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ODBTC를 위한 EMD 기법에 기반한 데이터 은닉

(Data Hiding Based on EMD for Ordered Block Truncation Coding)

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요 약

BTC (Block Truncation Coding)은 이미지 압축 기법의 일종으로서 간단하고 효과적이다. 그러나, 이 방법은 블록 크기를 크게 사용할 때 블록 효과가 증가하므로 이미지의 질이 좋지 않다. ODBTC(Ordered Dithering Block Truncation Coding)는 BTC와 같은 압축 능력을 유지하면서 블록 효과를 해결한 방법이다. 본 논문에서는 이와 같은 압축된 이미지를 이용하여 데이터를 하프톤 이미지에 저장하는 방법을 제안하고자 한다. EMD 방법은 Zhang과Wang[6]이 그레이스케일 이미지에 데이터를 은닉하도록 하도록 고안된 방법이다. 그런 이유로, 비트맵 이미지에는 적합하지 않다. 본 논문에서는 EMD가 어떻게 비트맵 이미지에 적용될 수 있는지를 제안한다. 또한, 본 논문의 실험에서, 우리가 제안한 방법이 하프톤 이미지에 효과적임을 증명한다.

Abstract

Block truncation coding (BTC) is a simple and efficient image compression technique. However, it yields images of unacceptable quality and significant blocking effects are seen when the block size is increasing. Ordered dither block truncation coding (ODBTC) was proposed to solve above problem maintaining the same compression capability. In this paper, we propose a data hiding method which can be applied to halftone images. EMD was developed by Zhang and Wang [6] for data hiding in the grayscale image. Therefore, EMD is not proper for bitmap images. In this paper, we show that EMD can be used to apply bitmap halftone image. In our experiments, we prove that our method is efficient in a halftone image.

Keywords : Data Hiding, BTC, ODBTC, EMD

I. Introduction

The Internet has become a convenient channel for data transmission. However, Internet is open. Therefore, many people do not have ensured to protect transmitted data. For instance, E-mail is used to communicate with each other personally. For safety communication and copyright, data hiding had been researched a lot of researchers in various kinds of schemes. In fact, data hiding technique cannot take safety of the message data hiding conceals the existence of secret messages while cryptography protects the content of messages. That is, the purpose of data hiding only conceals the existence of it. Until now, it has been proposed so many kinds of secret communication methods that can conceal the messages[1~6].

In addition, many researchers have been investigated grayscale images on data hiding;

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however, data hiding on halftone was less research than that of a grayscale image. Halftone images were made by the procedure to transform continuous-tone images such as grayscale images into two-tone images, e.g., from 8bit-gray level images to 1-bit binary images. It is possible that halftone techniques are divided into three categories including ordered dithering(Ulichney, 1987)[7], error diffusion(Floyd and Steinberg, 1975)[8] and direct binary search (Lieberman and Allebach, 1996)[9].

Delp and Mitchell proposed Block truncation coding (BTC) in 1979[3]. BTC have many advantages such as simple, efficient and low computation complexity. However, BTC is less image quality than ODBTC(Order Dithering Block Truncation Coding), which was introduced by Guo in 2008[2]. In this paper, we will used EMD method for data hiding with halftone image. Recently, a few papers have been proposed to embed information into BTC compressed images. PAN[3] employed statistics feature of pixel block patterns to embed data, and utilizes the HVS characteristics to reduce the introduced visual distortion. For this reason, it is impossible to hide big size message. Shu-Fen TU[4] was shown that the binary image combined with the watermark to construct the ownership share with the aid of the XOR operation. This method was not really hide information in host images. Tseng[5] proposed a technique of data hiding that the background image can be eliminated and the hidden visual pattern can be revealed precisely. It is expected that a large quantity of data is difficult to be embedded into halftone images considering visual quality degradation, for less information redundancy can be employed.

In this paper, we will be used *EMD* method for data hiding in halftone. The problem of [2~5] is impossible to hide data enough capacity in cover image. In addition, those method did not provide good stego image for data hiding. In order to solve these problem, we proposed novel method to hide enough data into the cover image.

Ⅱ. Related Works

2.1 *EMD* method

The *EMD* was proposed by Zhang and Wang[6], a novel method for data hiding in an image with schemes of modification directions. The *EMD* method is that each secret digit in a $(2n+1)$-ary notational system is carried by n cover pixels, when $n \geq 2$ and, at most, only one pixel is increased or decreased by.

