_x(x,y;t)i + G_y(x,y;t)j] \end{aligned} \tag{3}$$

Among them, i, j are unit direction vector. Based on intuitionistic fuzzy sets structure of image texture information transmission model, we can obtain the center v_i of the partial derivative through the objective function of zero even traversal features and logical difference variable scale features. With the propagation direction of the horizontal and vertical conductive sub-regional division, we can find an image with the current highest priority to be repaired optimal sample block intact from a large sample area, get image texture information conduction model structure design. In the current block has been repaired by seeking objective function zero uniform traversal features and differential logic variable scale features to get partial derivatives center and make derivative zero. The state equation of the introduction of intuitionistic fuzzy sets is described as follows:

$$\begin{cases} f(x_1,x_2) = r_1 x_1 (1 - \frac{x_1}{N_1} - \sigma_1 \frac{x_2}{N_2}) = 0 \\ g(x_1,x_2) = r_2 x_2 (1 - \sigma_2 \frac{x_1}{N_1} - \frac{x_2}{N_2}) = 0 \end{cases} \quad (4)$$

In the above formula, r_1 represents the confidence level of the edge pixels, and r_2 represents confidence level of an unknown a priori the pixel, σ_1 is the information transmission to be repaired multidimensional spectral peak, N_1 is the noise component. Through the building of the introduction of image texture information transmission model of intuitionistic fuzzy sets, multidimensional spectrum peak search method is used to construct the information characteristic of image texture structure space by the minimax eigenvalue shunt into the image noise subspace and signal subspace [10], thus laying a solid foundation for repairing.

2.2. Priority Determination on Unrepaired Block

In the building of the structure of image texture information transmission model, it need to repair quickly to determine priorities. Based on the literature [5], this paper proposes neutron spatial characteristic information multidimensional search method to design subspace model structure. The model diagram is shown in Figure 1.

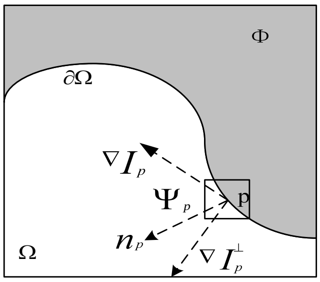

Figure 1. Determination model based on multi-dimensional subspace repair block search

Figure 1 shows Ω denotes the damaged area (white area). ∅ represents intact region (gray area). $\partial\Omega$ represents an edge line region and the damaged area of the intact. p represents the pixel to be repaired in $\partial\Omega$. Ψ_p expressed in points in the center of the pixel block to be repaired the collection. In the block priority determination, firstly, update the edge pixels and use multi-dimensional subspace feature information search method. Multidimensional search subspace feature information iterative equation is:

$$u^{(n+1)}(x,y) = u^{(n)}(x,y) + \delta u_1^{(n)}(x,y) \quad (5)$$

$$u_1^{(n)}(x,y) = M\Delta_s u^{(n)}(x,y) + N\Delta_t u^{(n)}(x,y;d) \quad (6)$$

In the above formula, $n = 1,2,...,T$ represents the iteration number, T is the total number of iterations, $u^{(n)}(x,y)$ is the pixel value, δ is the update speed, it represents the common characteristic feature subspace information and the texture structure of the two parts. The size of the image to be repaired is assumed as $m \times n$, the size of block Ψ_p is $s \times s$, and achieve the priority to be repaired pixel location determination by the above iterative search.

2.3. Update of a Priori Unknown Pixel Confidence

In order to maintain the continuity of repairing of the damaged area of image, it must update point of repaired confidence. The updated guidelines is:

$$I(y)=C(p)\ \forall y \in \Psi_p \cap \Omega \tag{7}$$

After Ψ_p is repaired, confidence $I(y)$ of original y is all updated confidence $0<C(p)<1$ of Ψ_p. The average number of the number of edge pixels in each calculating is $\bar{b}$ .In the traditional method, it uses AFSA efficient global search of the Update information to obtain fuzzy membership and cluster centers iterative update expression is:

$$v_i = \frac{\sum_{k=1}^{n}(1-(1-u_{ik}{}^{\alpha})^{1/\alpha})^m (x_k + \beta \overline{x_k})}{(1+\beta)\sum_{k=1}^{n}(1-(1-u_{ik}{}^{\alpha})^{1/\alpha})^m} \tag{8}$$

$u_{ik}{}^{\alpha}$ is the diversity factor, β is the fuzzy membership matrix for the parameter neighborhood information. Because the maximum number of y is no more than s^2 . The highest computational complexity of updated priori unknown pixel confidence after repairing t is $O(ts^2)$. Through updating the priori unknown pixel y information, the unknown pixels become known information, so as to provide a priori information for image restoration

3. The Introduction of Artificial Fish Imperceptible Decomposition Algorithm and Improved Image Restoration Algorithm

The image texture structure information conduction model and the block to be repaired and priority determination algorithm that proposed above has failed to achieve template matching and joint decomposition, so it is difficult to have a good result of image restoration. This paper uses artificial fish swarm micro decomposition to pixel features and combines brightness compensation to improve the priori unknown pixel repair performance.

