Entropy **2015**, *17*, 1218-1235; doi:10.3390/e17031218

OPEN ACCESS
entropy
ISSN 1099-4300
www.mdpi.com/journal/entropy

Article

Information Hiding Method Using Best DCT and Wavelet Coefficients and Its Watermark Competition

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Academic Editors: James Park and Wanlei Zhou

Received: 15 January 2015 / Accepted: 10 March 2015 / Published: 12 March 2015

Abstract: In recent years, information hiding and its evaluation criteria have been developed by the IHC (Information Hiding and its Criteria) Committee of Japan. This committee was established in 2011 with the aim of establishing standard evaluation criteria for robust watermarks. In this study, we developed an information hiding method that satisfies the IHC evaluation criteria. The proposed method uses the difference of the frequency coefficients derived from a discrete cosine transform or a discrete wavelet transform. The algorithm employs a statistical analysis to find the best positions in the frequency domains for watermark insertion. In particular, we use the BCH (Bose-Chaudhuri-Hocquenghem) (511,31,109) code to error correct the watermark bits and the BCH (63,16,11) code as the sync signal to withstand JPEG (Joint Photographic Experts Group) compression and cropping attacks. Our experimental results showed that there were no errors in 10 HDTV-size areas after the second decompression. It should be noted that after the second compression, the file size should be less than $\frac{1}{25}$ of the original size to satisfy the IHC evaluation criteria.

Keywords: BCH code; IHC evaluation criteria; information hiding; watermark competition

1. Introduction

Digital watermarking is a method that is used widely to protect the copyright of digital contents, and it is one of the underlying techniques required to realize the vision of ubiquitous computing [1–3].

Steganography based on various forms of information hiding is the focus when detecting the presence of a hidden message, whereas watermarking and fingerprinting are different problems. These issues have been studied in various fields [4–8].

Structural changes in protected contents occur often in real-world applications. Therefore, experimental benchmark evaluations of digital watermarking are needed to assess the techniques that are available at present. However, very few researchers have tested their algorithms extensively. Kutter and Petitcolas considered the methods used to evaluate and compare the performance of robust invisible watermarking systems [9]. They applied a duality approach to the watermarking evaluation problem where the evaluation criteria were divided into two groups: functionality and assurance [10].

In addition, several research groups have developed benchmarking tools, such as Stirmark, which can be used to select an attack from a comprehensive list [11]. Other benchmarking tools have been developed as part of the European Certimark program, which began in 1999 [12], the WET (Watermark Evaluation Testbed) project at Purdue University [13], the OpenWatermark framework [14], a theoretical framework for practical evaluations [15], a benchmarking tool based on genetic algorithms [16], a systematic method for determining the number of test images [17] and a stochastic approach [18] that also considers the evaluation method.

The First International Workshop on Information Hiding and Its Criteria for Evaluation (IWIHC2014) (http://www.ieice.org/iss/emm/ihc/en/iwihc2014/), which included a watermarking competition, was held in Japan in conjunction with a major security conference, called ASIACCS2014 (ACM Symposium on Information, Computer and Communications Security). This workshop aimed at ascertaining the current state-of-the-art in digital watermarking algorithms. Only a few methods have been reported that satisfy the watermark criteria for images [19–22]. In this workshop, we presented results in two competition categories: highest tolerance and highest image quality. In particular, we used the difference of the frequency coefficients derived from a discrete cosine transform and an error-correcting code (ECC) to satisfy the requirements of the Information Hiding and its Criteria [23], which both require coding tolerance and cropping tolerance.

In this study, we focused on the problem of obtaining the solution with the highest image quality according to the IHC evaluation criteria. Our proposed algorithm employs a statistical analysis to find the best positions in the frequency domains (a discrete cosine transform (DCT) or a discrete wavelet transform (DWT)) for watermark insertion. It should be noted that one of the most important goals is to satisfy the IHC evaluation criteria, but an additional objective is the introduction of our own IHC evaluation criteria.

The remainder of this paper is organized as follows. In Section 2, we present brief summaries of the IHC criteria. Section 3 describes the proposed algorithm, including watermark construction with an ECC, embedding, extraction and hiding capacity. The experimental results and conclusions are presented in Sections 4 and 5, respectively.

2. Summaries of the IHC Criteria

There have been many studies of digital watermarking, but the state-of-the-art has not yet reached the level required. The IHC Committee is working to improve this situation by promoting the development of digital watermarking techniques. In particular, it aims to help develop standard evaluation criteria and to sponsor watermark competitions based on these criteria [23].

In this section, we summarize the requirements of the IHC evaluation criteria.

2.1. Image Quality Assessment

The six images (color images that each contain more than 10 M pixels) provided by the IHC should be watermarked and then compressed. The file size should be less than $\frac{1}{15}$ of the original size after the first compression, and the file size should be less than $\frac{1}{25}$ of the original size after the second compression. The peak signal-to-noise ratio (PSNR) for each pair should be higher than 30 dB.

