

# Dynamic Image Enhancement Algorithm in Heterogeneous Environments

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## Abstract

Image acquisition in heterogeneous environments tends to lead to inadequate information and poor image quality. In order to improve the image quality of dynamic data in heterogeneous environments, an enhanced technology of dynamic data information based on Radon scale transformation is proposed. The gray histogram feature information parameters of images in heterogeneous environments are extracted. The feature quantities are fused and optimized in the central region of image clustering, and the multi-scale Retinex color feature components of dynamic data are extracted. Radon scale transformation is used to extract image centers in heterogeneous environments, enhance dynamic data of image centers, and improve image quality. The simulation results show that this method can enhance the dynamic data information of image centers in heterogeneous environments, and the output images have better imaging performance. The normalized correlation coefficient and peak signal-to-noise ratio (psnr) of the output images are higher than those of the traditional methods, which improves the peak signal-to-noise ratio (psnr) of the output image and improves the recognition performance of the image.

**Keywords:** heterogeneous environment; image; central dynamic data; enhancement; Radon scale transformation

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## 1. Introduction

Image enhancement technology is an important research branch of image processing. Through image enhancement processing, the specific details in the image are emphasized, the local information features of the image are highlighted purposefully, and the imaging visual effect of the image is improved. Research on dynamic data enhancement technology of image centers in heterogeneous environments seeks to expand the difference of different objects in the image edge profile, enrich the amount of information in images, and study image enhancement technology. It will have high application value in aerospace, radar recognition, fault diagnosis, infrared detection and other fields. With the development of multimedia information technology and digital image processing technology, image acquisition and imaging equipment are constantly being updated [1]. A variety of imaging equipment, such as mobile phones, digital cameras, laser scanners, and infrared imagers, have emerged, and they can effectively meet the needs of image acquisition under various conditions and uses. However, under some special conditions and environments, the imaging process is affected by the acquisition equipment, climate, light, and color difference, which leads to an insufficient saturation of the collected image information and poor recognition performance of the image. It is necessary to enhance the dynamic data of image centers in heterogeneous environments and improve the utilization efficiency of images. The research on information enhancement technology of dynamic image data in heterogeneous environments also has high application value in the fields of image restoration and image recognition. The related algorithm research has received great attention from scholars in the field of image processing [2-3].

Under the condition of insufficient information content, image acquisition is interfered by environmental factors, so it is difficult to enhance the information of this kind of image. In the traditional methods, the information enhancement technology of dynamic images in heterogeneous environments mainly includes the information enhancement technology based on wavelet noise reduction and resolution independent processing. Based on the image enhancement method of

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MeanShift corner detection, the particle filter method, and the Retinex image enhancement method, the above method improves the detail presentation ability of dynamic image data in heterogeneous environments by decomposing the RGB feature component of the images and combining the principal component feature analysis to reduce the noise and enhance the information. In reference [4], an infrared image background compensation technology based on morphological filtering was proposed for image enhancement. HCT transform and the joint sparse model were used for image fusion, and the filtering algorithm was combined to reduce image noise. The ability of detail feature representation of dynamic data of image centers in infrared heterogeneous environments was improved, and the quality of output image was better, but the calculation cost of this method was large. Image processing and output could not be realized in real time. In reference [5], an ultrasonic image denoising and enhancement technology based on multi-scale Retinex was proposed. Based on the multi-scale Retinex decomposition method, the color difference equalization of the image was carried out, and the ultrasonic image denoising and information enhancement were carried out combined with the spectrum separation method. However, the disadvantage of this method was that the anti-interference performance was not good. When the collected image details were insufficient, the output signal-to-noise ratio of the image was not high.

In order to solve the above problems, dynamic data information enhancement technology in heterogeneous environments based on Radon scale transformation is proposed in this paper. Firstly, the dynamic data in heterogeneous environments are processed by image block processing, and the dynamic data feature segmentation of images is realized by block region feature matching. Then, the dynamic data of image centers is enhanced by the grid block matching method, and the exposure compensation is realized. Radon scale transformation is used to extract the multi-scale Retinex color feature components of the dynamic image data in heterogeneous environments, and the dynamic data of image centers is enhanced. Finally, a performance test is carried out by the simulation experiment analysis method, and the validity conclusion is obtained.

