A Method for Block Compression of Images Based on Data-hiding

T Cui¹,², Q Zhou¹,², J Shen³, J Li¹,², Y L Hu¹,² and W Liang¹,²

¹National Key Laboratory of Science and Technology on Space Microwave, CAST, Xi’an, Shaanxi 710100, China
²China Academy of Space Technology (Xi’an), Xi’an 710100, China

Email: conan915@163.com

Abstract. The existing image block compression method does not reduce the amount of data after the image block processing. For the image with large amount of raw data, such as high-resolution remote sensing images, the image compression will consume more hardware resources and cause great pressure on the compression performance. Aiming at this situation, a method for block compressed of images based on data-hiding is proposed. The reference image block and similar image blocks are judged by the similarity of image blocks. The number of similar image blocks is hidden in the reference image block by data-hiding, and only the reference image blocks are subjected to JPEG2000 compression. The experimental results show that the method reduces the amount of data before image compression by 1/3 and increase the compression ratio of image compression by 1.5 times.

1. Introduction

The development of space technology, especially the development of space military technology, has made the spatial resolution of remote sensing imaging sensors increase rapidly, and the amount of data of spatial remote sensing images has also increased geometrically. However, the limited channel transmission and computational ability on the satellite cannot adapt to the massive data of spatial remote sensing images, which has become a bottleneck restricting the resolution of spatial remote sensing images [1]. At present, image compression methods such as JPEG2000 [2-4] have become an effective way to solve the contradiction between massive remote sensing data and limited transmission capability. However, subject to the limitation of compression multiples, these image compression methods still cannot meet the user’s real-time transmission requirements of massive remote sensing data. Therefore, the amount of data generated by high-resolution remote sensing images must be further reduced to meet the spatial transmission requirements of remote sensing image data.

In this paper, the data-hiding technology is combined with the image compression algorithm to reduce the original amount data of images. At present, there are researches on the combination of information hiding and image compression. For example, the literature[5] proposed a semantic image compression based on information hiding, using partial pixels of the original image to generate semantic images, and using information hiding technology to The estimation error of the pixel is embedded in the generated semantic image, and the compression of the original image is implemented by this method. Literature [6], [7] proposed a combination of information hiding and image compression based on SMVQ to optimize image compression performance. Literature [8] proposed an information hiding method for VQ compression, which has better compression performance than the...
same type of algorithm. In the application of information hiding to remote sensing images, the literature [9] proposed a lossless hidden transmission method based on histogram modification technology, but the research focus of this method is on information hiding capacity. It can be seen that the information hiding technology can improve the performance of image compression algorithm, but there are few studies on remote sensing image compression.

This paper proposes a method for block compression of images based on data-hiding. The procedure of image blocking, similarity decision and image block compression based on data-hiding is given. The implementation flow chart of the method is described in detail. The performance of the method is verified by the image in the standard image library. The simulation results show that the method can reduce the amount of data before remote sensing image compression by 1/3, and increase the compression ratio of remote sensing image compression algorithm by 1.5 times.

2. The proposed method

The block diagram of a method for block compressed of images based on data-hiding is shown in Figure 1, the method consists of an image block hiding method and a standard format compression method. JPEG2000 as a new generation of still image compression standard, can get high compression ratio while ensuring high image quality, in addition to a very good anti-error performance in the field of remote sensing image compression has been widely used [10]. Therefore, the standard format compression in the remote sensing image block compression method based on information hiding uses the JPEG2000 compression algorithm.

![Block Diagram](image.png)

**Figure 1.** The block diagram of a method for block compressed of images based on data-hiding

2.1. Image segmentation and image block similarity decision

Image blocking: 8bit quantization of each pixel to be compressed image block, block method is as follows: For a size of the image $M \times N$, block size $B$ is $m \times n$, the number of image blocks $k = \frac{M \times N}{m \times n}$. The resulting image blocks are $B_1, B_2, \ldots, B_k$.

