Design of Fractal Image Coding Compression and Transmission Model Based on Wavelet Transform

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Abstract. Coding and compression of image data is the key to high quality storage and transmission of image data. For this reason, this research designed a new fractal image coding compression and transmission model based on the wavelet transform process based on the analysis of the advantages and disadvantages of the basic fractal coding compression algorithm. Firstly, the image is decomposed by two-level wavelet transform, and then the decomposed high-level sub-images are subjected to basic fractal coding, and according to the similarity between the sub-image structures of different layers, the low-level sub-image fractal coding is constructed from the high-level fractal coding to realize the image High-quality transmission. Experimental results show that the model has achieved good application effects in shortening the image encoding time and improving the compression ratio.

Keywords: Wavelet transform · Fractal image · Image coding · Image compression · Transmission model

1 Introduction

The development of information technology brings more opportunities and challenges to image compression and transmission technology. Therefore, it is necessary to explore some new image coding and compression methods [1]. Fractal image coding has been paid more and more attention for its potential high compression ratio, but fractal coding can not solve the problem of obtaining higher compression ratio, especially shortening the coding time. Therefore, the combination of fractal coding and compression technology with other image processing technology may be an important method to solve these problems [2].

At present, fractal images are usually encoded, compressed and transmitted based on Gaussian model or Wiener filter. However, in practical application, it is found that the traditional image coding model has a long time and low application efficiency.

Wavelet transform is a kind of global transform, which has good positioning ability in time domain and frequency domain at the same time. It can focus on any detail of the processed image by gradually fine step size in time domain and spatial domain. Because

S. Liu and X. Ma (Eds.): ADHIP 2021, LNICST 416, pp. 15–25, 2022.
https://doi.org/10.1007/978-3-030-94551-0_2

of these advantages of wavelet transform, it has been widely used in the field of image processing [3].

Based on the above analysis, a new image coding compression and transmission model combining wavelet transform and fractal theory is proposed based on fractal coding theory. Firstly, the multi-scale image decomposition is carried out, and then the fractal coding of the high level sub-image is carried out according to the similarity of the sub-image structures of different frequency bands, and then the fractal coding of the high level sub-image is constructed to construct the fractal coding of the low level sub-image. Using this coding method, higher compression ratio can be obtained, and the coding time can be greatly shortened, so as to improve the efficiency of image transmission to a certain extent.

2 Fractal Image Coding and Compression Based on Wavelet Transform

Wavelet is a wave with limited energy and very concentrated in the time domain. The use of wavelet characteristics to analyze instantaneous variable signals can well extract faults. The wavelet analysis method can show the time domain characteristics and frequency domain characteristics of the signal well, so as to more accurately describe the signal and extract the fault [4]. For any function $f(t) \in L^3(R)$, a basic wavelet can be used to obtain a formula with the inner product of $f(t)$ after scaling and translation operations. The calculation formula is as follows: (1):

$$W_f(a, b) = \left[f, \psi(t)\right] = |a|^{\frac{1}{2}} \int f(x)\psi(\frac{1-b}{a})dx \tag{1}$$

In formula (1), $\psi(t)$ is the mother wavelet function, a is the expansion factor, and b is the parallel factor. The smaller $^1/_a$ is, the higher the corresponding frequency is, and the larger $^1/_a$ is, the lower the corresponding frequency is. Through the time-frequency analysis of the wavelet transform of the signal, observe the component of t corresponding to a a at a certain time [5].

The signal is divided into high-frequency and low-frequency sub-band by using the filter of frequency-domain averaging. The high-frequency part is retained every time, and then the low-frequency part is continued to be equally divided until the low-pass filter represented by the function. After analyzing the wavelet, the wavelet packet is decomposed. Wavelet packet is proposed to solve the two problems of poor frequency resolution in high frequency band and poor time resolution in low frequency band. Wavelet packet analysis can provide a more precise method. On the basis of multi-resolution analysis, the high frequency part is further subdivided, and the combination can be selected adaptively Appropriate frequency band, matching with the signal spectrum, so as to improve the time-frequency resolution [6]. The process is shown in Fig. 1.