## 2. Dynamic Data Feature Information Collection of Image Centers in Heterogeneous Environments

In order to enhance the information of image center dynamic data in heterogeneous environments, image acquisition and block processing are first needed. The image acquisition system is based on the digital equipment NikonD7200 of high resolution pixels, the sensitivity ISO is 100, the aperture is F14, and the climate condition of acquisition is night. Because the exposure time set in the process of image acquisition is insufficient, the darkness of the output image is low. The rendering ability of image detail features is not good, so it is necessary to carry out image enhancement processing. The image enhancement method constructed in this paper adopts the Radon scale transformation method. Firstly, the image center dynamic data feature segmentation technology is used for block processing, and the image pixel information is divided into blocks of  $4 \times 4$  grid area. Combined with Fourier transform, the scale information decomposition and feature acquisition of image center dynamic data in heterogeneous environments are carried out [6-7]. The multi-scale Retinex color feature components of image center dynamic data in heterogeneous environments are extracted by Radon scale transform, and the frequency and angle information parameters of images are obtained by ridge transform. The description of the dynamic data information enhancement process of image in heterogeneous environments is shown in Figure 1.

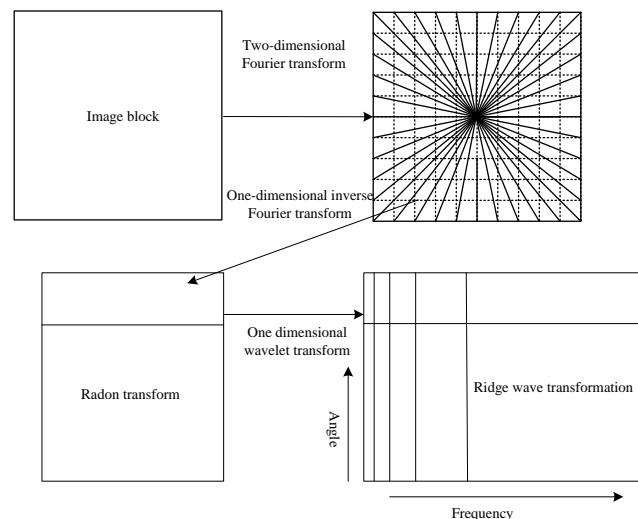


Figure 1. Block diagram of dynamic image data enhancement in heterogeneous environments

According to the spatial principal component analysis (KPCA) method, pixel feature matching is carried out in the

clustering center area of the image. The pixel feature distribution function of the dynamic image data in fuzzy heterogeneous environments is shown as follows:

$$W^{ij}(x, y) = \frac{G^{ij}(x, y)}{\sum_{i=1}^{n_x} \sum_{j=1}^{n_r} G^{ij}(x, y) + \varepsilon} \quad (1)$$

Where  $G^{ij}(x, y)$  is the template distribution value of dynamic image data in the pixel space with  $(x^{ij}, y^{ij})$  as the template value. The matching center of pixel characteristics divides the dynamic image data in heterogeneous environments, and the scale information fusion method is used to reconstruct the spatial distribution area of pixel points, which is recorded as follows:

$$G^{ij}(x, y) = \exp\left(-\frac{(x - x^{ij})^2 + (y - y^{ij})^2}{2\sigma^2}\right) \quad (2)$$

Frame scanning and corner matching are carried out on the geometric feature continuous region, which represents the dynamic data structure information of image centers in fuzzy heterogeneous environments [8-10]. The Harris corner detection method is used to output the corner F of the image, which is represented by the following formula:

$$F(x, y) = \sum_{i=1}^{n_r} \sum_{j=1}^{n_c} W^{ij}(x, y) \cdot O^{ij}(x, y) \quad (3)$$