A group of pixels is composed of as $(g_1, g_2, \cdots g_n)$. If the secret message is a binary stream, it can be segmented into many pieces with L bits, and the decimal value of each secret piece is represented by K digits in a $(2n+1)$-ary notational system, where

$$L = \lfloor K \cdot \log_2(2n+1) \rfloor \quad (1)$$

In this method, n pixels are used to carry one secret digit in the $(2n+1)$-ary notational system and, at most, only one pixel is increased or decreased by 1. According to a secret key, all cover pixels are permuted pseudo-randomly and divided into a series of pixels-groups, each containing n pixels. A vector $(g_1, g_2, \cdots g_n)$ in n-dimensional space is labeled with its f value, which is solved by equation (2) as a weighted sum modulo $(2n+1)$:

$$f(g_1, g_2, \ldots, g_n) = \left[\sum_{i=1}^{n}(g_i \cdot i)\right] \mathrm{mod}(2n+1) \quad (2)$$

2.2 *BTC* (Block Truncation Coding)

Delp and Mitchell proposed block truncation coding that is lossy compression technique for gray-level image. For this work, the image is divided into blocks of $M \times N$ pixels and each block is processed respectively. Following, we calculated the mean value (μ) and the standard deviation (σ) for each block. And, the first two sample moments are preserved in the compression. Each original block can be encoded two-tone that is composed of '0' and '1'. When a pixel value smaller than mean of block, set to '0', otherwise, set to '1'.

For block decompression, we need an original image and bitmap of a compressed image. Each block of B is composed of '0' and '1'. After calculation, the bit '0' of B is set to a, and the bit '1' of B is set to b, where a, and b are computed according to equation (3) and (4), and q stands for the number of bit '1' and m stands for the number of bit in B.

$$a = \mu - \sigma \bullet \sqrt{\frac{q}{m-q}} \quad (3)$$

$$b = \mu + \sigma \bullet \sqrt{\frac{m-q}{q}} \quad (4)$$

BTC is very simple algorithm, anyone can implement this image easily, and however, it shows lower quality than $ODBTC$ dithering image.

2.3 Ordered dither BTC

Ordered dithering is an image dithering algorithm. It is commonly used by programs that need to provide continuous image of higher colors on a display of less color depth. The algorithm achieves dithering by applying a threshold map on the pixels displayed, causing some of the pixels to be rendered at a different color, depending on how far in between the color is of available color entries. There are a few researches about improvement quality of a halftone image. $ODBTC$ is the good method to increase images quality for halftone.

For construct $ODBTC$, divide grayscale image into $M \times N$ block, and maximum value is set to $x_{\max}$ and minimum value is set to $x_{\min}$. Eq.(5) is the $ODBTC$ method.

$$o_{i,j} = \begin{cases} x_{\max}, \text{if } x_{i,j} \geq LUT_{i \bmod M\ j \bmod N} + x_{\min} \\ x_{\min}, \text{if } x_{i,j} < LUT^{(k)}_{i \bmod M\ j \bmod N} + x_{\min} \end{cases} \quad (5)$$

The $o_{i,j}$ denotes the output pixel value, and $x_{i,j}$ is a pixel of block and $k = x_{\max} - x_{\min}$. A significant feature of the $ODBTC$ is the dither array LUT, where each specific dither array has its corresponding 255 different scaling versions. The 255

131	70	185	124	139	77	178	116
39	193	23	247	46	201	31	240
162	100	147	85	170	108	155	93
15	224	54	209	8	232	62	216
139	77	178	116	131	70	185	124
46	201	31	240	39	193	23	247
170	108	155	93	162	100	147	85
8	232	62	216	15	224	54	209

(a)

(b)

(c)

그림 1. (a) 하프톤 스크린, (b) 크기 512×512 원본 그레이스케일 레나 이미지, (c) 512×512의 ODBTC 이미지

Fig. 1. (a) Halftone screen, (b) Original grayscale Lena image of size 512×512, (c) ODBTC image of size 512×512.

scaling versions are obtained by

$$LUT^{(k)}_{m,n} = k \times \frac{LUT_{m,n} - LUT_{\min}}{LUT_{\max} - LUT_{\min}} \quad (6)$$

where $1 \leq k \leq 255$, $1 \leq m \leq M$, and $1 \leq n \leq N$, $LUT_{\min}$ and $LUT_{\max}$ denote the minimum and maximum values in dithered array. The dynamic range of $LUT^{(k)}_{\min}$ must be added by $x_{\min}$ to provide a fair threshold with the pixel values in a block. Since the dither arrays $LUT^{(k)}_{\min}$ can be calculated in advance, the complexity can be significantly reduced in practical application.