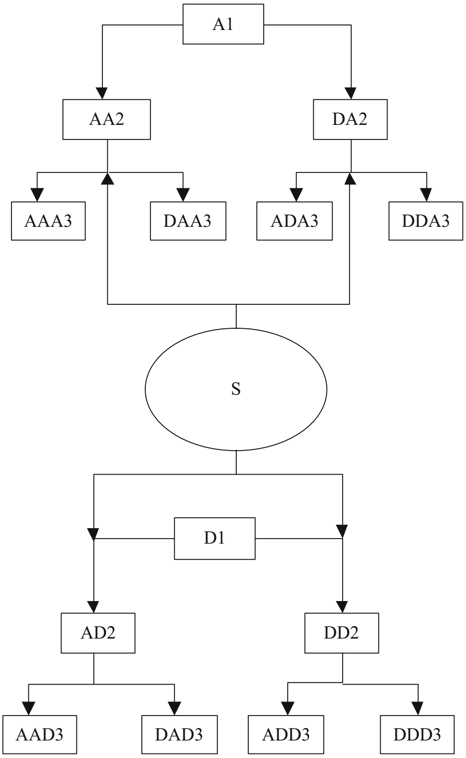

Fig. 1. Schematic diagram of the three-layer decomposition process of wavelet packet

The extracted signals are respectively represented as aaa3, daa3, ADA3, DDA3, aad3, dad3, add3, ddd3. Where a is the low frequency and B is the number after the high frequency letter, which is the level of wavelet packet decomposition. The formula of wavelet packet decomposition is s = aaa3 + daa3 + ADA3 + DDA3 + aad3 + dad3 + add3 + ddd3. According to the decomposition relation, the fault characteristics of the circuit are extracted [7].

Image coding based on fractal transform is a model coding technology developed on the basis of fractal theory. The main steps are as follows:

(1) The image to be encoded is divided into non overlapping small blocks, namely range block, referred to as R-block, while the image is divided into larger overlapping blocks, namely domain block, referred to as D-block. The combination of all the classified blocks is the original image, and the combination of all the overlapped blocks is just the “source” to find the affine compressed image blocks.
(2) The R-block and D-block are classified. Because an image can be divided into smooth region with smooth transformation, edge region with abrupt transformation and middle region with gentle transformation, and the matched blocks have the same regional properties. Therefore, in order to speed up the coding process and realize the matching search process between blocks with the same regional properties,

the segmented blocks must be divided into flat r block and D-block, edge R-block and D-block, and transition R-block and D-block according to the classification principle.

(3) For each R-block in the same region after classification, the matching D-block is found, so that D-block can approximate R through affine function. In this way, a group of affine transformation groups can be found, which is the segmentation iterative system. As long as the transformation of the system is contractive and simpler than the original system, the fractal compression can be realized.

To sum up, the basic fractal compression algorithm is the process of searching and matching R-block and D-block after image segmentation. This algorithm is characterized by high compression rate (1–2 orders of magnitude higher than the classical coding), and the operation speed has little to do with the improvement of image resolution, but the problem is that the amount of calculation is large and the coding compression time is long. Therefore, this paper proposes a new fractal image coding and compression technology based on wavelet transform.

After wavelet decomposition, the image is divided into four sub bands: low frequency sub-band ll which contains most of the image information, horizontal sub-band HL which contains texture features and edge information, vertical sub-band LH and diagonal sub-band HH.

The image decomposition algorithm based on wavelet multi-resolution analysis is to decompose the image by two-dimensional wavelet on the basis of selecting the appropriate orthogonal wavelet basis.