Based on linear affine subspace transformation, the appearance profile of image center dynamic data in fuzzy heterogeneous environments is calibrated [11-12]. The output expression of dynamic image data feature information collection in heterogeneous environments is described as follows:

$$\begin{aligned} E^{LBF}(\phi, f_1, f_2) = & \mu \int \frac{1}{2} (|\nabla \phi| - 1)^2 dx + \nu \cdot \text{Length}(C) \\ & + \lambda_1 \int \left[ \int K_\sigma(x - y) |I - f_1(x)|^2 H(\phi) dy \right] dx \\ & + \lambda_2 \int \left[ \int K_\sigma(x - y) |I - f_2(x)|^2 (1 - H(\phi)) dy \right] dx \end{aligned} \quad (4)$$

Where  $\lambda_1, \lambda_2, \nu, \mu$  are the pixel registration coefficients of image center dynamic data in the  $3 \times 3$  region template in heterogeneous environments.  $K_\sigma$  is the scale fusion parameter whose scale offset is  $\sigma$ . By selecting  $\sigma$ , the template registration scale of image center dynamic data in fuzzy heterogeneous environments is adjusted adaptively to realize image information acquisition [13].

### 3. Implementation of Dynamic Data Enhancement in Image Centers

#### 3.1. Information Fusion and Optimization Clustering Algorithm

On the basis of collecting dynamic data feature information of image centers, in order to solve the problem that dynamic data pixels of image centers are inconsistent in heterogeneous environments and result in poor imaging quality, a dynamic data enhancement technology based on Radon scale transformation in heterogeneous environments is proposed. The parameters of image gray histogram feature information extracted from heterogeneous environments are as follows:

$$\begin{cases} f_1^G = \frac{K_\sigma(x) * [H_\varepsilon(\phi(x)) I^G(x)]}{K_\sigma(x) * H_\varepsilon(\phi(x))} \\ f_2^G = \frac{K_\sigma(x) * [(1 - H_\varepsilon(\phi(x))) I^G(x)]}{K_\sigma(x) * (1 - H_\varepsilon(\phi(x)))} \end{cases} \quad (5)$$

At the position of the central pixel of the image, the affine edge is used to normalize the feature quantity to realize the information fusion and optimal clustering of the pixel feature points, and the Radon scale transformation algorithm is used to cluster the pixel points. The clustering objective function of the pixel points is as follows:

$$S_c = [S_0, \dots, S_{Q-1}]_{binary} = \left[ \sum_i^{Q-1} S_i \times 2^i \right]_{Dec} \quad (6)$$

$$S_i = \sum_j^{W \times W} I_x^j \quad (7)$$

Where  $Q$  is the pixel set of dark primary color, and  $W$  is the step size of fuzzy C-means clustering.

### 3.2. Edge Convergence and Information Enhancement of Gray Pixel Points

The Radon scale transformation algorithm is used to realize the edge convergence and information enhancement of gray pixel points.  $H_x, H_y$  are the pixel attribute distribution features of image center dynamic data distributed on the X axis and Y axis in fuzzy heterogeneous environments. The scale migration is modified according to the pixel points distributed by gray histogram, and the geometric invariance of Radon scale transformation is used in the clustering center region of the image. Taking the pixel value  $I_c$  as the center, the edge convergence is carried out in the dimension of  $N \times N$ , and the pixel clustering center matrix of the dynamic data of image centers in fuzzy heterogeneous environments is obtained as follows:

$$f_R(z) = \begin{pmatrix} f_x(z) \\ f_y(z) \end{pmatrix} = \begin{pmatrix} h_x * f(z) \\ h_y * f(z) \end{pmatrix} \quad (8)$$

Where  $f(z)$  is the feature vector of pixel distribution, and  $*$  is the convolution operation. The covariance matrix of edge profile feature extraction is constructed as follows:

$$C = O^T O \begin{bmatrix} \sum H_x(t)H_x(t) & \sum H_x(t)H_y(t) \\ \sum H_y(t)H_x(t) & \sum H_y(t)H_y(t) \end{bmatrix} \quad (9)$$