In Fig.1, (a) is a halftone screen, which is used to calculate LUT. (b) is original grayscale image and (c) is a halftone image of ODBTC.

Ⅲ. Proposed data hiding method for halftone

In this section, suppose the host image is of size

$P \times Q$ and *ODBTC* dithered image is constructed using Eq.(5) and (6). The algorithm for data hiding and extracting are described as follows.

3.1 Embedding algorithm

In this section, we describe data hiding algorithm for halftone image using *EMD* method. The figure as shown in Fig.2 and Fig.3 depicts the procedure of data hiding in a halftone image.

1) Divide the host image into blocks of size $M \times N$.
2) For data hiding, *ODBTC* image should be constructed by Eq.(5) and Eq.(6) from grayscale image. Fig.2 is shown a example that a block of *ODBTC* is constructed by equation. (a) is an original image block of baboon and (b) is a bit plane of the block and (c) is reconstructed by Eq.(5) and Eq.(6) with original block and bit plane block.
3) For applying *EMD* to bitmap block, it needs to be changed decimal values. In order to solve this problem, it should be a group by 8 pixels like Fig.3. In this way, we get g_1 and g_2. g_1 is 140 and g_2 is 68.

[140, 68] is a group pixel. We can calculate f value using EMD method of Eq.(2). f becomes a 8.

It needs to calculate $s = d - f \bmod (2n+1)$. When $d \neq f$, calculate s. If s is no more than n, increase the value of g_s by 1, otherwise, decrease the value of $g_{2n+1-abs(s)}$ by 1. We are assuming that d is 3 like Fig.3 and then $f = 1$ and $s = 2$. A group of pixel is becoming a [140, 69].

145	155	48	88
116	101	39	67
76	114	46	46
70	135	95	48

(a) Original image

1	0	0	0
1	1	0	0
0	1	0	0
0	1	0	0

(b) Bit plane

174	81	81	81
174	174	81	81
81	174	81	81
81	174	81	81

(a) reconstructed

그림 2. ODBTC의 예
Fig. 2. An example of ODBTC.

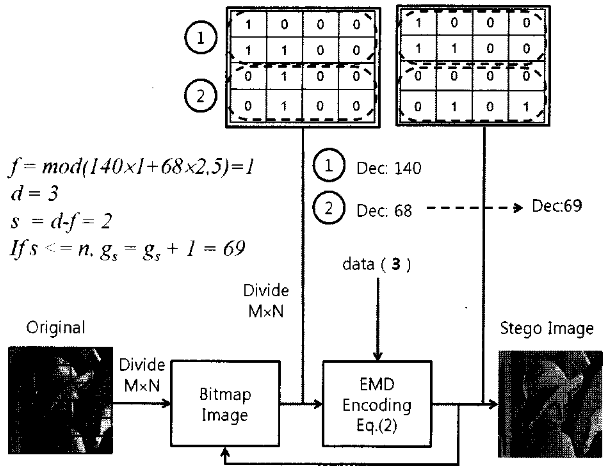


그림 3. 은닉 과정
Fig. 3. Embedding procedure.

If Gaussian filtering applied to halftone image, it is possible to get more good quality image than before. That is, receivers always hope that receiving image has a good quality.

3.2 Extraction algorithm

In this section, we describe data extraction method using *EMD* method with halftone image. The procedure is shown in Fig. 4. We will explain the following steps.

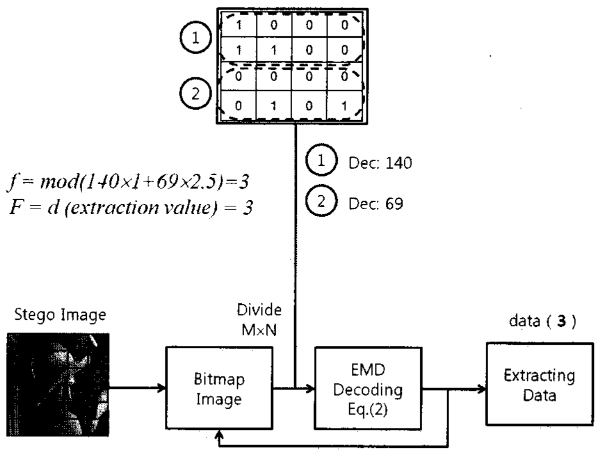


그림 4. 추출 과정
Fig. 4. Extraction procedure.

