Considerations of Image Compression Scheme Hiding a Part of Coded Data into Own Image Coded Data

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Abstract

In this paper, it is considered the image compression scheme, in which a part of coded data extracted in the coding process is hidden into the other parts of coded data of own image, especially into the block address data of the best matching block within restricted blocks. The proposed scheme is able to be used in a fractal image coding in which the best matching domain block is searched, in a vector quantization in image coding in which the best matching vector is searched, and in motion compensation of moving picture in which the best matching motion vector is searched. We study each image coding method and consider the features of each coding method using the proposed scheme.

Keywords: *Data hiding, Fractal image coding, Motion compensation, Vector quantization*

1. Introduction

There are some data hiding techniques. The water marking hides the personal IDs for protecting copyright[1]. The steganography hides the confidential information for confidential communication like communication data of spies[2]. The objective estimation of image quality hides the marker signals for the automatic objective estimation of image quality. By the way, from the point of technical view, any data are available to be hidden data[3].

In this paper we consider an image coding scheme using the data hiding technique. This paper is organized as follows: in Section 2, Basic principles of the proposed data hiding scheme. In Section 3, image coding methods using the proposed scheme. In Section 4 and 5, consideration is discussed and concluded, respectively.

2. Basic Principles of the Proposed Data Hiding Scheme

In the proposed image compression scheme, a part of coded data, which is extracted from the image in the coding process, is hidden into the other parts of coded data of own image. Here we focus the image coding methods in which a small block is defined as a unit of coding and decoding process like a fractal image coding, an image coding using vector quantization and a moving picture coding using motion compensation.

Fig 1 presents the proposed data hiding scheme restricting address of searching reference blocks as two bits are hidden. After inputting the pixel values of a current block, the pixel values of reference blocks for block matching and two bits hidden data "i" and "j", the hidden data(i,j) are checked. If "i" is "0", then address Ax(address of x-axis) are set even values, "1", odd values. If "j" is "0", then address Ay(address of y-axis) is set even values, "1", odd values. Only blocks having address(Ax,Ay), even/odd, are searched from the reference blocks. And the block most similar to the current block is selected as the best matching block.

3. Image Coding Methods Using the Proposed Scheme

3.1 Fractal Image Coding Method

A fractal image coding method does the block match processing at every small block by using the self-similarity in an image[4][5]. An original image for the fractal image coding is divided into range blocks (the block size is n×n) un-overlapped each other which are units of coding process, and also divided into domain blocks overlapped each other in the image, of which block size is lager than that of range block, for example 2n×2n.

First of coding process, the mean value and the standard deviation of pixel value of the range block are calculated. The range block where the value of this standard deviation is smaller than or equal to predetermined threshold value T_1 is classified into a flat block. For the flat block, only the mean value is transmitted to the decoding side. In the decoding side, the approximation reproduction is done by using only this mean value in the range block classified into a flat block.

The range block where the value of standard deviation of pixel value is more than T_1 is classified into a non-flat block. For the non-flat block, block matching processing is done by using the technique hiding data shown by Fig.1. The range block corresponds to a current block in Fig.1. Moreover, the domain blocks correspond to the reference blocks. And a part of bits of the mean value are selected as the hidden data. Odd numbers and even numbers of the address of the searched domain blocks are according to "0" and "1" of the hidden bits of the mean value, respectively.

Thus, after the restricted address is decided, the most similar domain block to the given range block is selected from the domain blocks having the restricted address as the best matching domain block.

