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Retraction

Retracted: Image Contrast Enhancement Method Based on Nonlinear Space and Space Constraints

Wireless Communications and Mobile Computing

This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope

(2) Discrepancies in the description of the research reported

(3) Discrepancies between the availability of data and the research described

(4) Inappropriate citations

(5) Incoherent, meaningless and/or irrelevant content included in the article

(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

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[1] Z. Zhao and X. Gao, "Image Contrast Enhancement Method Based on Nonlinear Space and Space Constraints," *Wireless Communications and Mobile Computing*, vol. 2022, Article ID 2572523, 9 pages, 2022.

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Research Article

Image Contrast Enhancement Method Based on Nonlinear Space and Space Constraints

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Remote sensing, environmental monitoring, pattern recognition, and other fields all use this critical and indispensable basic technology. The article proposes an image contrast enhancement detection algorithm based on a linear model to address the problem that the current global contrast enhancement detection algorithm does not have high classification accuracy under the low-intensity JPEG compression quality factor. To decompose the original image, use the biorthogonal wavelet transform. The improved fuzzy set enhancement algorithm is used for the low-frequency subband coefficient. The results obtained after simulating this algorithm show that it is very effective in improving contrast, enhancing image details, and suppressing noise. It has the ability to greatly improve the image's visual effect, as well as the advantages of parameter adaptation and high algorithm efficiency.

1. Introduction

Image cooling has become an indispensable component of its optimization, with applications in remote sensing, environmental monitoring, pattern recognition, and a variety of other fields [1]. The study of classical constrained mechanical systems is the focus of analytical dynamics. Due to their unique optimization mechanisms, robustness, and implicit parallelism, evolutionary algorithms based on biological evolution theory have received a lot of attention in recent years in many optimization fields [2]. Use the proposed criterion to judge the original image's contrast type, directly determine the grayscale transformation parameters for various types, and achieve the image's global contrast enhancement. The image is then transformed using the discrete stationary wavelet transform, and the nonlinear enhancement method is used to improve the details of the high-frequency subbands of each decomposition layer [3].

With the continuous advancement of network technology, people are no longer limited to the things that can be obtained by reaching out and are more willing to learn about different things in life through the network [4]. People get multiple images in the same area because of the different factors such as shooting angle, shooting distance, shooting conditions, and imaging sensor, the images obtained in the same area have changes such as rotation, offset, and zoom. Some remote sensing images have poor visual effects, such as insufficient contrast and blurred images; some images have better overall visual effects but are not prominent enough for the required information, such as edge parts or linear features; some image bands have a lot of large data, such as TM images, but the amount of information in each band has a certain correlation, which causes difficulties for further processing [5]. In order to comprehensively analyze various information in the same scene image, image registration is proposed, which is to combine different wavebands, different time phases, different imaging equipment, or under different angles, different positions, different climates, and other natural conditions in the same target area. Two or more images are required to complete the geometric calibration process. In the process of image collection and transmission, it is susceptible to the influence of external environmental factors, such as light intensity, transmission medium, and imaging system, which cause image quality to

decline [6]. The image formed on the camera image surface by the space observation image is typically low in contrast, the gray level distribution in the histogram is concentrated, and the target is submerged in the complex background. The image needs to be enhanced in order to improve the visual effect and image quality. Digital images are easily transmitted and spread and uploaded and downloaded on the Internet as an effective digital media and as an effective information carrier. Histogram equalization, histogram specification, grayscale transformation, and unsharp mask are examples of common contrast enhancement methods. Some effective new methods and theories have been proposed in recent years. The image should be improved. The image quality is improved, the visual effect of the image is improved, the required information is highlighted, the amount of image data is compressed, and preprocessing work is completed for further image analysis and interpretation using image enhancement technology [7]. The goal of the histogram grayscale transformation is to change the dynamic range of the image grayscale by modifying the grayscale of the input image and each pixel one by one according to certain rules. It can increase the grayscale's dynamic range, compress it, or compress it in a specific way. The dynamic area is compressed, and the other intervals are expanded. Nonlinear diffusion equations and fast explicit diffusion methods are used to construct the space in the improved SIFT remote sensing image registration algorithm based on nonlinear scale space. It has the advantage of preserving the scale space image. At the same time, edges and details increase the speed. The modern news agency is well-developed, and malicious image tampering and forgery are on the rise in the real world and online, posing a serious threat to social information issues. Despite the fact that point calculation is a simple technique, it is extremely important. The gray value of the output image generated after calculation for the input image is determined by the gray value of the corresponding input pixel, with no direct relationship to neighboring pixels [8].

