Agricultural Image Denoising, Compression and Enhancement Based on Wavelet Transform

Kejin Jia
School of Electrical Engineering, Hebei University of Science and Technology, Shijiazhuang, China
jwuser@126.com,

Xiaowei Zhang *
Shijiazhuang Municipal Development and Reform Commission, Shijiazhuang, China
*Corresponding author (E-mail: zhangxiaowei0323@126.com)

Abstract

Agriculture is related to people's livelihood, and with the rapid development of information technology, agricultural informatization can well promote the development of agriculture. Nowadays, collecting digital agricultural images through digital cameras or hand-held field image acquisition devices and analyzing the images can effectively acquire and identify the degree of disease in the process of crop growth. However, due to noise and other disturbances in natural environment, in order to ensure the quality of digital agricultural images, it is necessary to filter the signals. So in this paper, three steps of image denoising, compression and enhancement in signal filtering are studied. Wavelet transform is introduced to avoid the abrupt change of image features while eliminating high-frequency noise in traditional digital agriculture. Firstly, by analyzing the characteristics of the wavelet coefficients of natural images, an improved threshold function and threshold are used to remove the noise from the noise-contaminated pixels. Secondly, the steps of image compression by wavelet transform are described in detail, and a lifting algorithm of wavelet transform is given. Finally, two-dimensional stationary dyadic wavelet transform is used to enhance the digital agricultural image. Through simulation analysis, it is proved that the research on signal filtering steps of digital agricultural image quality in wavelet transform is effective, and can effectively improve the quality of digital agricultural image, which has a very important role in realizing agricultural image transmission.

Key words: Digital Agricultural Image, Wavelet Transform, Image Denoising, Image Compression, Image Enhancement

1. Introduction

Crops are indispensable renewable resources for human beings. They not only provide basic necessities for human beings, but also improve soil fertility, control soil erosion and improve the living environment of human beings. China is a big agricultural country, and doing well in agricultural production is a major matter related to the national economy and people's livelihood. According to statistics, the world's total grain output in 2000 was about 2.2 billion tons, of which China's grain output was about 500 million tons. However, in the process of crop growth and development, crops are often affected by various adverse environmental biological and abiotic factors, leading to crop diseases [1-3]. The direct loss caused by crop diseases is to reduce crop yields.

Therefore, rational and safe use of pesticides and control of pesticide pollution to agricultural products, soil and water have become an important issue that needs to be solved urgently. In order to ensure that pesticides can be effectively applied to eliminate crop diseases and improve crop yield, at the same time, pesticides can be rationally used to effectively reduce the pollution of pesticides to the environment. One of the preconditions is that agricultural producers must accurately obtain the information of crop growth status. The key basic technology is to quickly and accurately obtain the information of crop diseases. In this way, agricultural producers can adopt targeted prevention and control methods according to the disease information obtained, scientifically and systematically manage the field diseases, and recover the losses caused by the disease in the most economical way.

However, from the current actual situation, the identification and management of crop diseases in the field is extensive. Because the symptoms of crop diseases are often blurred at first, it is difficult to describe the appearance symptoms with accurate and quantitative figures, and agricultural producers often lack comprehensive knowledge of crop disease identification, so agricultural producers often deviate from the recognition of crop diseases and blindly spray pesticides on crop diseases. If we want to get accurate information about crop diseases, we must invite plant protection experts to carry out pathogen identification and
In the past 40 years, with the development of computer technology, a comprehensive technology has emerged. Computer image processing technology has developed very rapidly and its application has become more and more extensive. It has penetrated into many fields such as engineering, industry, medical care, aerospace, military, scientific research, agriculture and so on. Some technologies have been quite mature and have produced considerable objective economic benefits [7-10]. It integrates computer, automation, optics, vision, psychology, artificial intelligence, mathematics and many other fields. It uses an image sensor instead of the human eye to acquire the image of the object, transforms the image into a data matrix, and uses a computer instead of the human brain to analyze the image, so as to achieve the same effect as the optical system simulation processing. Digital image processing is the theory, method and technology of removing noise, enhancing, segmenting and extracting features from images by computer calculation [11-13]. Compared with human visual processing, digital image processing has many advantages, such as high processing accuracy, good reproducibility, quantitative, adaptability and large amount of data, so it has been widely used in many fields, especially in the field of agricultural engineering, showing incomparable advantages.