Assuming that signal $\left\{C_{j+1,m,n};\ m, n \in z\right\}$ is the approximate representation of two-dimensional image $f(x, y)$ at resolution $j+1$, the finite orthogonal wavelet decomposition formula of two-dimensional signal $\left\{C_{j+1,mt,n};\ m, n \in z\right\}$ is:

$$\begin{cases} c^1_{j,m_1,m_2} = \sum\limits_{k_1,k_2} h_{k_1-2m_1} h_{k_2-2m_2} c_{j+1,k_1k_2} \\ d^1_{j+1,m_1,m_2} = \sum\limits_{k_1,k_2} h_{k_1-2m_1} g_{k_2-2m_2} c_{j+1,k_1,k_2} \\ d^2_{j+1,m_1,m_2} = \sum\limits_{k_1+k_2} g_{k_1-2m_1} h_{k_2-2m_2} c_{j+1,k_1,k_2} \\ d_{j+1,m_1,m_2} = \sum\limits_{k_1,k_2} g_{k_1-2m_1} g_{k_2-2m_2} c_{j+1,k_1,k_2} \end{cases} \tag{2}$$

It can be seen that the image signal is decomposed into four parts c^1, d^1, d^2, d^3 through the two-dimensional wavelet decomposition of Eq. (2), corresponding to one low-frequency component and three high-frequency components of the image respectively. The main energy of the image signal is concentrated in the low frequency region, which reflects the average brightness of the image. The multi-level wavelet decomposition can be repeated for this part, and the detail edge information is mainly concentrated in the high frequency region, so it is necessary to code the high and low frequency components according to the human visual physiological characteristics.

The working principle of image acquisition designed in this paper is to call line synchronization signal, frame synchronization signal and pixel clock signal. The three signals cooperate with each other and work together to complete the collection of visually conveyed image information. The processor of the image clarification processing system disperses the image data. During the image data transmission, a data frame and a synchronization frame signal are carried at the same time, and a horizontal synchronization signal is output before and after the transmission. In the image acquisition, the rise of the frame synchronization signal represents the end of a visually communicated image data, and the decrease of the signal level represents the arrival of the visually communicated image data. The rise of the line sync signal strength represents the beginning of the image data frame data, and the module should immediately take the image information data; the fall of the line sync signal strength indicates the end of the image frame data, and the module will stop collecting information. The pixel clock signal in the collection represents the start of visually conveying the image pixel data, the rising of the pixel clock signal represents the beginning of the pixel data, and the falling of the pixel clock signal represents the end of the pixel data.

The basic idea of fractal compression based on wavelet transform is that the wavelet transform decomposes the image into sub images in different spatial frequency bands, and there is a great similarity between the corresponding sub image structures in different layers; and the fractal compression algorithm mainly uses the image spatial structure information for compression. In this way, the basic fractal compression can be carried out in the high-level sub image after wavelet transform, and according to the fractal characteristics, the similarity between different level sub images can be used to obtain higher compression ratio. At the same time, the number of image blocks in the classified r block domain and the corresponding overlapped D block domain after image segmentation can be greatly reduced by compression in the high-level sub image after wavelet transform The search time of matching is greatly reduced, so as to shorten the coding compression time. The process is as follows:

Step 1: wavelet decomposition of the image. Firstly, the original image is decomposed by one-stage wavelet transform to obtain four image components D10, D11, D12 and D13, and then the low-frequency component D10 is transformed by two-stage wavelet transform to obtain two-stage high and low-frequency components A0, D21, D22 and D23;

Step 2: segment and classify the wavelet transform secondary high frequency sub images D21, D22 and D23 respectively, and then compress them by using the block search matching method with the same regional property to obtain the fractal coding of the secondary sub images;

According to the fractal image's similarity, the first level coding is constructed.