3.1. Artificial Fish Swarm Micro Decomposition Model

In order to improve the accuracy of image restoration, we need to process the structural features of the image information so that the micro features of the image have an effective presentation and extraction. This paper uses artificial fish swarm global search algorithm for image feature tiny, combining the great clustering features of fuzzy set to obtain the target of the evaluation function. The image gray value time series is:

$$X = \{x_1, x_2, \cdots, x_n\} \tag{9}$$

Represented on the gray pixel image feature vector, n is the number of pixel. We use artificial fish micro feature decomposition method. The area of the search center of image segmentation is:

$$v = \{v_1, v_2, \cdots, v_c\} \tag{10}$$

Combined Fuzzy set theory and used fuzzy membership function that extended from Atanassov, it gives intuitionistic fuzzy sets $u=\{u_{ik}\}$. In fuzzy sets scale space, we use a combination of coarse and fine search (search step is 1) based on the best phase Quick search block matching algorithm. Assuming the speed of artificial fish migration in the search image micro feature point is:

$$v_{id}^{t} = v_{id}^{t-1} + (x_{id}^{t} - x_{d}^{*}).f_i \tag{11}$$

In the formula, v_{id}^{t} and v_{id}^{t-1} represent the i artificial fish in the search image micro feature point and artificial fish migration rate in the moment $t-1$ and t , f_i shows the pulse frequency of artificial fish swarm in the search image micro feature point, on behalf of the artificial fish the *i* group artificial fish swarm, it generally expressed Daigong individual fish swarm, which the expression f_i can be expressed as:

$$f_i = f_{\min} + (f_{\max} - f_{\min}).rand \tag{12}$$

$f_{\min}$ and $f_{\max}$ indicates artificial fish pulse frequency range, $rand$ expresses as pixels in the a priori unknown repair interval range uniformly distribution. Image enhancement based on a two-dimensional plane zeros discrete method, and then feature extracted to be micro matrix search step is *a*, and get a sample block Ψ_p that is not necessarily the best matching block Ψ_p' of Ψ_p, we use AFSA implementation details decomposition to obtain a micro decomposition results as:

$$\Psi_p' = \arg\left(\min_{\Psi_q \subset \Phi} d(\Psi_p, \Psi_q)\right) \tag{13}$$

In the above formula, by AFSA, we can obtain good sample block area to search, using $d(\Psi_p, \Psi_q)$ express the block Ψ_p as known to be repaired. In summary, we obtain precise fine image decomposition model and algorithm design process is shown in Figure 2.

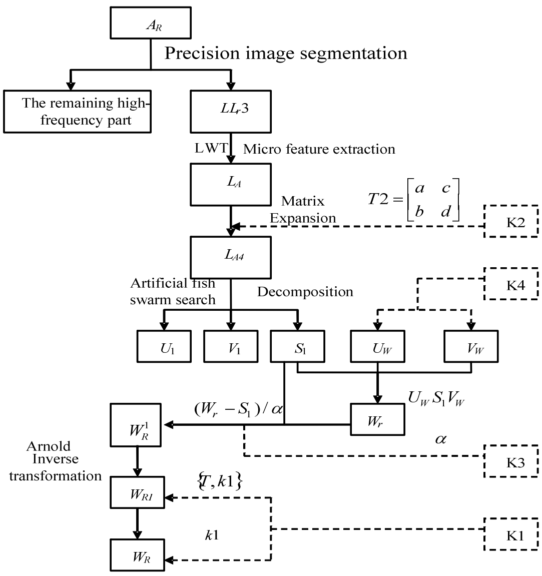

Figure 2. Flow Chart

In summary, the artificial fish swarm algorithm decomposition model provide a priori characteristic texture information for the eventual restoration of the image pixel location.

3.2. Improved Image Restoration Algorithm

Based on the image texture information conduction model and the artificial fish swarm algorithm decomposition model, we combine unite the edge feature points brightness compensation algorithm to achieve a priori unknown pixel image information repair. Algorithm key technologies are described as follows: In the artificial fish swarm algorithm decomposition model, we express the fish migration rate and then have to take the spatial position of the artificial fish transform definition is:

$$v_{id}^t = v_{id}^{t-1} + v_{id}^t \tag{14}$$

We use artificial fish swarm traversal search methods to find the image feature micro points in the process of edge feature brightness weak points for brightness. After the compensated image frequency band, the enhancement degree of expression is:

$$r_i^{t+1} = r_i^0[1 = \exp(-\gamma.t)] \tag{15}$$

It can be seen from the above equation that to find a best matching block $\Psi_p{}'$ of a priori unknown number of pixel repair need to traverse $O(nm/a^2 + 9s^2)$ times. We traversed through the micro search for the original pixels y unknown information in confidence after the restoration of an assignment, and then we got the texture structural information maximum likelihood estimation parameters iterative formula:

$$A_i^{t+1} = \alpha.A_i^t \tag{16}$$

Evenly distributed within a single artificial fish bearing individual pixels on the texture space area is represented by the attenuation characteristics, is a constant on the paper value of 0.37. Then, we use the finite difference method discretization method based on mathematical morphology theory of topological theory, a priori unknown pixel image information to repair some of the covariance matrix is:

$$R_x(\eta) = R_s\left(\psi_0, \sigma_\psi, \sigma_s{}^2\right) + \sigma_n{}^2 I \tag{17}$$