If you directly use various methods to enhance the input image without judging the contrast type of the input image in advance, and the intelligence and adaptability of some algorithms are poor, more human intervention is required. Spatial domain enhancement is a basic part of image enhancement technology, which includes point operations and neighborhood operations. According to Bayesian criterion, the threshold of noise and signal is estimated, and information entropy is used as the parameter selection criterion to realize the adaptive selection of parameters. Improve original algorithm to obtain higher algorithm efficiency.

2. Related Work

The noise was caused by an inconsistency in the photoelectric response caused by a defect in the camera's own software and hardware, according to [9]. It has been widely used in image capture as the camera's "digital" fingerprint, which can be used to detect image tampering. A linear model-based image tampering forensics scheme was proposed in [10]. This method detects and positions image stitching as well as specific image copying and pasting tampering. The PCA-SIFT algorithm was proposed in [11], which is used to reduce the dimensionality of the description using principal component analysis (PCA). According to the literature, SIFT's variable is a histogram of the gradient's position and direction [12]. The grayscale and directional gradient histograms are calculated using the radial and angular divisions of the detected regions of interest, as described in [13]. Literature [14] is a good place to start. Iterative region growth in the initial seed points is used to achieve matching, and the algorithm also relies on the initial feature points. To improve efficiency, [15] embeds a robust sample consistency judgment algorithm (RSCJ) in RANSAC. A robust method of (TAR) value, a triangular area based on K nearest neighbors (KNN), is described in [16]. Outliers were removed using geometric relations in [17]. Literature [18] generated Delaunay graphs to remove outliers and selected candidate outliers by comparing the differences in Delaunay structure. To improve accuracy, [19] added scale, direction, and distance constraints to the matching points. The RANSAC algorithm was improved by [20]. Even when the majority of the outliers are outliers and the deformation is large, this method can produce stable and accurate results.

The method used in this paper to distinguish contrast-enhanced images is an image contrast enhancement forensics technology based on linear models. It can effectively classify images and resist JPEG compression.

3. Brief Description of Image Enhancement Methods

3.1. Traditional Image Enhancement Methods

3.1.1. Grayscale Transformation Method. Due to the external environment such as noise and lighting or the device itself, the quality of the original digital image we obtain is usually not very high. Therefore, it is generally necessary to enhance the original digital image before performing operations such as edge detection and image segmentation on the image [21]. Image enhancement is to improve the image, make it more suitable for human vision, or highlight certain features for automatic recognition by the machine. Grayscale transformation is an image enhancement method that can be increased, which can increase the dynamic range of the image, expand the contrast of the image, and make the image clearer and more obvious. Grayscale transformation is also known as image contrast enhancement [22]. Grayscale transformation's contrast enhancement method is very effective. To process image pixels, the grayscale transformation method only uses the current pixel information, which is called point processing. It uses a transformation function to convert the gray level of each pixel in the previously unclear image into another gray level and then recombines it into a new image to complete the enhancement [23]. The piecewise linear method can be used to blank out the objects of interest or grayscale intervals, and three-segment linear transformation is commonly used to suppress those grayscale areas that are not of interest. The relationship between this method and the

processed image pixels, such as the location of the image pixels and the gray level of the image pixels, is, however, not close. Grayscale transformation curves come in a variety of shapes and sizes. The images themselves are quite complicated. Due to the ever-changing histograms of each pixel's grayscale statistics, it must be based on this in general for different images in order to adapt to various requirements and obtain better enhancement effects for the image. For the image, various grayscale transformation functions are chosen. Grayscale images are commonly used to concentrate on the algorithm. The difficulty in grayscale transformation is whether it is possible to design a more reasonable mapping function. It is required to perform operations such as storing, fetching, statistical histogram, and transformation for each pixel, which is difficult to achieve without a fast, large-storage computer. If you want to design a more reasonable mapping function, you must know what kind of processing needs to be done according to the characteristics of the image. The advantage of the grayscale transformation method is that it can greatly improve the human visual effect and is convenient for calculation, and the calculation speed is faster. Figure 1 shows the photosensitivity curve of the three primary colors plus color mixing.

Due to system noise, underexposure (or overexposure), relative motion, and other factors, the acquired image often has some differences (called degradation or degradation) from the original image. Image enhancement technology [24] is one of the most basic objects of digital image processing research. The main goal of image enhancement is to make the image highlight some aspect of the information in the image that is relevant to current needs while weakening or removing some unnecessary information. After degradation, the image's quality deteriorates, the amount of information extracted from it is reduced, and even incorrect information appears. The amplitude-frequency response of the degraded signal is shown in Figure 2.