The application of computer image processing technology in agriculture began in the late 1970s. It mainly deals with plant species identification, quality detection and classification of agricultural products. With the rapid development of computer hardware and software technology and image processing technology, its application in agriculture has made great progress. At present, the research in this field is a hot topic in the field of international agricultural engineering. Developed countries have begun to apply computer image processing technology and computer vision system in agricultural production and agricultural modernization, such as crop growth status information monitoring, agricultural seed resource management, automatic identification of agricultural insects, plant pathology research, genetic cell engineering research and so on. Machine vision technology includes image acquisition, image processing and pattern recognition. Machine vision can simulate the human eye to take close-range photography of the visible spectrum of crops, and then use artificial intelligence, digital image processing technology to analyze the image information and obtain the information needed by the research object.

All the above digital agricultural image information processing must ensure its good quality. If the quality of digital agricultural image is blurred, it will cover up its image features, which will bring great interference to the subsequent image processing. Therefore, filtering digital agricultural images is an important means to ensure image quality. This paper mainly studies image denoising [14, 15], compression and enhancement.

Image denoising is a classical subject in the field of image processing. Its purpose is to effectively suppress or completely eliminate noise interference, and to maximize the preservation of information such as image edges and details. Early image filtering techniques were mainly carried out in the spatial domain. Mean filtering [16, 17], median filtering [18], Wiener filtering [19] and so on all belong to this category. Although these classical algorithms and the resulting improved algorithms can achieve better filtering effect, they also have some defects that cannot be ignored: Firstly, this kind of algorithm destroys the edges and details of the image greatly, resulting in serious loss of image information; secondly, the traditional algorithm has a large amount of computation, and cannot adapt to the occasions where the real-time processing of signals and images is required. In order to overcome the shortcomings of the above algorithms, a frequency domain image filtering method based on Fourier transform is proposed [20, 21]. This method provides a new choice for people to solve the problem by converting the filtering problem to the frequency domain. Compared with the filtering method in the spatial domain, it has made some progress, but it is only applicable to the image with stable gray level change, but it cannot do anything for the non-stationary mutation signal and image.

Image compression refers to the technology of representing the original pixel matrix with less or less loss of finger information, also known as image coding [22-24]. Due to the huge amount of image data and the limitation of communication bandwidth and storage capacity, image compression plays an important role in digital television, network multimedia communication, conference television, videophone, remote sensing image transmission, image database, fingerprint storage of automatic fingerprint identification system and other applications. The principle is that the image has two characteristics: spatial correlation and temporal correlation. Any scene of a frame image is composed of several pixels. Therefore, a pixel usually has a certain relationship with some of its surrounding pixels in brightness and chroma, which is called spatial correlation. According to the analysis of image statistical characteristics, there is a strong correlation between adjacent pixels, adjacent rows and adjacent frames. If some coding method can reduce or cancel these correlations to a certain extent, the data compression of image information can be realized. A plot in a program often consists of image sequences composed of several consecutive frames. There is also a certain relationship between the front and back frames in an image sequence. This relationship is called temporal correlation. These two correlations make a lot of redundant information in the image. If we can remove these redundant information and only retain a small amount of irrelevant information for transmission, we can greatly save the transmission frequency band. The receiver can restore the original image on the premise of guaranteeing certain image quality by using these
non-correlated information and according to certain decoding algorithm.