Similarity decision of image blocks: The peak signal-to-noise ratio (PSNR) is calculated and averaged based on the image pixel gray value. It is a commonly used indicator to measure signal distortion [11]. Therefore, PSNR is also used as a basis for measuring the similarity of image blocks. The PSNR calculation method is as shown in equation (1).

$$PSNR = 10 \log \left( \frac{a_{\text{max}}^2}{MSE} \right)$$

$$MSE = \frac{1}{mn} \sum_{i=1}^{m} \sum_{j=1}^{n} (a(i,j) - \hat{a}(i,j))^2$$

In equation (1), MSE is the mean square error, $a(i,j)$ and $\hat{a}(i,j)$ are the corresponding gray value or color value in the image block $B_i$ and the image block $\hat{B}_j$, $mn$ is the total number of pixels of the image block $m \times n$, $a_{\text{max}} = 2^l - 1$, $l$ is the color depth, which means the number of bits occupied by one pixel. Here, $l = 8$.

When two image blocks satisfy the condition of equation (2), the two image blocks are considered to be similar.
In equation (2), $T$ is a PSNR threshold for determining similarity of two image blocks, and the value may be a reference value according to a PSNR value when the number of similar image blocks is $1/3$.

2.2. Procedure of image block compression method based on data-hiding

According to the above image blocking and image block similarity judgment basis, the specific implementation process of image block compression method based on data-hiding is formed, including the image compression procedure and the recovery procedure. The steps are as follows.

The compress procedure of image block based on data-hiding:

Step 1: According to the block method of the image block, a total of $k$ image blocks of $B_1, B_2, \cdots, B_k$ are obtained, and the corresponding image block number is the sequence $n = (1, 2, \ldots, k)$.

Step 2: Calculate the value of $PSNR(B_i, B_j)$ and determine the threshold $T, 1 \leq i \leq k, 1 \leq j \leq k, i \neq j$. Comparing the value of each PSNR with a threshold value $T$, which is greater than or equal to the threshold value $T$, determines that the two image blocks $B_i$ and $B_j$ that perform the PSNR calculation are similar, and records the image block $B_j$ similar to $B_i$ is numbered $b_i$, $B_i$ as the reference image block, the number $i$ is replaced by the number $j$ of $B_j$, and the image block number sequence $n$ is updated; If the value calculated by the PSNR is less than the threshold $T$, it is determined that the two image blocks $B_i$ and $B_j$ for performing the PSNR calculation are not similar, and the two numbers are not replaced;

Step 3: When $i \neq k, i+1$, then judge whether $i$ is in the sequence, if $i \in n$, return to step 2; if $i \notin n$, then $i = i+1$, until $i \in n$; when $i = k$, stop the PSNR calculation. The algorithm of similar image blocks finding is shown in Table 1:

| Algorithm 1 |
|-------------|
| **function** SimilarImageBlockFinding |
| $n=(1, 2, \ldots, k)$; |
| **for** $i$ to $k$ |
| If $i \in n$ then |
| **for** $j=i+1$ to $k$ |
| $T' = PSNR(B_i, B_j)$; |
| If $T' \geq T$ then |
| $n[j] = i$; |
| else |
| record $i$; |
| end if |
| else |
| record $i$; |
| end if |
| $i = i+1$; |
| **return** $n$; |
| **endfunction** |

Step 4: Binary encoding the similar image block number $b_i$ to obtain a binary code stream, and embedding the binary code stream into the reference image block $B_i$ by using a data-hiding algorithm, and then compressing only the reference image block $B_i$ by using a JPEG2000 image compression algorithm.
The recovery procedure of image block based on data-hiding:

Step 1: The receiving end decompresses the compressed image to obtain the original data of the image, which is the reference image block \( B_i \);

Step 2: De-hiding the reference image block \( B_i \) to obtain information of similar image block number \( b_i \);

Step 3: After obtaining each \( B_i \) image block and the image block number \( b_i \) similar to \( B_i \) in step 2, first place the image block data at the corresponding position in the sequence according to the number information of the compressed image block \( B_i \), and then filled with the data of the image block \( B_i \) in corresponding position of \( b_i \) until the end of the last image block \( B_i \), the complete original image is obtained.