The histogram is the foundation of various spatial processing techniques in image processing, and the grayscale histogram is the graph of grayscale and grayscale probability in the image [25]. The traditional histogram equalization algorithm works by switching the image histogram to nonlinearly stretch the histogram so that the histogram of the obtained image is evenly distributed. The histogram equalization algorithm is a classic and effective image enhancement algorithm that is widely used. It improves the image even more by altering the contrast. Using a function, redefine the gray value distribution [26]. During the image enhancement process, there is no need to investigate the cause of the image quality degradation, and the resulting image may not be very similar to the original image. Image enhancement can be a skewed process. Its purpose is to enhance the image's visual effect. The relationship curve between chromatic aberration distortion and exposure time is shown in Figure 3.

Image enhancement in the spatial domain is an important application of digital image enhancement. It is based on image pixel direct processing and a technology that enhances the constituent image pixels via linear or nonlinear transformation. Image enhancement is also used extensively in the military, digital entertainment, and multimedia fields. Equalization of histograms has some obvious flaws as well. After the histogram is equalized, the image's average value will be close to the gray level's midpoint, which is unrelated to the previous image. Purposefully emphasize the entire feature or part of the image for the image's application to us. Make the previous blurry image more clear by enlarging the differences in characteristics between the image's various objects. Grayscale histograms are grayscale histograms. The function is the graph of the relationship between the image's gray level probabilities, which is the image's most fundamental statistical feature. To meet the needs of some special analysis, improve image quality, add information, and strengthen image interpretation and recognition effects [27]. The histogram equalization algorithm has been greatly optimized in various fields after years of development, but it is still limited to its specific use range, and there is no way to achieve good adaptability, so there is still a lot of room for improvement.

3.2. Traditional Image Enhancement Method Processing.
The common method to improve image contrast in image processing is histogram equalization. The statistical table of image pixels is an image histogram. The probability density distribution function of the image pixels is the normalized histogram. Reflect the distribution information of image pixels. Image enhancement technology based on histogram equalization and prescribed processing can improve image contrast and grayscale range. The best method for processing images with concentrated gray levels is the histogram equalization algorithm. But it cannot deal with noise effectively. The classification of histogram equalization methods is shown in Figure 4.

Easy to digital image processing, the histogram of the image must be introduced into a discrete form. The discrete function of the histogram of the digital image whose gray level is in the range of $[0, L-1]$ is

$$h(r_k) = n_k. \tag{1}$$

Among them, r_k is the k level gray level, and n_k is the number of pixels of the gray level r_k in the image. In the image, the gray level of the pixel should be normalized and processed by the computer. The total number of pixels in the image n is divided by each value to obtain the normalized histogram:

$$P(r_k) = \frac{n_k}{n}, \quad 0 \le r \le 1, k = 0, 2, \Lambda, L-1. \tag{2}$$

$P(r_k)$ gives an estimate of the probability of r_k occurrence.

4. Image Contrast Enhancement Method Based on Nonlinear Space and Space Constraints

4.1. Image Contrast Enhancement Method Based on Nonlinear Space and Space Constraints of Partial Differential Equations.
With the rapid advancement of information technology, digital image processing is widely used in military,
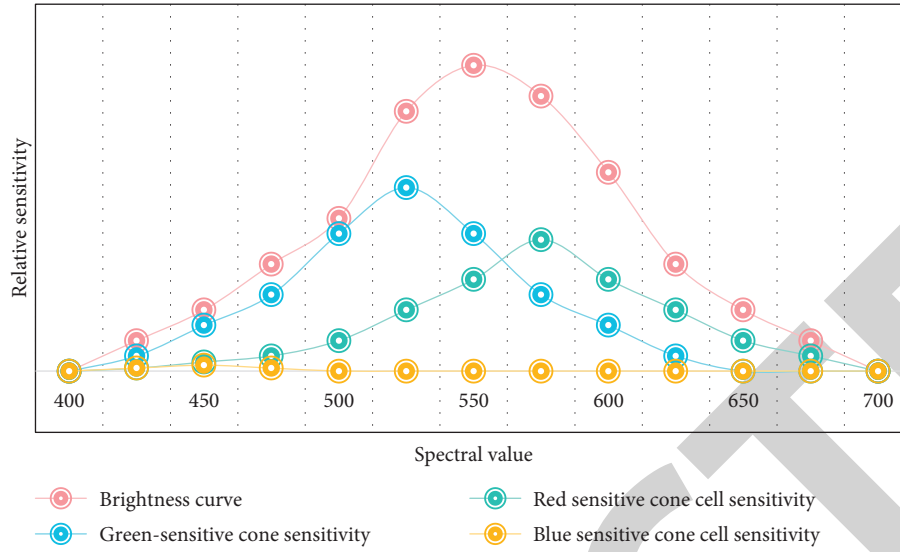
FIGURE 1: Photosensitive curve of three primary colors added and mixed.
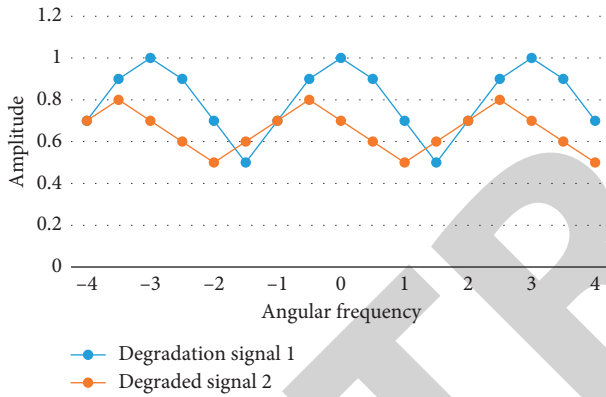