Digital image enhancement refers to the processing method that highlights some information in an image according to specific needs while weakening or removing some unnecessary information. Its main purpose is to make the processed image more applicable to a particular application than the original image. Therefore, this kind of processing is to improve the image quality for some application purpose. The result of processing makes the image more suitable for human visual characteristics or machine recognition system. Image enhancement techniques are mainly divided into two categories: spatial processing and frequency processing. Spatial domain method refers to the direct processing of the pixels in the image, which is basically based on gray mapping transformation. Frequency domain method is based on convolution theorem. Generally, image enhancement is achieved by modifying Fourier transform.

In order to improve the quality of digital agricultural image better, wavelet transform has good local time-frequency and multi-resolution characteristics, and can basically realize the separation of stationary and abrupt signals in the image. In this paper, wavelet transform is applied to image signal filtering. The three steps of image denoising, compression and enhancement are mainly studied by wavelet transform. The quality of digital agricultural images is improved, and the transmission and processing of agricultural images are easy to realize. The main contributions of this paper are as follows:

(1) Aiming at image denoising, by analyzing the characteristics of the wavelet coefficients of natural images, an improved threshold function and threshold are used to remove the noise from the noise-contaminated pixels.

(2) Aiming at image compression, the steps of image compression based on wavelet transform are described in detail, and a lifting algorithm of wavelet transform is given.

(3) Aiming at image enhancement, two-dimensional stationary dyadic wavelet transform is used to enhance digital agricultural images.

2. Proposed method

2.1. Image Denoising Based on Wavelet Transform

Image denoising is the first step of signal filtering for digital agricultural images. In this paper, the characteristics of wavelet coefficients of natural images are analyzed, and the selection of threshold functions and thresholds in wavelet threshold denoising technology is deeply studied. After that, the improved threshold functions and thresholds are applied to the pixels polluted by Gauss noise to remove Gauss noise.

1. Principle of wavelet denoising

The main theoretical basis of wavelet threshold de-noising method [25] is that wavelet transform, especially orthogonal wavelet transform, has strong de-data correlation. It can concentrate signal energy in some large wavelet coefficients in the wavelet domain, while noise energy is distributed in the whole wavelet domain. Therefore, after wavelet decomposition, the amplitude of the wavelet coefficients of the signal is larger than that of the noise coefficients. It can be concluded that the larger the amplitude of the wavelet coefficients are generally signal-based, while the smaller the amplitude coefficients are noise to a large extent. Therefore, the threshold method can preserve the signal coefficients and reduce most of the noise coefficients to zero.

The specific process of wavelet threshold denoising is: decomposing the noisy signal on each scale, preserving all wavelet coefficients at large scale and low resolution. For the high resolution wavelet coefficients at different scales, a threshold can be set. The wavelet coefficients whose amplitude is lower than the threshold are set to 0. The wavelet coefficients above the threshold are either preserved completely or processed by shrinkage. Finally, the processed wavelet coefficients are reconstructed by inverse wavelet transform to recover the effective signals.

There are two key factors in denoising by wavelet threshold method: the first is the selection of threshold function; the second is the selection of threshold parameters.

2. Selection of threshold processing function

By analyzing the limitations, advantages and disadvantages of traditional hard threshold function, soft threshold function, semi-soft threshold function and soft-hard threshold compromise method, the threshold function is improved on the basis of these functions. The new expression of threshold function constructed in this paper is as follows:

\[
\widehat{w}_{i,j} = \begin{cases} 
\text{sign}(|w_{i,j}|) \cdot \frac{2(1-a)\lambda}{1 + e^{b|w_{i,j}|}} & |w_{i,j}| \geq \lambda \\
-cw_{i,j} & |w_{i,j}| < \lambda 
\end{cases} 
\]  

(1)