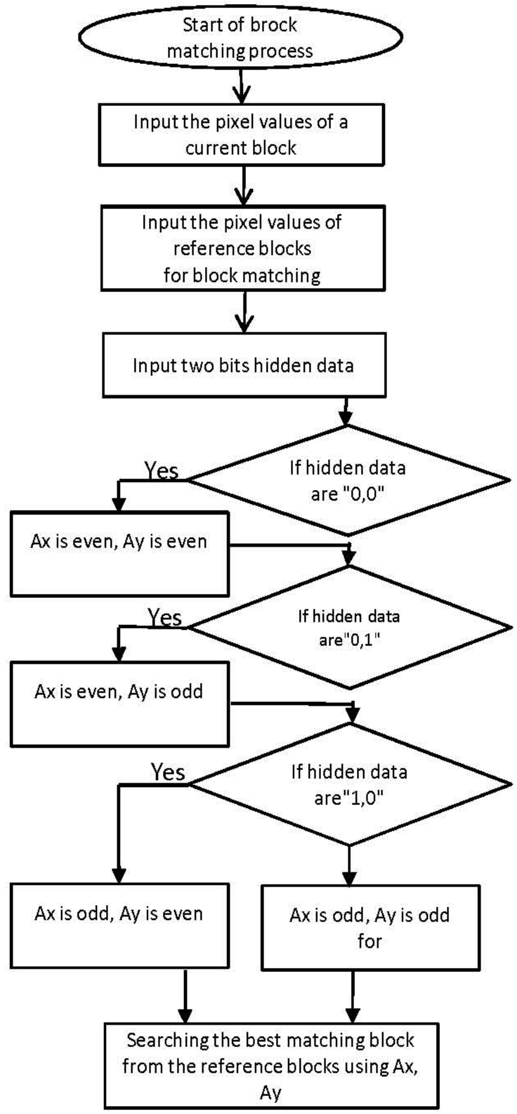

Fig 1. Proposed data hiding scheme restricting address of searching reference blocks (as two bits hidden). Ax is the coordinate of x-axis, Ay is the coordinate of y-axis of blocks searched in the reference blocks.

By the coding process, for all range blocks the non-flag identification flag and the mean value are transmitted to the decoding side.

For non-flat block, the standard deviation, the address of the best matching domain block and the affine transform information, which is used for making usable block pattern much more by right and left rotation etc., are transmitted, too.

By the decoding side, first an initial image of a low resolution is generated by using only the mean value of the range block received, and this is stored in the frame memory. The following decoding processing is repeated based on this initial image.

In the decoding processing, pixel values of all non-flat range blocks are reproduced by Equation (1) by using the transmitted various information and the initial image restored in the frame memory.

$$r_p(i,j) = \left\{\tau\hat{d}_q(i,j) - \hat{M}\left(\tau d_q\right)\right\}\frac{\sigma\left(r_p\right)}{\hat{\sigma}\left(\tau d_q\right)} + M\left(r_p\right) \quad (1)$$

where, $r_p(i,j)$: The value of pixel at coordinate(i,j) in the p_{th} range block normalized

$\tau d_q(i,j)$: The value of pixel in the q_{th} domain block made small and normalized

M : mean value

$\sigma(r_p)$: Standard deviation of the p_{th} range block

$\sigma(\tau d_q)$: Standard deviation of the q_{th} domain block in the domain pool including reference blocks

$\hat{*}$ denotes the values regenerated in the decoding side.

The decoding image obtained by this reproduction is to be the following initial image, and then the decoding processing of mentioning above is done until obtaining the image of an enough resolution or the change in the image settles.

The coding and decoding experiments are carried out. Test images are five, that is, "Lenna", "Girl", Airplane", "Mandrill" and "Earth", and 256×256 all of image size. Block size is 4×4 pixels in range block, 8×8 pixels in domain block. The threshold T_1 is 4.

Fig.2 shows the relation among number of hidden bits, PSNR, deterioration in PSNR and data compression ratio. Horizontal axis is number of hidden bits[bits], and vertical axis of left side is PSNR[dB] and it of right side is data compression ratio[%].

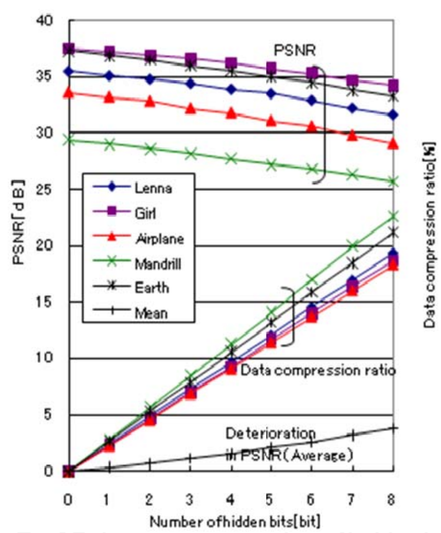

Fig.2 Relation among number of hidden bits, PSNR, deterioration in PSNR and data compression ratio.

Though the data compression ratio is different depending on a non-flat rate based on the image, the average of data compression ratio is shown by Equation (2), approximately.

$$Data\_comp \cong 2.5 \times h\_bit \quad (2)$$

where, Data_comp denotes data compression ratio, and h_bit , number of hidden bits.