3. Experiment results

In this paper, we use the standard image library lena.bmp, boats.bmp, airplane.bmp, peppers.bmp, baboon.bmp image as an example to simulate the method, the image size is 512x512.

3.1. Image compression process

1) Blocking the original image: divide these standard images into 8×8 image blocks, a total of \( 4096, B_1, B_2, \ldots, B_{4096} \);

2) Find similar image blocks: PSNR calculation is performed with each image block from \( B_1 \). For image blocks with PSNR greater than or equal to \( T \), the two image blocks are considered to be similar, and the number of the image block similar to \( B_1 \) is recorded, \( B_1 \) is a reference image block; then \( B_2 \) begins to perform a PSNR calculation with each image block, if \( B_2 \) has been replaced by \( B_1 \), then starts with \( B_1 \), and so on, until \( B_{4095} \); if a similar image block is found, the reference image block \( B_i \) is recorded and the image block number \( b_i \) similar to \( B_i \). The value of \( T \) taken by different images and the number of similar image blocks are shown in Table 2:

| Image  | Value of T | The number of Similar image blocks |
|--------|------------|-----------------------------------|
| Lena   | 35.5       | 1370                              |
| Boats  | 36.5       | 1379                              |
| Airplane | 38.5     | 1373                              |
| Peppers | 33.8     | 1326                              |
| Baboon | 24         | 1391                              |

3) Then, the number of \( b_i \) is binary coded, and the above coded numbers are respectively hidden into the reference image block \( B_i \) by the LSB(Least Significant Bit) algorithm[12], and then the image is compressed: only the remaining reference image blocks from which \( b_i \) is removed are compressed, and the replacement is reduced. The image block is equivalent to one compression of the original image, compression factor = \( 1/(1-(\text{similar image blocks}/4096)) \)=1.5 times;

4) The compressed image data is transmitted in a certain data format.

3.2. Image recovery process

1) After receiving the compressed image data, the receiving end identifies the data of each image block according to the synchronization byte, and then identifies the corresponding image block according to the image block number;

2) Decompressing the compressed data of the image block to obtain original data of each image block.
3.2. Compressing method

1) Block before compression;
2) Judging the similar image block hidden in the payload data by the frame type byte, and recovering the hidden image block number $b_i$ by using the corresponding de-hiding algorithm;
3) Each image block is arranged in the corresponding position according to the number, and the image block numbered $b_i$ is directly replaced by the image block data numbered $B_i$ to obtain complete image data.

3.3. Result analysis

The compression method proposed in this paper combines the information hiding technology with the image compression algorithm, pre-processes the original data of the image by judging the similarity of the image block before performing JPEG2000 compression on the image, and then uses JPEG2000 to perform 4 times compression.

It can be seen from Table 3 that the PSNR value obtained by the compression method of this method is close to the PSNR value of 6 times compression of JPEG2000. Therefore, the method uses JPEG2000 to compress the image by 4 times but achieves a compression effect of 6 times, and improves the compression performance; and the method does not require complex mathematical operations, only needs to calculate the PSNR value between each image block, the complexity is greatly reduced.

| Image  | The method of this article (PSNR value) | JPEG2000 (PSNR value) |
|--------|----------------------------------------|-----------------------|
| Lena   | 41.2                                   | 41.8                  |
| Boats  | 42.9                                   | 41.5                  |
| Airplane | 44.4                           | 43.5                  |
| Peppers | 39.6                                   | 39.7                  |
| Baboon  | 30.0                                   | 31.0                  |

A comparison of the restored image obtained by the present method and the original image is shown in Figure 2.
4. Conclusions
In this paper, a method for block compression of images based on data-hiding is proposed. The similarity of image blocks is used to identify the reference image blocks and similar image blocks. The data-hiding algorithm is used to hide the number of similar image blocks in the reference image blocks. The reference image block is JPEG2000 compressed for transmission. Compared with JPEG2000 standard compression, it can be seen that the method does not need complicated mathematical operation, the complexity is greatly reduced, the consumption of hardware resources such as memory is reduced, and the image compression ratio is improved by 1.5 times.

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