In this expression, \(a\), \(b\) and \(c\) are three regulatory factors. By changing the values of these three
factors, the threshold function also changes correspondingly. Usually, \( a \) and \( c \) take values in the range of 0 to 1. These three factors change the orientation of the new threshold function by changing the values, and then affect the filtering effect of noisy images \([26-30]\). For example, takes \( a = 1 \), \( c = 0 \), \( b \) is an arbitrary value, the function becomes a hard threshold function. When all three factors are zero, \( a = b = c = 0 \), the threshold function becomes a soft threshold function. When \( a \in (0,1) \), \( c = 0 \) and \( b \) tend to be infinite, the improved function becomes a function similar to soft threshold function. When \( a \in (0,1) \), \( c = 0 \) and \( b \) tend to zero, the improved function becomes a processing function similar to the soft-hard threshold compromise method. In addition, when \( \left| \hat{w}_{i,j} \right| < \lambda \), instead of simply zero \( \hat{w}_{i,j} \) as hard threshold function or soft threshold function, \( \hat{w}_{i,j} \) is multiplied by a smaller coefficient \( c \) in the range of 0 to 1. Because in reality, the wavelet coefficients below the threshold are not all composed of noise coefficients, and they are mixed with image signals in varying degrees. We can reserve these coefficients appropriately according to the actual situation. It is likely to play a role in image clarity and make the denoising effect better. \( b \) parameter on exponential function characterizes the compression degree of wavelet coefficients by the threshold function, which overcomes the high frequency component loss caused by the constant \( \lambda \) deviation of soft threshold function in \( \left| \hat{w}_{i,j} \right| \geq \lambda \). From this we can see that \( a \), \( b \) and \( c \) play different roles in the new threshold function.

In addition, through the analysis of the new function, we can also find that the threshold function is a continuous function, which makes up for the discontinuity of the hard threshold function and the shortcomings of the break point problem. Moreover, by changing the values of three parameters\( a \), \( b \) and \( c \), the deviation of soft threshold function is overcome, which is not consistent with the theory that noise decreases with the increase of wavelet coefficients due to constant deviation. In addition, this function makes up for the high-order non-conductible of the soft threshold function, so the new threshold function is more convenient and flexible to use, and the denoising effect is better.

3. Selection of threshold

Threshold selection is very important. If the threshold is too small, more noise will be retained, which makes the denoising effect not obvious. The output image and the input image have little difference, and still contain a lot of noise. If the threshold is too large, the details of the image will be lost and the image will be blurred. In practical applications, the uniform threshold \( \sigma \sqrt{2 \log(N)} \), \( \sigma \) are often used to represent the variance of mixed noise, \( N \) is used to represent the length of the signal. Due to the unknowability of variance \( \sigma \), we usually estimate it according to the first-level wavelet decomposition coefficients:

\[
\hat{\sigma} = \frac{\text{MAD}}{0.6745}
\]  

(2)

In the above formula, \( \text{MAD} \) represents the median of the absolute value of the first-level wavelet decomposition coefficients. 0.6745 is the adjustment coefficient of Gaussian noise standard variance, and the variance of noise signal satisfies the condition \( \sigma < \hat{\sigma} \leq 1.01\sigma \), so the noise variance \( \sigma \) is estimated approximately according to the value of \( \hat{\sigma} \).

In the process of denoising by using wavelet transform, we find that according to the characteristics of wavelet transform, Gauss white noise with zero mean is still Gauss white noise with zero mean after orthogonal wavelet transform. That is to say, the wavelet coefficients of Gauss white noise after wavelet transform are still white noise with zero mean and \( \sigma \) variance, and the Gauss white noise has negative singularity. That is to say, the amplitude of wavelet coefficients of Gauss white noise decreases with the increase of decomposition scale \( j \), and even the wavelet spectrum disappears gradually. However, when the decomposition scale increases, the effective signal can still be clearly displayed after wavelet transform \([31-34]\). Therefore, it is unreasonable for all decomposition layers to choose the same fixed global threshold in wavelet denoising. According to the characteristics that the noise amplitude decreases with the increase of decomposition scale and the signal amplitude increases with the increase of decomposition scale, it is more reasonable to select a local threshold, and the threshold should decrease with the increase of decomposition scale. According to this theory, we know that the amplitude of signal and noise is closely related to the decomposition scale \( f \), so considering the factor that the selected threshold changes with the decomposition scale, the improved expression of threshold function

\[
\hat{\sigma}_{j} = \frac{\text{MAD}_j}{0.6745}
\]  