Let a subblock $X = \left(x_{i,j}\right) \in R^{n\times n}$, then X be normalized as:

$$\hat{X} = \left(\hat{x}_{i,j}\right) = X - \overline{x}I \tag{3}$$

$$\hat{x}_{i,j} = \frac{x_{i,j} - \overline{x}}{\sqrt{\sum_{i,j}\left(x_{i,j} - \overline{x}\right)^2}} \tag{4}$$

Nine blocks and features are defined as:

$$q(x) = \begin{cases} \sum_{2}^{j=0} \sum_{2}^{i=0} \left| \hat{x}_{ik+1,j+1} \right| n = 2k + 1 \\ \sum_{1}^{j=0} \sum_{1}^{i=0} \left(\left| \hat{x}_{ik+1,jk+1} \right| + \left| \hat{x}_{(i+1)k,(j+1)k} \right| \right) + \sum_{1}^{i=0} \left(\left| \hat{x}_{2k,ik+1} \right| + \right. \\ \left. \left| \hat{x}_{k,ik+1} \right| + \left| \hat{x}_{ik+1,2k} \right| + \left| \hat{x}_{ik+1,k} \right| \right) n = 2k \end{cases} \tag{5}$$

Obviously, the sum of nine blocks of sub block $\hat{X}$ is the sum of its four vertices, the middle points on the four edges, and the center points (for even order sub blocks, the middle points on the edges take the sum of the middle two points, and the center points take the average value of the sum of the four points in the center).

Let $R, D \in R^{n \times n}$, then the following inequality holds:

$$E(R, D) \geq \frac{n}{32} \sigma_R |q(R) - q(D)|^2 \tag{6}$$

Where: $\sigma_R = \frac{R - rI}{n}$. Sub block $Q = \left(q_{i,j}\right) \in R^{n \times n}$ is defined as follows:

$$q_{i,j} = \begin{cases} 1 \ i \in \{1, k+1, 2k+1\} \text{ and} j \in \{1, k+1, 2k+1\} \\ 0 \text{ other} \end{cases} \tag{7}$$

Through the two-level wavelet decomposition, the image is decomposed into 7 subbands, the wavelet coefficients of the low frequency subbands are retained, and the signs of the wavelet coefficients of the remaining 6 subbands are separately coded.

For these 6 subbands, the fractal image coding based on the nine-block sum feature is performed. For the first-level subband image, it is divided into R blocks (cannot overlap, 8 × 8 size)and D blocks (can overlap, 16 × 16 size). For the secondary sub-band image, it is divided into R blocks (can not overlap, 4 × 4 size) and D blocks (can overlap, 8 × 8 size).

Take the entire contracted block of each D block as a codebook, then set the standard deviation threshold, the standard deviation threshold of the code block, and the radius of the neighborhood, and filter the codebook to form a new codebook, which is ordered according to the nine blocks and the feature size. The fractal code of each subband is synthesized into the fractal code of the entire original image. According to the fractal code information, each subband is decoded to obtain the decoded image, and then the inverse wavelet transform is performed to generate the reconstructed image.

3 Fractal Transmission Model Based on Wavelet Transform

The fractal transmission model based on wavelet transform is set up. The fractal transmission model is the basic part of the normal operation of the whole work. The fractal transmission model based on wavelet transform is shown in Fig. 2.

It can be seen from Fig. 2 that the fractal transmission model based on wavelet transform designed in this paper is based on B/S structure and data source.

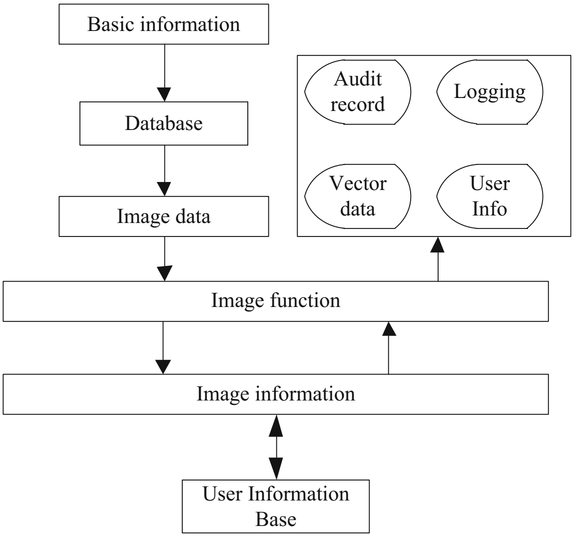

Fig. 2. Fractal transmission model based on wavelet transform

Vector data is the core part of collection, which establishes important parameters for the system. Topology data can facilitate users to find information and quickly find the target area.

