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Image Data Local Compression Research Based on Wavelet Transform

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Abstract—The wavelet transform with multi-resolution characteristic in time and frequency domain is an important method on image compression. it provides image compressed both high image quality and high compression ratio. For meeting the increasing requirements in image visual and data compression, Some wavelet coefficients from multi-layers decomposition must be extracted and preprocessed by multi-scale at different frequency bands, Main feature information such as the edge part and mutation point of image signal should be extracted effectively, a large number of redundant information can be removed. The compression process will be stop until the image signal can be reconstructed approximately from these feature information. If fewer wavelet coefficient images can restore image well, the feature extraction and data compression are realized. The simulation shows that wavelet transform is fully competent for image data compression.

Keywords-data compression; feature extraction; wavelet transform; image decomposition

1. Introduction

The traditional image compression algorithm based on discrete cosine function transformation decompose the signal in the frequency domain, according to the correlation between feature information of the image signals, data compression can be realized by removing redundant information and extracting the main features of coefficients, but the method can not provide detail images information in time-domain. While this application needs is extensive to image process in military, medical, aerospace and satellite remote sensing. If the image local details needed high resolution based on high compression ratio and image quality, only frequency domain analysis can do nothing now. Sometimes, signal coefficients need be processed in time and frequency domain respectively, each areas concerned provide for different compression accuracy [1].

The wavelet transform is a time-scale analysis method on signal process. It has not only the characteristics of multi-resolution analysis but also the analysis ability to denote local signal characteristics in time and frequency domain respectively. It is a time-frequency localization analysis method on fixed window size but with variable shape, the time window and frequency window all can change arbitrarily. That is, the low-frequency part has the high frequency resolution, and the high-frequency part has the high time resolution.

For ensuring high image resolution and clarity, the noise component and irrelevant information must be deleted, the main information carried by high-resolution image is retained, the image data compression is crucial. As the image detail contains in high-frequency part mainly, the wavelet transform with multi-resolution in time-frequency domain comply with high resolution of high frequency signal, which is compete for image data compression and feature extraction.

With time and frequency domain characteristics of adaptive multi-resolution analysis of wavelet transform in feature extraction and image processing advantages. Wavelet analysis is used in image processing widely, and the application mainly includes image compression, image denoising, image enhancement, image fusion, image decomposition, and so on. This article explores the image based on wavelet transform an effective

method of local data compression [2]. The image local compression method based on wavelet transform preprocessing is discussed here.

2. Image Compression

The image data occupy not only memory space and a large number of transmission bandwidth. Therefore, image compression is necessary, which include lossy compression and lossless compression.

The former compression permits some differences exist in the image before compression and after compression, and it is applied to landscape and people images widely, the compression ratio as high as 40 to 1. For the human eye is not sensitive to these difference, the original image can be replaced by some approximations, which reflect the compromise deal with accuracy of image data, storage space and bandwidth.

The latter compression requires image before compression and after compression are same exactly. And it is used for certification signature, file signature images and medical images to avoid wrong judgment, and the compression ratio as low as 2 to 1.

For the correlation exist among adjacent pixels and among different color components widely, the image data include high space redundancy. Therefore, the compression ratio as high as possible should be obtained based on good image visual effect.

The image compression processes include three parts of transformer, quantizer and coder.

The first part reflects the correspondence between original images and transformed images. The image data representation for more easily compressed is provided by removing redundancy in image data.

The second part process the transformed image data into symbols at finite length, the irreversible process mapped the multi-objects into one-target, which result in the loss of image information directly.

The third parts code the transformed coefficients at the way of fixed length or variable length. The latter way called entropy code too, it denote the transformed image coefficients distribution as shorter discrete random process.

3. Wavelet Transform for data Compression

The construction for orthogonal wavelet function is very important in data compression process based on wavelet transform [3].

$$\left(\varphi_{m,n},\varphi_{j,k}\right)=\int_{-\infty}^{\infty}\varphi_{m,n}(t),\varphi_{j,k}(t)dt=\begin{cases}1, & m=j,n=k\\ 0, & other\end{cases}$$

The function $f(t)$ is expanded based on wavelet basis by orthogonal wavelet transform, so it is denoted as the following formula:

$$f(t)=\sum_{m=-\infty}^{\infty}\sum_{n=-\infty}^{\infty}D_{m,n}\varphi_{m,n}(t)$$