(3)

where \( \text{MAD}_j \) is the median of the absolute value of the \( j \)-level wavelet decomposition coefficients.
should establish some relationship with the decomposition scale. Therefore, the formula of threshold is determined in this paper as follows:

$$\lambda_j = \sigma \sqrt{2 \log(N) / \log(2^{j+1})}$$

(3)

In the above formula, \(j\) represents the number of decomposition layers, \(\lambda_j\) represents the threshold of decomposition layer \(j\). According to the threshold expression, when \(j = 1\), 

$$\lambda_j = \sigma \sqrt{2 \log(N)} = \lambda.$$

That is, when the decomposition scale is 1, the threshold function is the same as the calculation formula of the unified threshold. When \(j > 1\), Threshold \(\lambda_j\) decreases with the increase of decomposition scale \(j\), which is consistent with the characteristic that noise amplitude decreases with the increase of decomposition scale. Therefore, the improved expression of threshold function is more reasonable.

2.2. Image Compression Based on Wavelet Transform

In this paper, the second step of digital agricultural image signal filtering is image compression. According to the function of wavelet threshold in image compression, good image compression effect can be achieved by setting reasonable threshold.

1. Steps of image compression based on wavelet transform

When the image is compressed, if the original image has multiple components, it is decomposed into several single-component images according to its components. In order to process larger images, the component image can be divided into several tiles. If the image is not very large, the whole image can be regarded as a piece. In this way, tile-component becomes the basic unit of original image or reconstructed image. Therefore, the object of wavelet transform is a complete slice component, which can ensure that at least one slice of the scope of DCT does not appear blocking effect. After wavelet transform, the slice is decomposed into several resolution levels, each resolution level consists of several sub-bands, in which the frequency domain characteristics of the slice components described by the transform coefficients are included. Then the transform coefficients of sub-bands are quantized and divided into rectangular arrays of smaller "coding blocks", which are the basic units of later bit plane coding. Entropy coding of coefficient bits is carried out from high to low in order of importance in the bit plane of the coding block, and the compressed bit stream is obtained. In order to repair errors, markers are added to the stream. The final stream is preceded by a header that describes the decomposition level of the original image, the encoding method and the related content of the image for location, extraction, decoding and reconstruction. According to this header information, the decoder can reconstruct the image of the original image in a specific resolution and a specific area without decoding all the bit-streams according to its special needs. The process is shown in Figure 1.

![Figure 1. Image compression process](image)

2. Lifting algorithm of wavelet transform

Because there is a simple relationship between all multi-resolution analysis of the same scale function, lifting technology uses this relationship and biorthogonal relationship to determine the remaining degrees of freedom to construct biorthogonal wavelets. Designers can completely control these degrees of freedom to design the actual required wavelets. Once the wavelet is determined, the compactly supported biorthogonal dual wavelet and scale function can be determined immediately by lifting method, so lifting method is a user-oriented design method. Essentially, the purpose of lifting is to select a general multi-resolution analysis with a special scale function, and then use lifting method to modify the multi-resolution analysis until it meets the designer's requirements. It is usually used to improve the vanishing moment of the wavelet or the approximation order of the scale function. The traditional wavelet transform, i.e. the first generation of wavelet transform, establishes
time-frequency analysis by Fourier transform. The lifting method of wavelet transform uses Euclidean algorithm to find the maximum common factor between low-pass and high-pass filters. It maximizes the computational redundancy between the two filters and greatly reduces the computational complexity of Mallat algorithm. The high frequency component of the signal is obtained by basic polynomial interpolation, and the low frequency component of the signal is obtained by constructing scale function.

Lifting algorithm gives a simple and effective method to construct biorthogonal wavelet. It uses basic polynomial interpolation to obtain the high frequency component of the signal, and then constructs the scale function to obtain the low frequency component of the signal. The basic idea of lifting algorithm is to gradually construct a new wavelet with better properties through a basic wavelet (Lazy Wavelet).