In the information fusion and optimization clustering center, the principal direction scale function and transfer function of the single region are expressed respectively as

$$y_i = W_i^T M_i = [y_{i1}, y_{i2}, \dots, y_{ii}] \quad (10)$$

$$y_T = W_T^T M_T = [y_{T1}, y_{T2}, \dots, y_{TT}] \quad (11)$$

Under a certain number of neighborhood blocks, the characteristic dimensions of dynamic data enhancement in image centers in heterogeneous environments are as follows:

$$G(w) = \exp \left\{ -[\log(\omega / \omega_0)]^2 / 2[\log(\sigma / \omega_0)]^2 \right\} \quad (12)$$

The projection of the main direction of the image on the X axis and Y axis can be expressed as follows:

$$f_{lg-M}(z) = (f_{lg}(z), f_{lg-x}(z), f_{lg-y}(z)) = (f_{lg}(z), h_x * f_{lg}(z), h_y * f_{lg}(z)) \quad (13)$$

Where  $f_{lg}(z) = f(z) * F^{-1}(G(\omega))$ ,  $F^{-1}$  is the Fourier inverter, the central pixel with strong edge information is classified into one class, and the image enhancement output is obtained [14].

### 3.3. Dynamic Data Information Enhancement and Optimization of Image Centers

According to the above processing results, the dynamic data of images in heterogeneous environments are enhanced. Due to the difference of color and light in image acquisition, the background features of the image information sensitive region are transformed by multi-scale Radon transform. The white balance sensitivity coefficient of the image decomposed by level I Radon is  $H_i$  ( $i = 1, 2, 3, 4, 5$ ). For a fuzzy image with noise, the edge information components of the image are obtained by three-layer wavelet decomposition.

$$E_{HL_i} = \sum_j (c_j^{HL_i})^2 \quad E_{HH_i} = \sum_j (c_j^{HH_i})^2 \quad E_{LH_i} = \sum_j (c_j^{LH_i})^2 \quad (14)$$

Where  $c_j^{HL_i}$ ,  $c_j^{LH_i}$ , and  $c_j^{HH_i}$  are the light intensity transmittance in each direction of the image, and the affine invariant moment of the image is obtained along the gradient direction. With adaptive pixel segmentation, the enhancement coefficient and segmentation scale of the image meet the following constraints:

$$WSSIM_{H_i} = \omega_{HL_i} \cdot WSSIM_{HL_i} + \omega_{LH_i} \cdot WSSIM_{LH_i} + \omega_{HH_i} \cdot WSSIM_{HH_i} \quad (15)$$

The template feature matching values for calculating the dynamic image data in heterogeneous environments on the Radon scale translation coordinate system  $(a, b_m)$  is expressed as follows:

$$g(x, y) = f(x, y) + \varepsilon(x, y) \quad (16)$$

Where  $f(x, y)$ ,  $g(x, y)$ , and  $\varepsilon(x, y)$  represent the segmentation scale of the map region, the mean value of noise distribution, and the measurement error respectively [15-17]. The blind de-convolution of the image is carried out by constrained fuzzy kernel estimation, and the soft matting of the output image is recorded as FWSSIM.

$$FWSSIM(X, Y) = \frac{\omega_{LL} \cdot WSSIM_{LL} + \sum_{i=1}^5 (\omega_{H_i} \cdot WSSIM_{H_i})}{\omega_{LL} + \sum_{i=1}^5 \omega_{H_i}} \quad (17)$$

Furthermore, the color difference neutralization is realized by standardized prior blind deblurring processing, and the exposure sensitive difference value  $J^{dark}(x)$  of the image is approximated to 0. After the above image processing, the holographic map with good signal-to-noise ratio is obtained, which is expressed as follows:

$$Q_w(a, b, f) = \sum_{w \in W} c(w) (\lambda(w) Q_0(a, f | w) + (1 - \lambda(w)) Q_0(b, f | w)) \quad (18)$$