1) Divide the stego image into blocks of size $M \times N$.
2) Find the maximum and minimum value of each block, similar to Fig.4, and first value of two

groups is assigned to g_1 and second value of two groups is assigned to g_2. [140, 69] is a group pixel. We can calculate f value using EMD method of Eq.(2). In this case, f becomes a '3'. '3' means a message value.

Fig. 4 shows that the procedure of decoding with halftone image using EMD method. As can be seen from the Fig. 4, decoding procedure is very simple process.

Ⅳ. Experimental results

We used seven 512×512 original grayscale images and matlab software for our experimentation. To evaluate the introduced distortion, we apply an effective quality metric, weighted SNR (WSNR). Given two versions of an image of size $M \times N$ pixels, one clean (denoted x) and the other binary one (denoted y), the weighted signal-to-noise ratio (WSNR) of the binary image is computed as follows [3].

$$WSNR(dB) = 10\log_{10}\left(\frac{\Sigma_{u,v}|(X(u,v)\,C(u,v))|^2}{\Sigma_{u,v}|(X(u,v)-Y(u,v)\,C(u,v)|^2}\right) \tag{7}$$

where $X(u,v)$, $Y(u,v)$ and $C(u,v)$ represent the DFT of the input image, output image and CSF, respectively, and $0 \le u \le M-1$ and $0 \le v \le N-1$. In the same way SNR is defined as the ratio of average signal power to average noise power, WSNR is defined as the ratio of average weighted signal power to average weighted noise power, where the weighting is derived from the CSF. Since the halftone image attempts to preserve the useful information of the gray level image, we compare the stego image with the original gray level image. Similar to PSNR, a higher WSNR means higher quality. In our experiments, the WSNR between the gray level Lena and the halftone Lena is 36.9987dB, while the WSNR between the gray level Lena and the watermarked Lena is 33.034dB. It can be seen that the introduced distortion of the visual quality is slight.

Fig. 5 is shown the comparison WSNR between

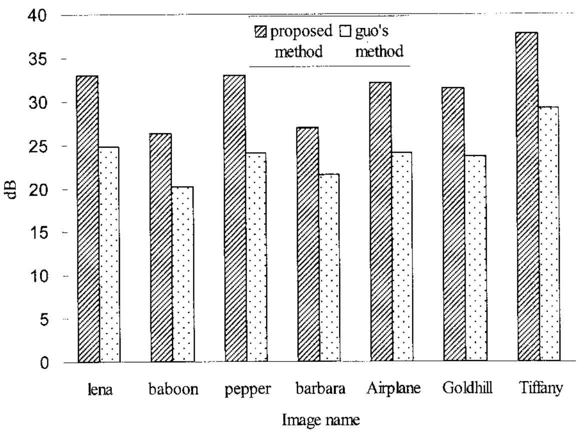
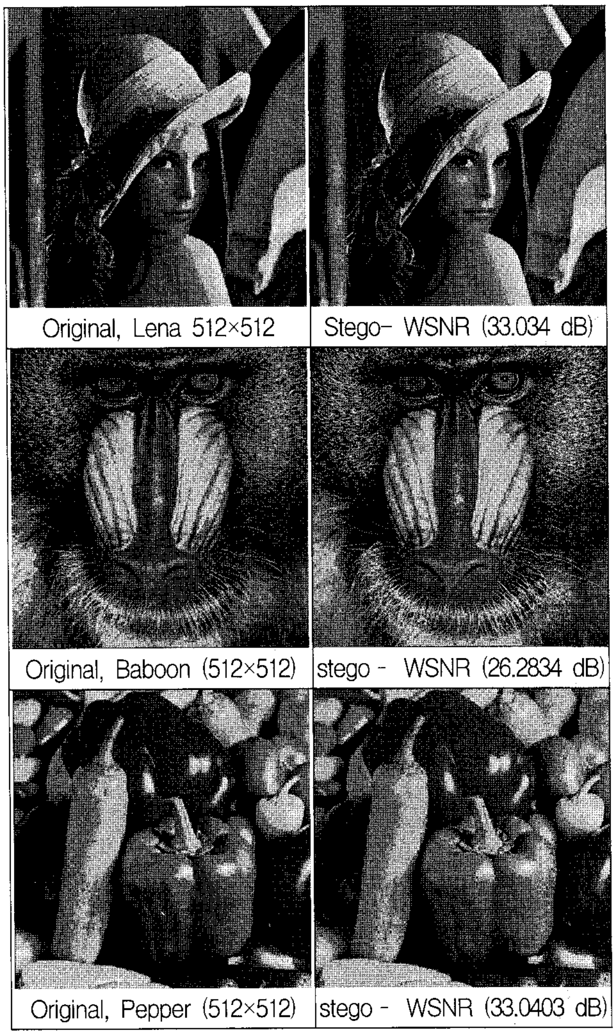


그림 5. 우리가 제안한 방법과 guo의 방법과 이미지 질 비교

Fig. 5. Comparison image quality between our method and guo's method.