The wavelet transform can be realized by lifting algorithm, and the standard operation can also be realized. The whole process does not need auxiliary units, so the storage space can be saved. The relationship between the inverse transformation and the positive transformation is very simple. It only needs to reverse the order of the positive transformation, so it is very convenient to realize it by computer programming. After decomposing the wavelet transform into lifting process, it can be realized in integer form. Therefore, lossless image compression can be realized by lifting algorithm.

2.3. Image Enhancement Based on Wavelet Transform

In this paper, the last step of digital agricultural image signal filtering is image enhancement, which mainly uses two-dimensional stationary dyadic wavelet transform to enhance digital agricultural image.

Two-dimensional stationary dyadic wavelet is a new algorithm based on two-dimensional dyadic wavelet transform proposed by Mallat et al. It is a new kind of two-dimensional dyadic wavelet transform. It not only goes out of the inertial thinking of the traditional two-dimensional dyadic wavelet transform, but also extends the discrete two-dimensional stationary wavelet transform. The transformation results proposed by Mallat et al. are mainly composed of low-frequency components, horizontal and vertical high-frequency components. The two-dimensional discrete dyadic stationary wavelet transform has more high-frequency information components in the diagonal direction than the transform proposed by Mallat et al. But the computational complexity of the two algorithms is different. The computation of two-dimensional discrete dyadic stationary wavelet transform is slightly larger than that of Mallat's fast algorithm of two-dimensional dyadic wavelet transform, but the former can get better high-frequency information in the diagonal direction of the image. Moreover, it can also give the Mallat decomposition algorithm of dyadic wavelet, that is, in Mallat two-channel filter bank, the dyadic wavelet filter is used to replace the orthogonal or biorthogonal wavelet filter to implement the decomposition algorithm, and the maximum modulus of dyadic wavelet can also be applied to image edge detection.

The flow chart of image enhancement based on two-dimensional stationary dyadic wavelet transform is shown in Figure 2. The specific steps are as follows:

(1) Two-dimensional stationary dyadic wavelet transform of image

Firstly, the image to be processed is decomposed by \( k \) level dyadic wavelet transform to obtain \( 2k - 1 \) sub-band images, including one low-frequency sub-band and \( 2k - 2 \) high-frequency sub-band images.

(2) Enhancement of high frequency sub-band coefficient

The high frequency sub-band coefficients are enhanced by the following formula:

\[
M(G(x, y), w_j) = w_j G(x, y)
\]  

(4)

Where \( G(x, y) \) represents the denoised coefficients, \( j \) represents the series of dyadic wavelet decomposition, \( i \) represents the \( i \) high-frequency sub-band image of Layer \( j \), \( w_j > 1 \) is the enhancement factor of corresponding sub-bands, \( M(G(x, y), w_j) \) represents the corresponding sub-band coefficients after enhancement.

(3) Binary wavelet reconstruction

The enhanced high frequency and low frequency sub-bands are reconstructed by \( k \) level dyadic wavelet.

(4) Piecewise gray level transform

The reconstructed image is processed again, and the final enhanced image is obtained by segmented gray transformation. The formula of piecewise gray transformation is as follows:
Where $f_{\text{max}}$ is the maximum gray value of an image pixel, $Tf(x, y)$ represents the pixels after gray scale transformation, $M \in (0, 255]$, $N \in (0, f_{\text{max}}]$. In the application, the range of $M$ and $N$ can be adjusted according to the actual situation, so as to get the best effect of the image.

$$
Tf(x, y) = \begin{cases}
\frac{f(x, y)M}{N}, & f(x, y) \in [0, N] \\
\left(\frac{f(x, y) - N(255 - 2M)}{(f_{\text{max}} - 2N)} + M\right), f(x, y) \in [N, f_{\text{max}} - N] \\
\left(\frac{f(x, y) - f_{\text{max}} + N)M}{N} + 255 - M\right), f(x, y) \in [f_{\text{max}} - N, f_{\text{max}}]
\end{cases}
$$

(5)