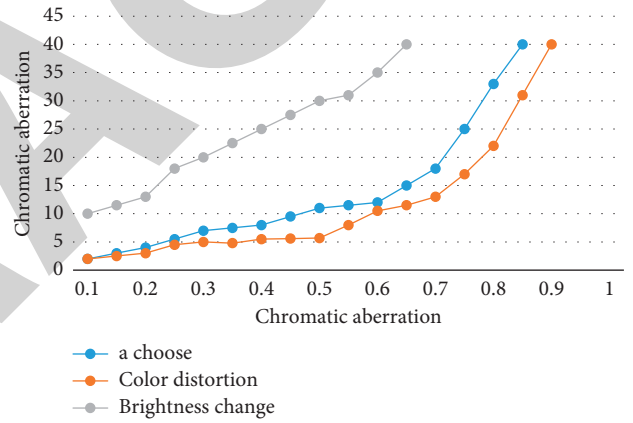FIGURE 2: Degraded signal amplitude-frequency response.

FIGURE 3: The relationship curve between chromatic aberration distortion and exposure time.

engineering, and multimedia technologies. The purpose of image denoising and enhancement is to improve image quality and make it closer to the needs of practical applications, so it has very good research value. Image resolution refers to a measure of the ability to distinguish certain feature details from an image. It can be shown that the finer the feature details of the image, the higher the resolution of the image. The noisy step signal is shown in Figure 5.

With the rapid progress of multimedia digital video technology, digital image processing is widely used in various aspects such as aerospace, national defense, surveillance, people's life, and multimedia technology. It can help people see and understand image information more directly and accurately. It allows us to use image data more effectively. Image enhancement is an effective method to improve image quality and visual effects, creating good conditions for subsequent image processing and video tracking. The contrast of enhanced images is the main aspect of image enhancement. Specifically it refers to the resolution of the spatial fineness in the image. Image denoising and enhancement are a research direction that has emerged with

the development of imaging technology. The noise image is shown in Figure 6.