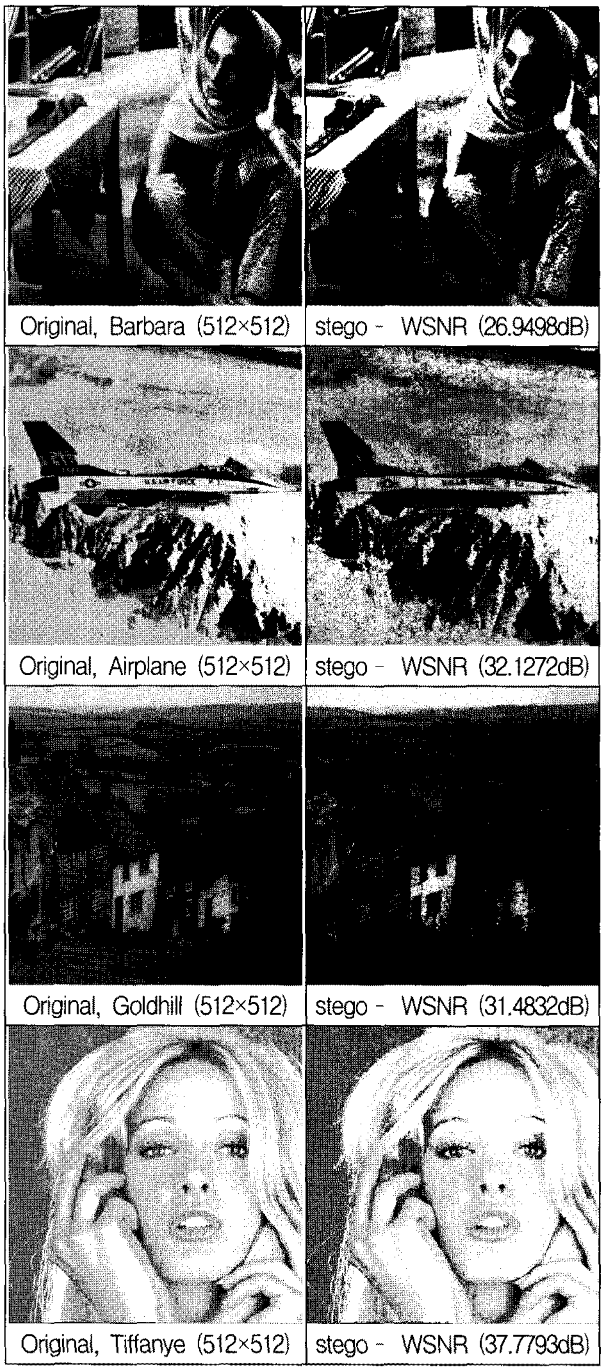


그림 6. 원본 이미지와 스테고 이미지의 비교
Fig. 6. Comparison between original image and stego image.

our proposed method and guo's method. As you can be seen this figure, WSNR of our method is better than that of guo's method. In this aspect, our proposed method improved WSNR of guo' method.

Fig. 6 shows original grayscale and stego image, which is constructed by our experimentation. As you can see that, it is difficult to discriminate the original image and stego image in Fig.6. Moreover, our method is possible to embed about 2bit in a 4×4 pixel block, while guo's method is possible to embed 1bit in a block.

V. Conclusion

BTC is well known halftone coding algorithm; however *ODBTC* gives a higher image quality than that of *BTC* algorithm. That is why, we choose *ODBTC* to construct cover image. In addition, we experimented data hiding with halftone image using *EMD* method. The *EMD* method was developed for data hiding in grayscale image. In fact, it is not easy to apply *EMD* method to halftone image. In order to solve this problem, we combined 8-bit to a unit for getting decimal value. In this way, it is possible to apply *EMD* to halftone image. *EMD* method was limited grayscale image, however our proposed method shows it is possible to hide data in a bitmap image using *EMD* method. As a result of our experiment, *EMD* is efficient to hide data in a halftone image.

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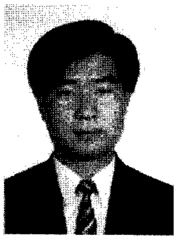
저 자 소 개



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