3. Experiments

After image denoising based on wavelet transform, image quality will inevitably change. In order to evaluate the performance of image denoising algorithm based on wavelet transform, this paper uses objective evaluation method to evaluate the performance. It means that the denoised image is calculated by some mathematical formula and analyzed quantitatively to get specific index data. This paper mainly uses peak signal-to-noise ratio (PSNR) to evaluate the image quality after denoising. The expression is as follows:

$$
PSNR = 10 \log_{10} \left(\frac{Q^2}{M \times N \sum_{j=0}^{M-1} \sum_{k=0}^{N-1} [f(j, k) - \hat{f}(j, k)]^2}\right)\ (dB)
$$

(6)

Where $f(j, k)$ is the original image information, $\hat{f}(j, k)$ is the image information after denoising, $M \times N$ is the total number of pixels in the image information, $Q$ is the maximum gray level. The higher the PSNR value, the better the image denoising effect.

Mean square error (MSE) of objective method is also used as the fidelity evaluation criterion of compressed image. Its expression is as follows:

$$
MSE = \frac{1}{M \times N} \sum_{j=0}^{M-1} \sum_{k=0}^{N-1} [\hat{f}(j, k) - f(j, k)]^2
$$

(7)

Where $\hat{f}(j, k)$ is the original image, $f(j, k)$ is the restored image after compression and decompression.

Finally, the information entropy is used as the evaluation criterion of image enhancement performance. The gray density of the enhanced image is expressed as follows:

$$
p(f) = p\{L = x\}, x \in L
$$

(8)
Its gray density calculation is the same as the method of calculating gray distribution density in histogram, and the formula of information entropy is as follows:

\[ H(x) = -\sum_{x \in L} p(x) \log_2 p(x) \]  

(9)

The value of information entropy represents the amount of information contained in an image. The larger the information entropy, the richer the information contained in the image and the higher the image quality. On the contrary, the less information contained in the image, the lower the image quality.

4. Discussion

Before filtering the digital agricultural image signal, this paper needs to gray the image. The processing results are shown in Figure 3, in which Figure 3 (a) is the original image and Figure 3 (b) is the grayscale image.

![Figure 3. Image graying process](image)

Firstly, based on the wavelet transform, the signal of digital agricultural image is filtered. The first step is to denoise the image. By analyzing the characteristics of the wavelet coefficients of the natural image, the improved threshold function and threshold are used to remove the noise from the noise-contaminated pixels.

In this paper, Gauss noise is added to the gray image to get the image with noise, as shown in Figure 4. From the figure, we can see that the image with noise and blurred image features hide the feature information of the image, which is not conducive to image recognition and other processing. Therefore, it is necessary to denoise the digital agricultural image.

![Figure 4. Image with noise](image)

In this paper, the median filter processing method is used as a comparison, as shown in Figure 5 (a) is the image processing image with noise by median filter, and Figure 5 (b) is the result of the image denoising method based on wavelet transform. It can be seen from the subjectivity of the graph that the denoising effect of this method is better than that of the classical median filter.
In order to evaluate the performance of denoising algorithm more objectively, this paper uses PSNR to make quantitative analysis, and the comparison results are shown in Table 1. As can be seen from Table 1, although image denoising based on median filtering can improve the PSNR of the image, the improvement is limited, only 3.9. The image denoising based on wavelet transform, whether hard threshold or soft threshold, has been improved by 4.7 and 5.3, respectively, compared with the median filtering method. In view of the improvement of threshold function and threshold, PSNR is improved by nearly 10% on the basis of the improved wavelet transform. The results of Figure 5 and Table 1 show that the image denoising of digital agricultural image is effective and has good performance.