Image enhancement, which creates favorable conditions for subsequent image processing and video follow-up, is an important way to improve image quality and visual results. It is also thought to be a technology for improving image visual effects or transforming images into technologies suitable for human observation and machine analysis. The general definition of image contrast enhancement is related to the image's overall intensity and the edges of the object. The image created by the space observation image on the camera image surface is typically low in contrast, with a concentrated intensity distribution in the histogram and the target submerged in a complex background. Image denoising and enhancement have always been important research objects in the field of image science and engineering because of the factors that will undoubtedly cause image quality degradation during imaging equipment and processes. The remote sensing image registration process with nonlinear scale space and spatial constraints is shown in Figure 7.
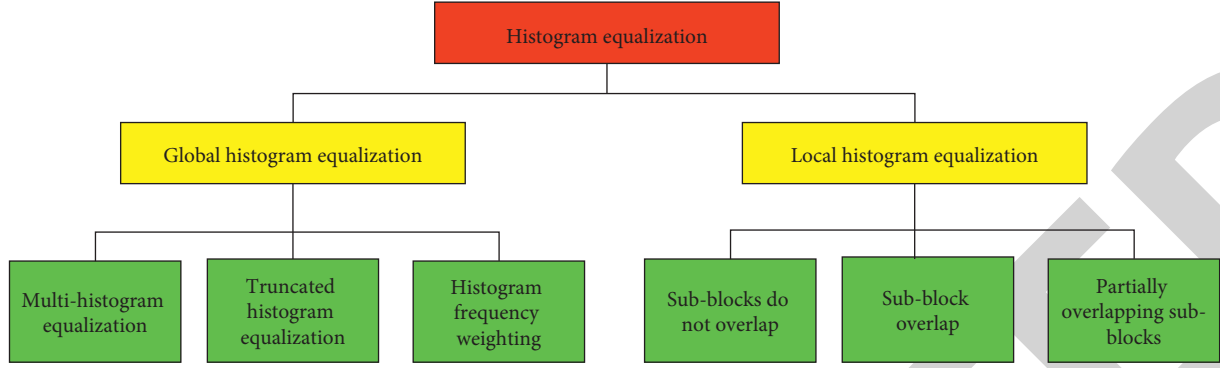
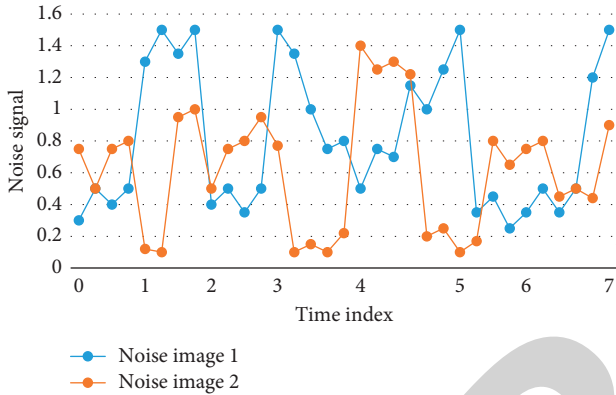FIGURE 4: Classification of histogram equalization methods.
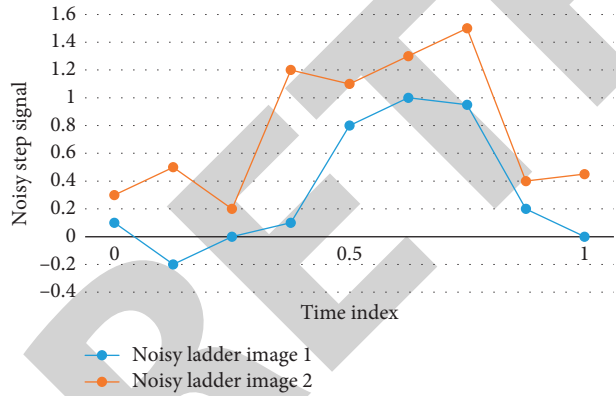

FIGURE 5: Noisy ladder signal.

FIGURE 6: Noisy image.

For digital images, the optical system of the image acquisition device, the detection resolution of the photoelectric converter, the conversion accuracy of the conversion circuit, and the signal-to-noise ratio are the main factors that determine the spatial resolution. Enhancing the texture details of the image and adjusting the brightness and contrast of the image are the main aspects of image enhancement. The blood axe can be observed, analyzed, and further processed. The factors that degrade the image quality are generally the following four aspects: the defocus of the imaging system, the relative movement of the imaging device and the object, the inherent defects of the imaging device, and external

interference. The image hardware acquisition equipment includes three parts: optical imaging system, photoelectric converter, and digital quantization circuit. One of the important reasons for the reduction of image contrast is the uneven distribution of external light during the image acquisition process. The actual image we get can be regarded as the response of the shooting device to the light intensity of the object's reverse characteristic. The uneven illumination makes the image dark in some places and highlighted in some places. The image information in the dark or highlighted areas we mentioned cannot capture what the eye sees well. The enhancement of image texture details refers to the enhancement of the edge strength of objects on the image. It makes the texture details of the image more prominent. In order to reduce or even eliminate the need for ladders, more and more experts and scholars have begun to replace the TV algorithm with high-order regularization methods. The TV norm recovery signal is shown in Figure 8.

Image brightness enhancement is the process of dimming the highlight image or part of the image while brightening the dark image or part of the image to make the brightness of the entire image more uniform. The actual images of these areas, on the other hand, contain a wealth of information. The contrast between these details is minimal. As a result, enhancing the image's contrast in these areas has significant application value. The corresponding biorthogonal filter is obtained using the low-pass filter and downsampling operation in the degradation model. A biorthogonal mapping based on the Laplace pyramid transform is formed by combining the biorthogonal filter and the low-pass filter. The degradation model constraints are implemented through the mapping.