Wherein

$$Q_0(x, y) = \frac{\sigma_{xy}}{\sigma_x \sigma_y} \cdot \frac{2\bar{x}\bar{y}}{\bar{x}^2 + \bar{y}^2} \cdot \frac{2\sigma_x \sigma_y}{\sigma_x^2 + \sigma_y^2} \quad (19)$$

$$\lambda(w) = \frac{H(a | w)}{H(a | w) + H(b | w)} \quad (20)$$

In the above formula,  $H$  is the information entropy of dynamic image color difference neutralization in heterogeneous environments. Based on the standardized sparse priori representation method [18], the dynamic image enhancement output is obtained as follows:

$$\text{Im} a(x_t) = J + p(x_t | z_t, u_{t-1}, z_{t-1}, \dots, u_0, z_0) \quad (21)$$

Wherein

$$J = \sum_{k=1}^n \sum_{i=1}^c u_{ik}^{*m} d(x_k, v_i) + \beta \sum_{k=1}^n \sum_{i=1}^c u_{ik}^{*m} d(\overline{x_k}, v_i) \quad (22)$$

The color difference contrast of the image is  $J$ , and  $n$  is the number of pixel points in the image. Combined with the initial evaluation parameters of the dynamic data imaging of image centers in heterogeneous environments, the dynamic data enhancement processing of image centers is realized.

#### 4. Simulation Experiment and Result Analysis

In order to verify the application performance of this method in the realization of dynamic data optimization imaging and information enhancement processing in image centers in heterogeneous environments, a simulation experiment is carried out. The algorithm is programmed by Matlab 7 simulation software. The resolution is  $T_m = 12$ , the image with exposure duration of image acquisition using optical digital imaging equipment is  $500 \times 240$ , and the pixel distortion threshold value is  $\varepsilon = 0.25$ . The scale coefficient is  $\xi = 1.25$ , the fuzzy kernel convolution of Radon transform is  $100 \times 125$ , the image noise intensity is 0, and the variance is 0.043 Gaussian noise. In the image block, each small block contains  $8 \times 8$  pixels, and the 12-dimensional feature vector is obtained as the training set of dynamic data enhancement in the image center. In image quality evaluation, the peak signal-to-noise ratio (PNSR) is used as the image quality evaluation index. The larger the PNSR value, the better the quality. The formula of PNSR is as follows:

$$\text{PNSR} = 10 \log_{10} \frac{I_{\max}^2(i, j)}{\frac{1}{M \times N} \sum_{i=1}^M \sum_{j=1}^N (I(i, j) - I'(i, j))^2} \quad (23)$$

Where  $I(i, j)$  represents the pixel value of the dynamic data  $(i, j)$  of image centers in the original heterogeneous environments, and  $I'(i, j)$  represents the pixel value of  $(i, j)$  after image enhancement.

The canonical correlation coefficient (NC) is used to evaluate the robustness of image center dynamic data information enhancement in heterogeneous environments.  $\text{NC} \in (0, 1]$ , and the larger the NC value, the higher the robustness of the representation algorithm. The formula of NC is as follows:

$$\text{NC} = \frac{\sum_{i=1}^M \sum_{j=1}^N w(i, j) \times w'(i, j)}{\sqrt{\sum_{i=1}^M \sum_{j=1}^N w(i, j)} \sqrt{\sum_{i=1}^M \sum_{j=1}^N w'(i, j)}} \quad (24)$$

According to the above simulation environment and parameter settings, the simulation experiment of image center dynamic data enhancement processing is carried out, and the dynamic data of an image center in a heterogeneous environment is given as shown in Figure 2.

The analysis of Figure 2 shows that the image edge information is dark and blurred due to the insufficient information content of the original image, and the information characteristics of the image cannot be distinguished, so it is necessary to enhance the dynamic image. In this paper, the dynamic images in heterogeneous environments are processed by image block processing, and the dynamic data of image centers is enhanced by the grid block matching method. The dynamic image enhancement results are shown in Figure 3.