<table>
<thead>
<tr>
<th>Algorithm</th>
<th>PSNR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noisy image</td>
<td>66.3</td>
</tr>
<tr>
<td>Image denoising based on median filtering</td>
<td>70.2</td>
</tr>
<tr>
<td>Image denoising based on soft threshold</td>
<td>75.5</td>
</tr>
<tr>
<td>Image denoising based on hard threshold</td>
<td>74.9</td>
</tr>
<tr>
<td>Method of this paper</td>
<td>85.1</td>
</tr>
</tbody>
</table>

Similarly, this paper designs the image compression steps of digital agricultural image signal filtering, gives the steps of image compression by wavelet transform, and gives the lifting algorithm of wavelet transform. Table 2 shows the qualitative performance analysis of image compression algorithm. From Table 2, we can see that the MSE of image compression is only half of the traditional wavelet transform, which is twice as good as the traditional wavelet transform.

<table>
<thead>
<tr>
<th>Algorithm</th>
<th>MSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional wavelet transform</td>
<td>48.3</td>
</tr>
<tr>
<td>Wavelet transform lifting algorithm</td>
<td>23.9</td>
</tr>
</tbody>
</table>

For the third step of digital agricultural image signal filtering processing: image enhancement, this paper uses two-dimensional stationary dyadic wavelet transform enhancement processing, using histogram enhancement as contrast, to process the denoised image. The results are shown in Figure 6, and the qualitative analysis is shown in Table 3. Combining Figure 6 and Table 2, it can be seen that compared with histogram enhancement, the method in this paper achieves better results and enhances information entropy by 1.75.

<table>
<thead>
<tr>
<th>Algorithm</th>
<th>MSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional histogram</td>
<td>48.3</td>
</tr>
<tr>
<td>Wavelet transform lifting</td>
<td>23.9</td>
</tr>
<tr>
<td>Method of this paper</td>
<td>35.6</td>
</tr>
</tbody>
</table>

**Table 1. Performance comparison of denoising algorithms**

**Table 2. Comparison of compression performance of different algorithms**

**Figure 5. Comparison of different denoising methods**

**Figure 6. Image enhancement using different methods**
Table 3. Comparison of enhanced performance of different algorithms

<table>
<thead>
<tr>
<th>Algorithm</th>
<th>Information entropy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Histogram enhancement</td>
<td>4.67</td>
</tr>
<tr>
<td>Method of this paper</td>
<td>6.42</td>
</tr>
</tbody>
</table>

5. Conclusions

Information processing can effectively promote the development of agriculture, and the quality assurance of digital agricultural images is an important prerequisite for image recognition and other processing. Therefore, it is necessary to filter digital agricultural images. In order to improve the quality of digital agricultural images and combine the advantages of wavelet transform, this paper studies three steps of image denoising, compression and enhancement in signal filtering. Through wavelet transform and its improvement, different processing methods are designed for image denoising, compression and enhancement. In addition, through the simulation analysis, we can find that by improving the threshold function and threshold selection of wavelet transform, it can effectively improve the performance of wavelet transform in image denoising, and has a good denoising effect. And by using the lifting algorithm of wavelet transform, it has better image compression performance than traditional wavelet transform. Finally, the use of two-dimensional stationary dyadic wavelet transform for image enhancement has also achieved good results, which can illustrate the research on signal filtering processing steps of digital agricultural images in this paper, effectively improving the quality of digital agricultural images, has a very important role in the realization of agricultural image transmission.

References

and Petrology.

Han, M., Zhao, Y., Zhao, H., Han, Z., Yang (southern Ordos Basin, China) "significance for unconventional petroleum exploration, with a case study from the Triassic Yangang Formation" (Marine and Petroleum Geology).


Fan, A., Yang, R., van Loon, A. J (Tom), Yin, W., Han, Z., “Classification of gravity-flow deposits and their significance for unconventional petroleum exploration, with a case study from the Triassic Yanchang Formation (southern Ordos Basin, China)”, Journal of Asian Earth Sciences. 161, pp.57-73.

Han, M., Zhao, Y., Zhao, H., Han, Z., Yan, H., “A comparison of amorphous calcium carbonate crystallization in aqueous solutions of MgCl2 and MgSO4: implications for paleo-ocean chemistry”, Mineralogy and Petrology. 112, pp.229-244.