4.2. Image Contrast Enhancement Algorithm Based on Nonlinear Space and Space Constraints. The first step is to count the number of idle gray levels L_r with zero pixels in the entire gray range $[0, 255]$ in the original image histogram. In theory, gray levels that are absolutely unoccupied, that is, gray levels with a frequency of 0, should be classified as idle gray levels, but because the image is affected by the imaging device, there will be some noise points. Therefore, the gray levels whose gray level appearance frequency is less than a certain threshold Δ are classified as idle gray levels, which
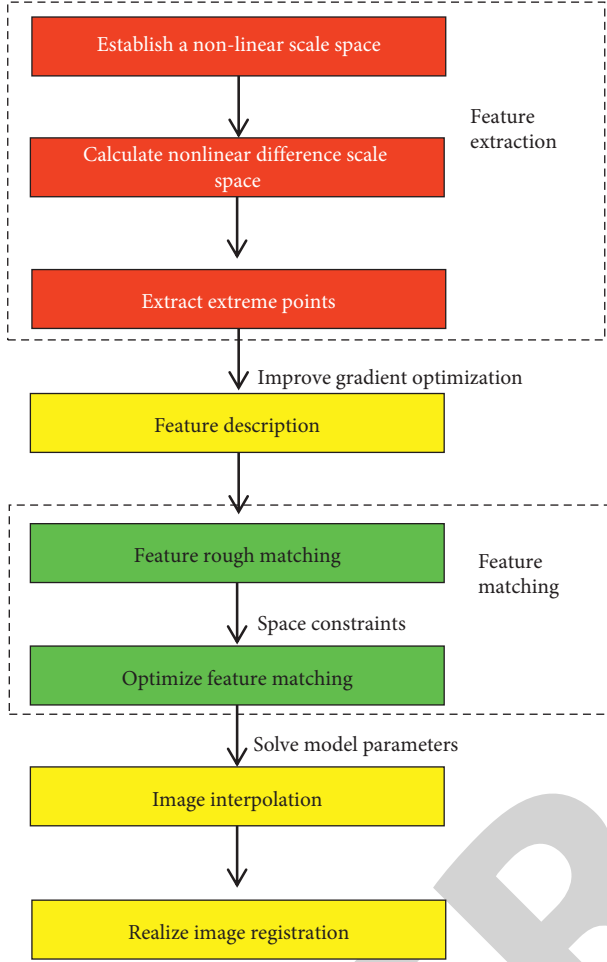
FIGURE 7: Flowchart of remote sensing image registration with nonlinear scale space and spatial constraints.

can relatively reduce the interference of noise gray levels with extremely small appearance frequency on idle gray level statistics. The value of Δ is the key to enhancing the processing effect. Too much Δ will cause the effective signal to be compressed, while Δ is too small and the enhancement effect is not obvious.

Assuming that the image size is $W \times H$, and A is the average value of the image histogram, that is, the $A = (W \times H)/256$, threshold value is $\Delta = 0.3A$. The processed image obtained in this way has the highest signal-to-noise ratio, the noise is removed very cleanly, and the contrast is greatly improved. The visual effect is better. That is, the histogram is corrected to

$$\text{his}'[r] = \begin{cases} \text{his}[r], & \text{his}[r] \geq \Delta, \\ 0, & \text{his}[r] < \Delta. \end{cases} \tag{3}$$

Counting the number of gray levels of $\text{his}' = 0$ is L_r.

The second step is to calculate the number of effective gray levels L_e in the entire gray range $[0, 255]$:

$$L_e = 255 - L_r. \tag{4}$$

In the third step, the number of idle gray levels L_r calculated in the previous step is allocated according to the

frequency of occurrence of effective gray levels. The frequency of each gray level determines the allocation of idle gray levels in this case. Gray levels with a higher frequency are given a lower n, while gray levels with a lower frequency are given a higher n. In this way, the histogram equalization method can stretch the gray level interval of the target's details with a low frequency, enhance the detail part, and avoid the background segment with a higher gray level frequency for the target with a lower gray level frequency. Paragraph fusions are when two or more paragraphs are combined into a single unit.

Suppose the gray level probability density function is

$$P_k = \frac{n_k}{n}. \tag{5}$$

Among them, n is the total number of pixels.
n_k—The gray level is the frequency of r_k.
Then the calculation formula of the number of idle gray levels L_k allocated to the effective gray level is

$$\frac{L_k}{L_r} = \frac{1 - P_k}{\sum_{i=0}^{255} (1 - P_i)}. \tag{6}$$

That is:

$$L_k = \frac{L_r (1 - P_k)}{\sum_{i=0}^{255} (1 - P_i)}. \tag{7}$$

In this way, the number of gray levels L_k' occupied by the effective gray level whose gray level is r_k is

$$L_k' = 1 + L_k. \tag{8}$$

In the fourth step, these nonzero effective gray levels are arranged in a nonlinear stretch within the entire gray range, and the transformation function is

$$s_k = T(r_k) = \sum_{i=0}^{k} L_i'. \tag{9}$$

Since images acquired in practical applications frequently have low contrast, the image must be processed to achieve a better visual effect. Traditional image enhancement methods are no longer able to meet people's image quality requirements because the edge of the image is sometimes uncertain or ambiguous. In 1980, Moret, a French mathematician, proposed the wavelet transform. The wavelet transform can decompose a signal into space and scale (i.e., time and frequency) without losing any information from the original signal. The principle of the wavelet operator is shown in Figure 9.