2.2. Tolerance Assessment

The files should be decompressed after the second compression. Ten HDTV-sized (1920×1080) images should be cropped from each decompressed image of 4608×3456 pixels. The vertices of these cropped images are listed in the document describing the IHC criteria. The watermark should be sufficiently tolerant, such that it can be detected in no less than 200 bits in each cropped image.

2.3. Watermark Information

The amount of watermark information that needs to be embedded comprises 200 bits. The information should be generated using eight ordered maximal length sequences. The initial values are listed in the document describing the IHC criteria.

3. Proposed Method

3.1. Overall Approach of Our System

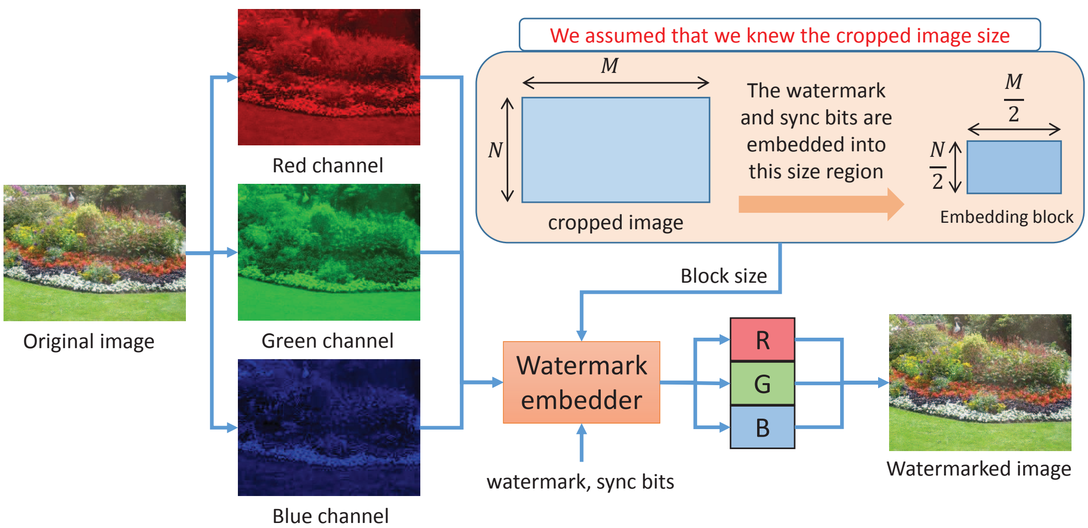


Figure 1. Diagram of our overall watermarking system.

Color images, such as RGB images, are comprised of three independent channels for the red, green and blue primary color components. Figure 1 shows the splitting of the color channels for a full RGB color image. In our system, the embedding process is applied to each channel repeatedly.

In this study, the cropping positions are based on the IHC evaluation criteria. Therefore, it is assumed that the cropped image size is known. According to the IHC evaluation criteria, 10 HDTV-sized (1920×1080) images should be cropped from each decompressed IHC standard image (4608×3456).

If a cropped image is selected as an area of $M \times N$ pixels in the watermarked image, we can select a size of $\frac{M}{2} \times \frac{N}{2}$ as an embedding block. At this point, the watermark and sync bits are embedded in each embedding block. For the entire original image ($H \times V$, where H is the horizontal size and V is the vertical size) with each color channel, the number of embedding blocks is computed as $\frac{2\times H}{M} \times \frac{2\times V}{N} = \frac{2\times 4{,}608}{1{,}920} \times \frac{2\times 3{,}456}{1{,}080} = 24$ (rounding toward zero).

In this study, we prepared 10 types of watermark for embedding, which could be represented in binary form and generated using eight ordered maximal length sequences with 10 types of initial values based on the IHC evaluation criteria. The binary watermark (200 bits) was first coded using the well-known BCH codes to produce the actual embedded bits, as shown in Figure 2.