The basic data source collection and calculation process is as follows:

$$u_{ad} = \sum_{n=1} (\varphi_{ad} - \varphi_s) \times \partial(x_1, y_1) \tag{8}$$

In formula (8), u_{ad} represents the collected data, φ_{ad} represents the vector data contained, φ_s represents the useless data, and $\partial(x_1, y_1)$ represents the coordinate position of the data node in the space vector data.

$$u_{bd} = \sum_{n=1} (\varphi_{bd} - \varphi_m) \times \partial(x_2, y_2) \tag{9}$$

In formula (9), u_{bd} is the collected data, φ_{bd} is the vector data containing data features, φ_m is the useless data, and $\partial(x_2, y_2)$ is the node coordinate position.

$$u_{cd} = \sum_{n=1} (\varphi_{cd} - \varphi_n) \times \partial(x_3, y_3) \tag{10}$$

In formula (10), u_{cd} represents the collected POI data, φ_{cd} represents the vector data containing the characteristics of the POI data, φ_n represents the useless data in the POI data, and $\partial(x_3, y_3)$ represents the coordinate position of the POI data node in the space vector data.

Integrate formula (8), (9), (10) into formula (4), and the result obtained is all the space vector data collected.

$$u_d = \varphi_{ad} + \varphi_{bd} + \varphi_{cd} \tag{11}$$

In formula (11), u_d is the space vector data collected in the network geographic information system [8].

The collected basic data source is applied to the transmission service, so as to better collect internal data and facilitate users to find information. The collected transmission data is divided into three types, and all kinds of transmission services present parallel relationship [9, 10], as shown in Fig. 3.

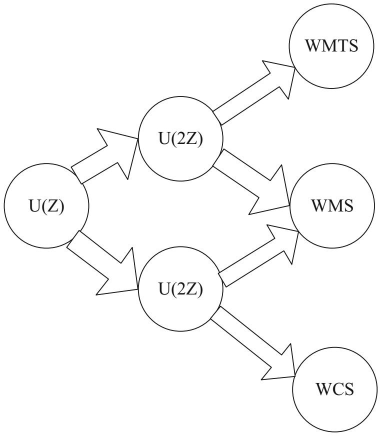

Fig. 3. Schematic diagram of the relationship between transmission vector data

Observing Fig. 3, it can be seen that the collected transmission data includes network map transmission (WMTS) data, network image transmission (WMS) data, and network information transmission (WCS) data. These three types of data run under the control of a user terminal, so the collected data The three kinds of data must be collected at the same time. If collected separately, it will seriously affect the working efficiency of the user side.

The collected transmission function data mainly includes 6 function data, which are display data, query data, collected data, coded data, audit data and management data [11, 12]. When collecting vector data, the established space vector database should be collected to improve collection efficiency. Including submitted vector data and unsubmitted vector data.

4 Experimental Study

In order to verify the effectiveness of the fractal image coding compression and transmission model based on wavelet transform, the performance of the fractal image coding compression and transmission model is compared with the traditional fractal image coding compression and transmission model.

Test image: couple; Lena; woman2; crowd, etc. (block segmentation), experimental platform: Windows 10 operating system (2.3 ghz i5-6300hq/8 GB memory), algorithm is implemented by MATLAB r2016a software. The experimental environment is shown in Fig. 4.