Expansion coefficients as: $D_{m,n}=\left(f,\varphi_{m,n}\right)=\int_{-\infty}f(t)\varphi_{m,n}(t)dt$

For it is a finite length signal:

$$f(t)=\sum_{m=m_0}^{m_1}\sum_{n=n_0}^{n_1}D_{m,n}\varphi_{m,n}(t)$$

A function $\overline{f(t)}$ with fewer coefficients should be searched to approach toward $f(t)$ under a given error c, if $c=0$, which stands for lossless compression. That is:

$$\overline{f(t)}=\sum_{m=m_0}^{m_1^{'}}\sum_{n=n_0}^{n_1^{'}}D_{m,n}\varphi_{m,n}(t),$$

here, $\left\|f(t)-\overline{f(t)}\right\|\le\varepsilon$,

and $\left(m_1^{'}-m_0^{'}\right)\times\left(n_1^{'}-n_0^{'}\right)<\left(m_1-m_0\right)\times\left(n_1-n_0\right)$.

Therefore, the key to image compression is searching for a group of wavelet basis function $\{\varphi_{m,n}(t)\}$.

At first, the wavelet coefficients of image signal are re-arranged according to the sequence which is from big to small.

$f(t)=\sum_{k=1}^{M} c_k \varphi_k(t)$, $\varphi_k(t)$ is a new arrangement of $\varphi_{m,n}(t)$.

Then, the signal function is constructed with the formula: $\overline{f(t)}=\sum_{k=1}^{M'} c_k \varphi_k(t)$,

here, $M' \le M=(m_1-m_0)\times(n_1-n_0)$, and $\left\|f(t)-\overline{f(t)}\right\|_2=\sqrt{\sum_{k=M+1}^{M} c_k^2} \le \varepsilon$.

Finally, $\overline{f(t)}$ replaced $f(t)$. The image data compression would be realized effectively [4]

Appropriate orthogonal wavelet basis is selected to decompose image signal with multi-scale, the image complete comprehensive filtering, multi-frequency signal is decomposed into sub-signals with different frequency. The image visual effects on different frequency response is also inconsistent, which is not sensitive to low-frequency part but high-frequency part, so a two-dimensional image realized coefficients decomposition by orthogonal wavelet transform, the redundant frequency components can be removed and image data can be compressed[5].

4. The Image Local Compression Realization

The image compression is realized by two-dimensional wavelet analysis. A series of sub-image with different resolution can be obtained after an image is decomposed by wavelet transform, and sub-image with different resolution corresponds to the different frequency. The high frequency values are most close to 0, the higher the signal frequency is, and the more obvious this phenomenon is. The most important information in an image locates to low-frequency part, therefore, the simplest compression method is wavelet decomposition, and it removes the high frequency part of the image and only retains the low frequency part.

The image compression results based on wavelet transform shown in figure 1 respectively. Firstly, the original image signal is decomposed by wavelet transform, and the layers coefficients image with one layer decomposition can be given. Then, the multi-layer coefficients image can be obtained to reconstruct into a new image compressed, at last, the image will be composed of four layers of wavelet coefficient image, according to image vision requirements these coefficients will be processed respectively. Image of layers coefficients with four layer decomposition are shown here, the middle part in image is covered in the latter two sub-images.