The common shortcoming of the histogram equalization method and the grayscale transformation method is that the noise is amplified while enhancing the contrast. Existing algorithms either do not consider the influence of noise, or use the statistical characteristics of noise to achieve threshold denoising while enhancing, and most of them assume that some statistical characteristics of noise are known. Image enhancement processing is necessary, which is the prerequisite for segmentation and recognition and the basic denoising principle. The comparison of wavelet coefficients before and after image compression is shown in Figure 10.
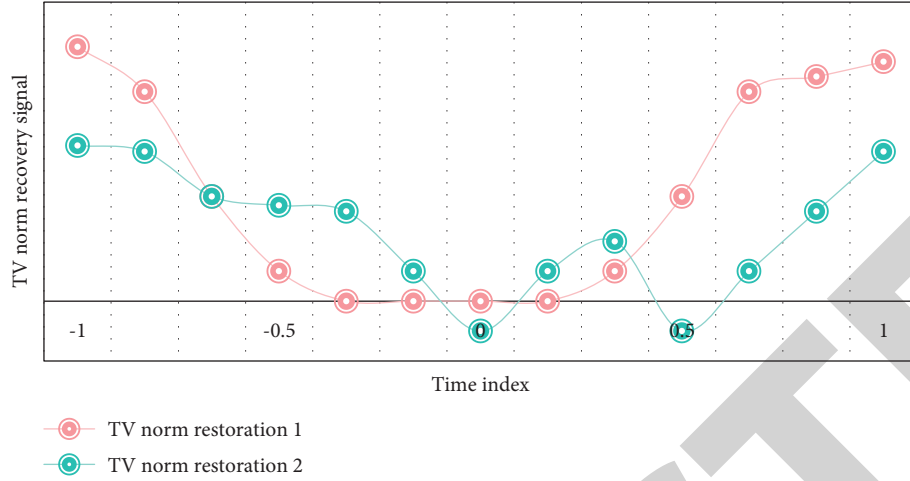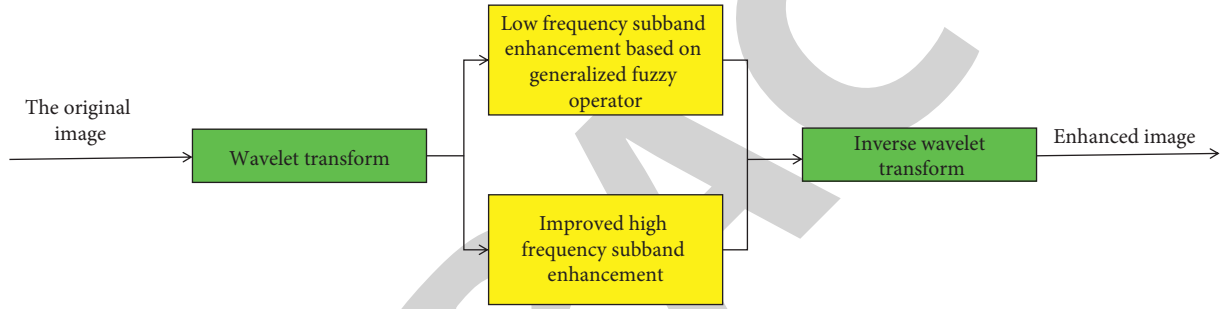
Figure 8: TV norm restoration signal.

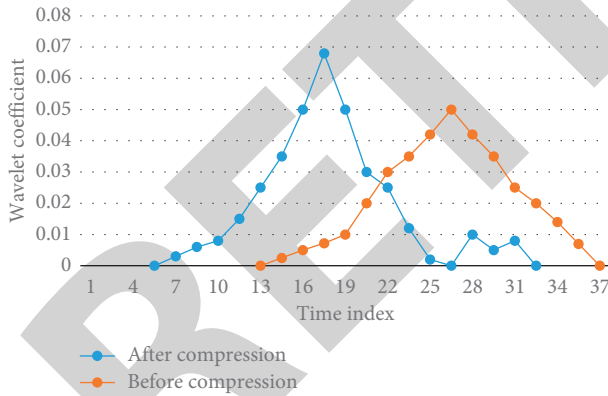Figure 9: Principle diagram of wavelet algorithm.