It increases in proportion to an increase of the number of hidden bits though PSNR is different according to the image. The deterioration in PSNR on the average is shown by Equation (3), approximately.

$$Det\_inPSNR \cong 0.37 \times h\_bit \quad (3)$$

where, Det_inPSNR denotes deterioration in PSNR.

3.2 Image Coding Using Vector Quantization

In the image encoding process, pixel values are quantized to reduce volume of information. Some pixels values included in a block are quantized simultaneously in the vector quantization while one pixel value is quantized in the scalar quantization[6]. An original image is divided into blocks(the block size is m×m), which is an unit of coding process. This is a vector space that consists of all pixels value included in the block. The output vector to which the error margin is minimized is composed referring to all the input vectors for this vector space, and the code book that consists of the output vector group is made.

First of coding process, the input images are blocked by the off-line processing by the size of 4×4, the mean value is removed afterwards, and it normalizes it with a standard deviation. The code book of a predetermined size is made by using the LBG algorithm[7] after this processing.

Next, the input image is blocked by the size of 4×4 as well as the time of the off-line processing, and the mean value and the standard deviation are calculated. After the mean value is pulled, the input image is normalized by standard deviation in the on-line processing of encoding.

After this normalizing processing for each block, block matching processing is carried out using data hiding technique by Fig.1. The normalized input block is corresponds to a current block in Fig.1. Moreover, the vector codes in the vector code book correspond to the reference blocks. And a part of bits of the mean value are selected as the hidden data in Fig.1. An odd number or an even number of the address of the searched vector codes is according to “1” or “0” of the hidden bits of the mean value.

Thus, after the restricted address is decided, the most similar vector code to the normalized input block is selected from the vector code books having the restricted address as the best matching domain block. And the address is output as an index for the best matching vector.

The coding and decoding experiments are carried out. Test images are five, that is, “Airplane”, “Earth”, “Girl”, “Lenna” and “Mandrill”, and all of image size is 256×256. Block sizes are 4×4 pixels. The code book used in the experiment is made by using images “Airplane”, “Lenna” and “Mandrill”, and the size is 4096.

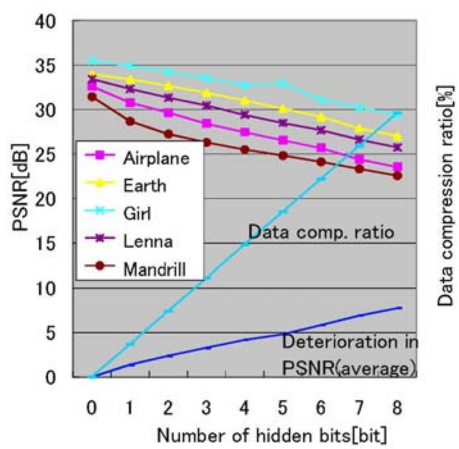

Fig.3 Relation among Number of hidden bits, PSNR, Deterioration in PSNR and data compression ratio.

Fig. 3 shows the relation among the number of hidden bits, PSNR, deterioration in PSNR and data compression ratio. Horizontal axis is number of hidden bits, and vertical axis of left side is PSNR and it of right side is data compression ratio.

The data compression ratio is shown by Equation (4).

$$Data\_comp \cong 3.6 \times h\_bit \qquad (4)$$

where, Data_comp denotes data compression ratio, and h_bit , number of hidden bits.

It decreases in proportion to an increase of the number of hidden bits though PSNR is different according to the image. The deterioration in PSNR on the average is shown by Equation (5), approximately.

$$Det\_inPSNR \cong 0.95 \times h\_bit \qquad (5)$$

where, Det_inPSNR denotes deterioration in PSNR.

3.3 Inter-frame Coding Using Motion Compensation

MPEG2[8] that is the motion compensated inter-frame predictive coding is studied as another example of doing the block match processing that uses the proposed data hiding technique.

Input image is blocked by small block of 16×16 which is an unit of coding process. These blocks are un-overlapped each other in the image. In the frame memory FM, reconstructed images past encoded and decoded have been accumulated. The blocks included in the FM are overlapped each other in the images from the FM. It centers on the position of the encoded current block, and the area of the length and breadth plus or minus 15 pixels in the frame memory is used as a range of the motion compensation. It searches for the block where the block match is the best to the encoded current block in one pixel from among the range of the motion compensation.