The modified image of Figure 3 is extracted and enhanced by Radon scale transform, and the dynamic data enhancement output of the image center is shown in Figure 4.

Compared with the original image and the image processed in Figure 4, the image hiding information, which cannot be expressed in the dynamic data of image centers in heterogeneous environments, is effectively restored and enhanced. The ability of image detail feature expression is enhanced, and the imaging quality of image is effectively improved.



Figure 2. Original image to be processed



Figure 3. Results of dynamic data enhancement in image center



(a)



(b)

Figure 4. Dynamic image enhancement results between (a) global image and (b) local enlarged image

In order to compare the performance of different algorithms, the image evaluation index is analyzed by using the proposed method and the traditional method, and the comparison results are shown in Figure 5. Figure 5 shows that the peak signal-to-noise ratio (PSNR) and normalized phase relationship of the output image are higher than those of the traditional method, which demonstrates that the imaging quality, robustness, and anti-noise performance of the image are better than those of the traditional method.

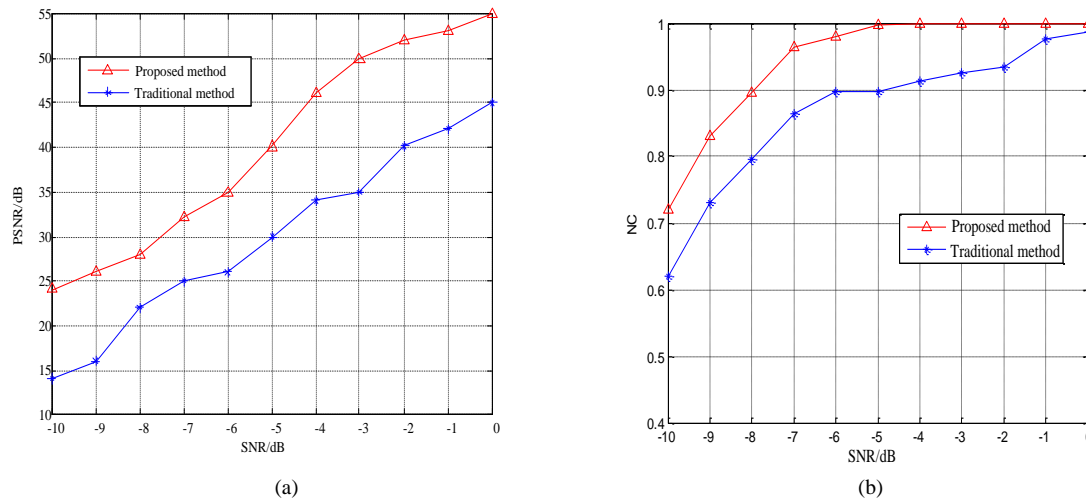


Figure 5. Image processing quality performance comparison between (a) PSNR and (b) normalized cross-correlation

## 5. Conclusions

In this paper, a dynamic image enhancement technology in heterogeneous environment based on Radon scale transformation is proposed. The dynamic data of image centers in heterogeneous environments are processed by image block processing, the dynamic data feature segmentation of image centers is realized by block region feature matching, the dynamic image is enhanced by the grid block matching method, the exposure compensation is realized, and the dynamic image centers in heterogeneous environments are processed by multi-resolution noise reduction. The gray histogram feature information parameters of images in heterogeneous environments are extracted, and the feature quantity is fused and optimized in the clustering center area of the images. The multi-scale Retinex color feature component of the dynamic data of image centers in heterogeneous environments is extracted by Radon scale transformation, so as to enhance the dynamic images and improve the imaging quality. The simulation results show that this method can enhance the dynamic images in heterogeneous environments, and the output images have better imaging performance. The normalized correlation coefficient and PSNR of the output images are higher than those of the traditional method, which improves the PSNR of the output images and improves the identification performance. This method has good application value in dynamic image enhancement [19-20].

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