In the above formula, ψ_0 is the sampling variance of the data matrix, σ_ψ is the number of snapshots. Assume statistically independent between successive snapshots. Individual maps through artificial fish to each point in the image micro feature points of the search space. We use the artificial fish behavior as the objective function to solve the problem in image micro feature points search optimization process. The final iteration of the algorithm and the cycle can be run implemented on GPU to achieve the purpose of image restoration.

4. Simulation Experiment and Result Analysis

In order to test and validate the method based on artificial fish swarm micro decomposition and image brightness compensation priori unknown pixel repair performance, we conduct a simulation experiment. Experimental samples taken from a large image database Criminisi Cow, Rabbit and Wall for the test image samples. In the priori unknown image pixel image restoration performance testing, the dimensions are: 9×9, 11×11, in order to demonstrate the algorithm and traditional algorithm in two groups of image samples to repair the visual effects, sampling of the block template: 9×9, cursory search step:. We use this algorithm and sub-space search algorithm in [8] with a priori unknown pixel imprinting to comparative simulation. Visual test samples are 3 to 5 respectively.\

(a) Original image (b) Object removed image (c) Our method (d) method in[8]

Figure 3. Cow

(a) Original image (b) Object removed image (c) Our method (d) subspace method

Figure 4. Rabbit

(a) Original image (b) Object removed image (c) Our method (d) subspace method

Figure 5. Wall

Figure 3-5 shows the removing and repairing effect of three groups test samples image, the simulation results were analyzed as follows: marking circle of Figure 3 and Figure 4 can be found serious structural rupture and discontinuity after the repair using the subspace traditional restoration algorithm change in priori unknown pixel area, and combined results, we can see in Figure 5, using the algorithm of this paper have good visual effects after the restoration of the image. The reason is often that the use of this algorithm can be introduced artificial fish swarm micro decomposition prior knowledge, updating a priori unknown pixel confidence in image repair, restoration priority in favor of a strong structural information determined to be the next repair block direction, and the use of traditional methods cannot effectively calculate unknown confidence information pixel. Therefore Figure 3-5 to be repaired is preferably visually repair image.

In order to quantitative analysis the repair quality and performance based on a sample template size 9×9, coarse search step is used to calculate the SNR comparison method to test the repair time and image restoration after comparison of the data obtained test results shown in Table 1. The results from Table 1 are:

(1) Using this algorithm and conventional subspace repair algorithm need to be repaired with the repair time image size increases, and the complexity of the algorithm depends on the image size increases by contrast calculation algorithm complexity. The results of these two properties is consistent with the actual situation and theory to prove the effectiveness of the algorithm.

(2) Using this algorithm, the error of signal to noise ratio of repaired images are smaller, and maintain at less than 6%. It indicates that the proposed algorithm is more than subspace algorithms to ensure the quality of the restored image.

(3) It can be seen from the time of those two Repair algorithms, the larger the size of the repair image, the greater time ratio R of QSOMB algorithm to repair, but as the size of the restoration of image becomes larger and its value tend to 42. Selected when the R value is 3 always less than the R-value 4. From analysis, the algorithm in this paper has better convergence and stability.

In summary, our algorithm can ensure the visual of repaired image effectively than the traditional subspace algorithms, and it costs smaller time to repair and improve the stability and convergence to achieve holographic. Therefore, the artificial fish image restoration algorithm proposed in this paper is a more excellent performance of image restoration algorithms.

Table 1. The Performance

Image Dataset	Our method		Subspace		R=T2/ T1	(U-V) /SNR (%)
	Computing time:T_1(S)	Repaired image SNR:U(dB)	Computing timeT2(S)	Repaired image SNR：V(dB)		
Cow (512×384)	208.66	22.512	1697.233	18.789	9.01	↑2.05
Rabbit (402×336)	20.595	33.561	174.388	33.187	8.47	↑1.12
Wall (262×350)	12.28	30.407	85.967	30.489	7	↓0.30

5. Conclusion

We present an algorithm with priori unknown pixel that can be realized on the recovery of missing information, which have important applications in the field of image target recognition and remote sensing detection. This paper proposes a method based on artificial fish restoration micro decomposition with priori unknown holographic pixels. Besides, building structure of image texture information transmission model to repair piece of priority decision. Trough update of a priori unknown pixel confidence, we introduce micro image decomposition model of artificial fish algorithm and combine with the edge feature point's brightness compensation algorithm so as to achieve a priori unknown pixel image information repaired. Studies show that the algorithm in this paper has a good visual effect, saves repairing time effectively and improves the stability and convergence. Our method will apply in the image restoration algorithm, fuzzy object recognition and feature extraction and other fields with high value.

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