Figure 10: Comparison of wavelet coefficients before and after image compression.

Consider the following discrete noise signal model:

$$g[i, j] = f[i, j] + \varepsilon[i, j], \quad i, j = 1, \ldots, N. \tag{10}$$

The form written as a matrix is

$$g = f + \varepsilon. \tag{11}$$

Among them, the matrix $g = \{g[i, j]\}_{i,j}$ represents the input signal, $f = \{f[i, j]\}_{i,j}$ represents the unknown certain signal, and $\varepsilon = \{\varepsilon[i, j]\}_{i,j}$ represents the noise signal. Suppose that the noise DDD is a stationary random signal, so there

are $E\varepsilon[i, j] = 0$, $E\varepsilon^2[i, j] = \sigma^2 \ \forall i, j = 1, \ldots, N$. This article is limited to the study of uncorrelated white noise, that is, $E\varepsilon[i, j]\varepsilon[k, 1] = \delta_{i-k, j-1}\sigma^2$.

In order to reconstruct the original signal, a nonredundant orthogonal discrete wavelet transform is performed on both sides of the model:

$$X = Wf, \tag{12}$$

$$V = W\varepsilon, \tag{13}$$

$$Y = Wg, \tag{14}$$

$$Y = X + V, \tag{15}$$

where W is a two-dimensional orthogonal wavelet transform operator and W is an orthogonal matrix. The signal's main energy is concentrated on a small number of wavelet coefficients using the above transformation. It is also simple to show that the orthogonal transformation of stationary white noise is still stationary white noise; i.e., the noise energy is the same across all coefficients.

In this article, we intend to use the "soft threshold" function proposed by Donoho. This "soft threshold" operation is expressed by the following formula:

$$Y_\delta = D_\delta \circ Y, \tag{16}$$

in

$$D_\delta = \text{diag}\{d[m,m]\}, \tag{17}$$

$$d[m,m] = \begin{cases} 0, & |Y[i,j]| < \delta, \\ 1 - \dfrac{\delta}{|Y[i,j]|}, & |Y[i,j]| \geq \delta. \end{cases} \tag{18}$$

Among them, $i, j = 1, \ldots, N$, $m = 1, \ldots$. Note that the operation of equation (16) is a nonlinear operation. In the same way, we have

$$X_\delta = D_\delta \circ X. \tag{19}$$

From equation (14) and equation (16), the inverse transformation of the input signal is

$$g_\delta = W^{-1} \circ Y_\delta. \tag{20}$$

Then the comprehensive operation can be expressed as

$$g_\delta = A_\delta \circ g. \tag{21}$$

It is related to the threshold and the input signal g.

From the foregoing, it can be seen that if an estimator based on the statistical characteristics of noise is used to estimate the optimal threshold, the standard deviation of the noise must be used, which is almost impossible in practical applications. Consider here the generalized confirmation principle to solve this problem.

5. Conclusions

Image enhancement technology has been applied in a variety of fields as science and technology have progressed, and many image enhancement algorithms have been developed, each with its own set of benefits and drawbacks. Digital image processing is a critical tool for people to recognize and use objective objects, and it is used in a wide range of fields. Its research has gained the same prominence as fundamental subjects like mathematics and physics. Direct histogram equalization can effectively process images with low contrast and relatively concentrated gray scale, but it cannot take into account denoising and detail preservation, as shown by the analysis of visual effects and histogram characteristics. Although the partial differential enhancement method based on gradient field equalization can improve the partial dark or bright details caused by uneven illumination when evaluated qualitatively, the enhancement effect is not ideal for images that are too dark or too bright with low contrast. To generate the multiscale representation of the remote sensing image, the nonlinear diffusion equation and the fast explicit diffusion equation are used, which avoids the calculation of the gradient amplitude and direction by the Gaussian scale space operator, overcomes the irregular and complex intensity transformation relationship between the remote sensing image pairs, and increases the resolution. The number of correct point pairs that match is determined. The proposed parameter calculation method adaptively selects parameters based on subband coefficients, allowing adaptive image

enhancement. The phenomenon of noise expansion and loss of detail will appear during image enhancement, and this is still an area for future improvement; finding an algorithm that can enhance a class of images is the focus and difficulty of image enhancement research, and it is also the future development direction of image enhancement.

Data Availability

The data used to support the findings of this study are included within the article.

Conflicts of Interest

All the authors do not have any possible conflicts of interest.

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