Next, it searches for the block where the block match is the best to the encoded current block in 1/2 pixels from among with oneself and the block of eight neighborhood centering on the block chosen at these intervals of one pixel. The motion vector obtained at intervals of 1/2 pixels is decided as the best motion vector.

After motion compensation, the input block image is pulled the inter-frame predictive block image obtained by motion compensation. The obtained predictive error block image is transformed by DCT in 8×8 sizes each, and quantized.

In the MPEG2, both the best motion vector and the predictive error are transmitted to the decoding side. If the difference in block pattern between the real best motion vector and the changed motion vector by using data hiding technique are large, the volume of quantized predictive error become much more instead decrease of hidden data by using data hiding technique. In addition, the influence has a bad influence for the encoding processing of the following image frame. Then, we used the data hiding technology in the processing of the motion vector search with a small difference of the movement vector at 1/2-pixel intervals.

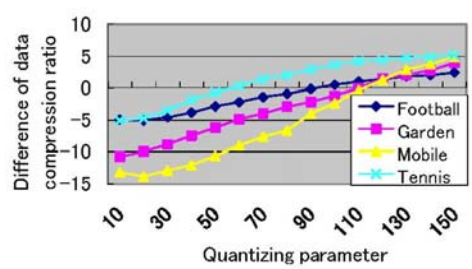

Fig. 4 Relation between quantizing parameter and difference of data compression ratio.

The coding and decoding experiments are carried out. Test images are four, that is, “Football”, 125 frames and 352 ×240pixels, “Garden”,115 frames and 352 ×240pixels, “Mobile”, 140 frames and 352 ×240pixels and “Tennis”, 112 frames and 352 ×240pixels.

Fig. 4 shows the relation between quantizing parameter and data compression ratio. Horizontal axis is the quantizing parameter, and vertical axis is the difference of data compression ratio between MPEG2 with data hiding technique and without one. When the value on vertical axis is positive, the feature of the proposed method is better than that of original MPEG2. When the value is minus, worth than that of original MPEG2. We did not obtain an good result though we limited the use of this technology to the processing with a small difference of the movement vector at 1/2 intervals.

4. Considerations

First of all, it thinks about the image quality degradation by the influence that introduces the proposed scheme using data hiding technique. The image quality of 25dB or more is still obtained though there is a sacrifice of about 3.5dB even when the data of eight bits is hidden like understanding the introduction into the fractal image coding from Fig. 4 and Equation (5). Deterioration is large for the fractal as it is understood to introduce this technology into the vector quantization from Fig. 7 and Equation (7), and even when the data of four bits is buried, 25dB or more is obtained.

Next, it thinks about the data compression ratio by the influence that introduces this technology. When the data of one bit is hidden like understanding the introduction into the fractal image coding from Fig. 4 and Equation (4), the data of 2.5% can be reduced. 3.6% can be reduced like understanding this technology is introduced into the vector quantization from Fig. 7 and Equation (6), and this is an increase of 1.1% for the fractal image coding. In this, it is a cause in the fractal image coding and the vector quantization that the volume of data transmitted is actually different. Because a lot of kinds of the block pattern are prepared to the point where the fractal image coding introduces the affine-transformation aiming at the improvement of the image quality, the volume of information originally transmitted is abundant. On the other hand, it doesn't have the same block pattern in the vector quantizing. As a result, the data reduction ratio is growing more than the fractal coding as for the vector quantizing.

MPEG2 that is encoding the motion compensated predictive inter frame coding did not achieve a good effect of the introduction of this technology because a similar block pattern was few because the number of blocks included within the range of the motion compensation was little, and the prediction error quantized due to deterioration in the motion compensation accuracy grew, and it gave the influence that deterioration in the predictive accuracy is bad for the following frame processing.”

5. Conclusion

The data concealment technology was introduced, and it proposed a new image encoding technology that concealed a part of the image encoding data in other parts of own image. It was examined to apply this technology to the fractal image encoding, the vector quantizing, and MPEG2 that was the block processing. Because quality degradation was a little, the encoding efficiency was able to be achieved though it was possible to put on the fractal image coding where a lot of similar block patterns were included in the search reference block as a result of the experiment. Because the volume of data transmitted that it was original in the vector quantizing m was a little, a higher data reduction rate was able to be achieved. Because the volume of data originally transmitted was a little, a higher data reduction rate was able to be achieved in the vector quantizing.

Future tasks are the achievement of a concrete real machine.

10. References

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