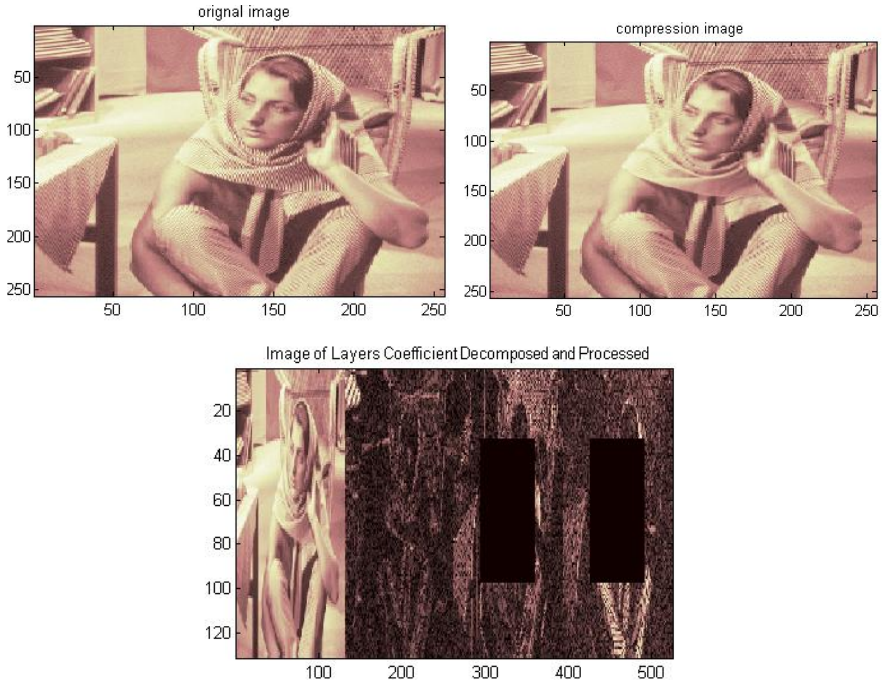

Figure1. Image Compression and Process

The result analysis shown as follows. The wavelet coefficients reflect the details information of original image at each frequency band, the local image compression can be realized by local detail coefficients processed. If the middle of image detail coefficients are set to zero, then, the image compressed shown that only the middle part become blurred, while other parts of the details information is still legible [6].

Actually, multi-layers wavelet transform always complete in image local compression. The action mode of threshold value can be reflected on these facts, such as selecting the proportion of zero coefficients or energy retention components, different threshold value can act on detail coefficients in three different directions respectively, the local compression in image partition can be realized.

5. The Threshold Determination in Two-dimensional Image Compression

The image compression is an important application in two-dimensional wavelet analysis. It is characterized by high compression ratio, high compression speed, the essential characteristics still remains in image compressed, such as strong anti-interference ability. In order to meet a variety of needs in image compression and feature extraction, the appropriate preprocess is always required for image coefficient, for example, different threshold value and stretching transformation and distortion can acted on these coefficients [7].

For the threshold processing care about only the absolute value of coefficients but not the location of coefficients, therefore, the threshold method on two-dimensional wavelet transform coefficient is similar to the case of one dimension. The following simulation will select two methods on image compression, one is the ddencmp command for searching the default threshold value, another is the wdcbm2 command based on empirical formula, and the compression results were compared here.

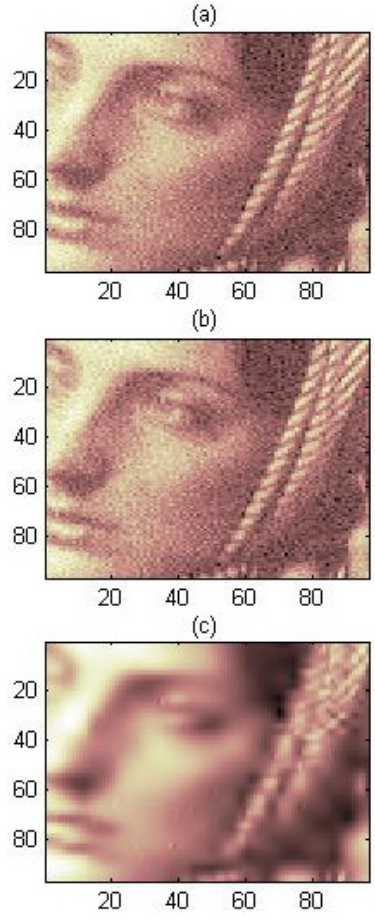

Figure2. Image Compression with Threshold

The image compression with global threshold process and hierarchical threshold process are shown in figure 2, in sub-figure b, the energy components is 99.9547%, and the zero coefficient components is 43.7382%, in sub-figure c, the energy components is 95.0113%, and zero coefficient components is 90.6733%.

From the image compression result comparison, the high compression ratio can be obtained in the case of smaller energy loss, because the layers and the direction which are relevant to threshold method, which can realize the threshold value process by image details information.

6. Conclusion

There is a lot of redundant irrelevant information in image data, in order to obtaining good image visual effect, and the image compression is beneficial for information storage, processing and transmission. The image coefficient in all layers will obtained after an image is decomposed by multi-layer wavelet. These coefficients contains main feature information of original image, and a large number of redundant information can be removed effectively, the wavelet coefficient is processed by global and local threshold method, then, the image can be restored by fewer wavelet coefficients, by which the data compression object is achieved. In a conclusion, the wavelet analysis method improves image visual quality and the image features extraction, texture details are identifiable and the image can be restored well by wavelet coefficient.

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