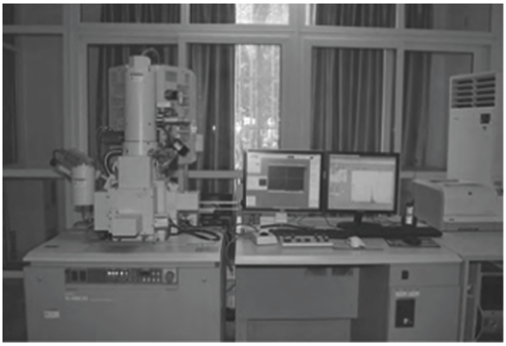

Fig. 4. Test environment

In the above detection experimental environment, in order to avoid the uniformity of experimental results, the traditional image equalization enhancement and transmission model in the compression domain based on MSR algorithm is taken as the comparison model, and it is compared with the fractal image coding compression and transmission model based on wavelet transform proposed in this paper. The number of selected images is 1200, and the size of each image is 50 cm × 50 cm, and the gray level is 256. The experimental results are as follows.

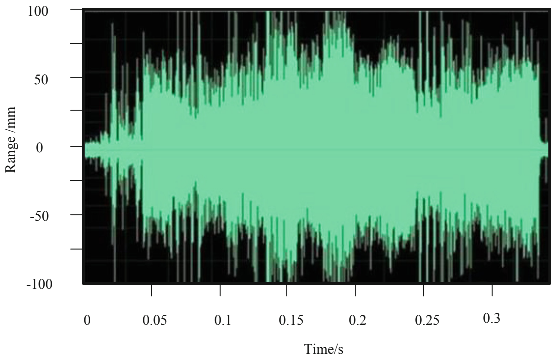

Fig. 5. Transmission waveform of traditional model

Figure 5 and Fig. 6 show the transmission waveforms of different models. By comparing Fig. 5 and Fig. 6, it can be seen that the time-frequency characteristics detected by the model in this paper are clearer than those detected by the traditional model.

The energy of the transmitted signal under normal conditions is mainly concentrated in the low frequency band. Under different damage levels, the emitted energy is distributed in the high frequency band with a wide frequency range. The entire time period shows obvious energy fluctuations. The non-stationary characteristics are obvious. There are also obvious differences in energy distribution between different degrees. In each frequency range, energy intensity and energy fluctuation elapsed time are obviously

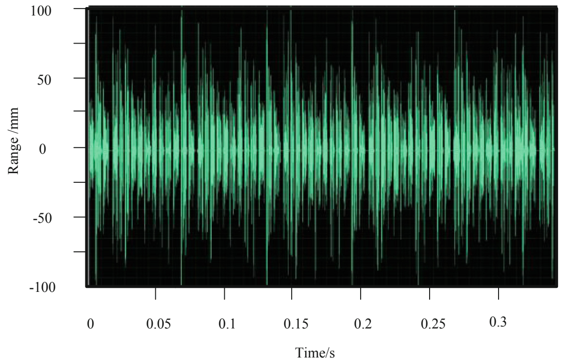

Fig. 6. Transmission waveform of this method

different. As the transmission degree increases, the vibration energy increases, and the fluctuation elapsed time decreases accordingly. It can be seen that the difference between different signals in the discrete wavelet time-frequency domain is obviously more prominent than the difference in the time domain, indicating that the discrete wavelet transform can fully display the time-frequency characteristics of the fault and better analyze the image.

It can be shown that the traditional model is difficult to judge the data encoding only by relying on the signal time domain waveform, but the model in this paper has better classification effect and can better realize the image transmission on the premise of ensuring the image quality.

5 Conclusion and Prospect

Of this study is to design a fractal image coding based on wavelet transform compression and transmission model, the secondary decomposition of the wavelet transform to image, on the basis of on the top of the decomposed sub image basic fractal coding, according to the similarity between different straton image structure, from senior fractal coding structure low straton fractal image coding, so as to realize the high quality of image transmission. Experimental results show that this model can achieve high quality image transmission on the premise of guaranteeing image quality.

However, due to the limitations of research time and equipment, the method in this paper still has a great scope for development. In the future research, the model will be further optimized from the perspective of improving transmission efficiency.

Fund Projects. National Natural Science Foundation of China: The Key Technologies about Fast Coding and Quality Controlling of Fractal Image Compression (61961036).

Natural Science Foundation of Guangxi:Research on the Key Technologies about Decoder for Reliable Transmission of HEVC for Microscopic Video(2020JJA170007).

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