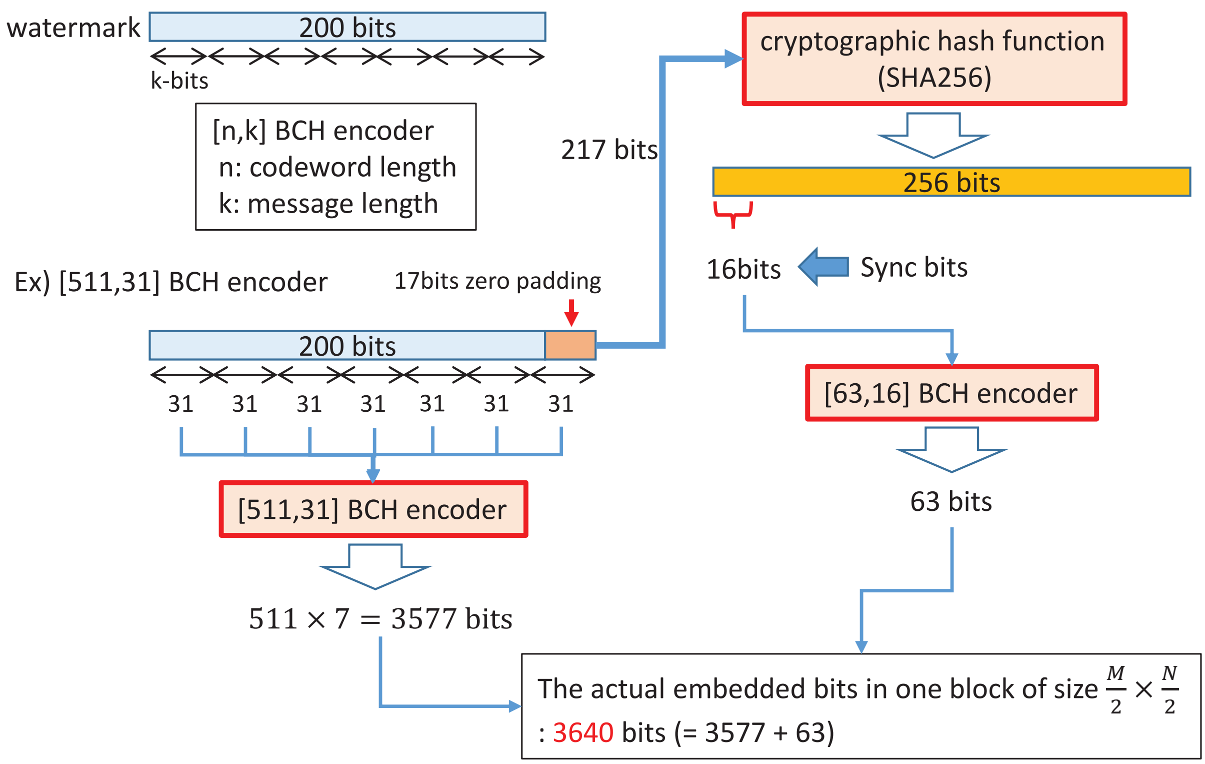


Figure 2. The actual embedded bits are comprised of sync bits and the watermark codeword.

3.2. Encoding the Watermark

The BCH code is named after Bose, Ray-Chaudhuri and Hocquenghem, who described methods in 1959 and 1960 for designing codes over GF(2)with a specified design distance. Subsequently, the decoding algorithms were developed by Peterson *et al.* [24].

As shown in Figure 2, the BCH encoder generates a BCH code with message length k and codeword length n. For a given codeword length n, only specific message lengths k are valid for a BCH code. The error-correction capability (t) of the valid $[n, k]$ pair used in this study can be described as follows: $[n, k, t]$. Tables 1 and 2 show all of the possible combinations for a BCH code of codeword lengths $n = 63$ and $n = 511$. In this study, we used $[511, 31, 109]$ for the watermark bits and $[63, 16, 11]$ for the sync bits based on a heuristic method. All of the test results obtained in the present study were generated using MATLAB. The BCH code implementation is readily available in the Communications System Toolbox in MATLAB.

Table 1. Number of correctable errors in the BCH code for n = 63.

n	k	t	n	k	t	n	k	t	n	k	t
63	57	1	63	39	4	63	24	7	63	10	13
63	51	2	63	36	5	63	18	10	63	7	15
63	45	3	63	30	6	***63***	***16***	***11***			

Table 2. Number of correctable errors in the BCH code for n = 511.

n	k	t	n	k	t	n	k	t	n	k	t
511	502	1	511	367	17	511	238	37	511	103	61
511	493	2	511	358	18	511	229	38	511	94	62
511	484	3	511	349	19	511	220	39	511	85	63
511	475	4	511	340	20	511	211	41	511	76	85
511	466	5	511	331	21	511	202	42	511	67	87
511	457	6	511	322	22	511	193	43	511	58	91
511	448	7	511	313	23	511	184	45	511	49	93
511	439	8	511	304	25	511	175	46	511	40	95
511	430	9	511	295	26	511	166	47	***511***	***31***	***109***
511	421	10	511	286	27	511	157	51	511	28	111
511	412	11	511	277	28	511	148	53	511	19	119
511	403	12	511	268	29	511	139	54	511	10	127
511	394	13	511	259	30	511	130	55			
511	385	14	511	250	31	511	121	58			
511	376	15	511	241	36	511	112	59			

3.3. Approach to One-Bit Embedding

In the first approach, a DCT was applied to an 8×8 pixel block-unit in one embedding block (960×540) to produce an $\frac{M}{2} \times \frac{N}{2}$ sized area. As a second approach for testing the best positions in the frequency domains, we selected 12 areas of the wavelet coefficients based on a statistical analysis.

As shown in Figure 3, this method can embed 4020 bits into one embedding block, because two pairwise DCT or DWT blocks are needed for one-bit embedding. The shaded elements in Figure 3 indicate the best positions for comparing the pairwise DCT or DWT coefficients in this study. Figure 4 presents an example of the application of statistical data in this study, which shows the statistical data for the IHC standard image (flower garden). To consider the quality and tolerance of image compression, we selected some frequency areas with relatively low entropy.

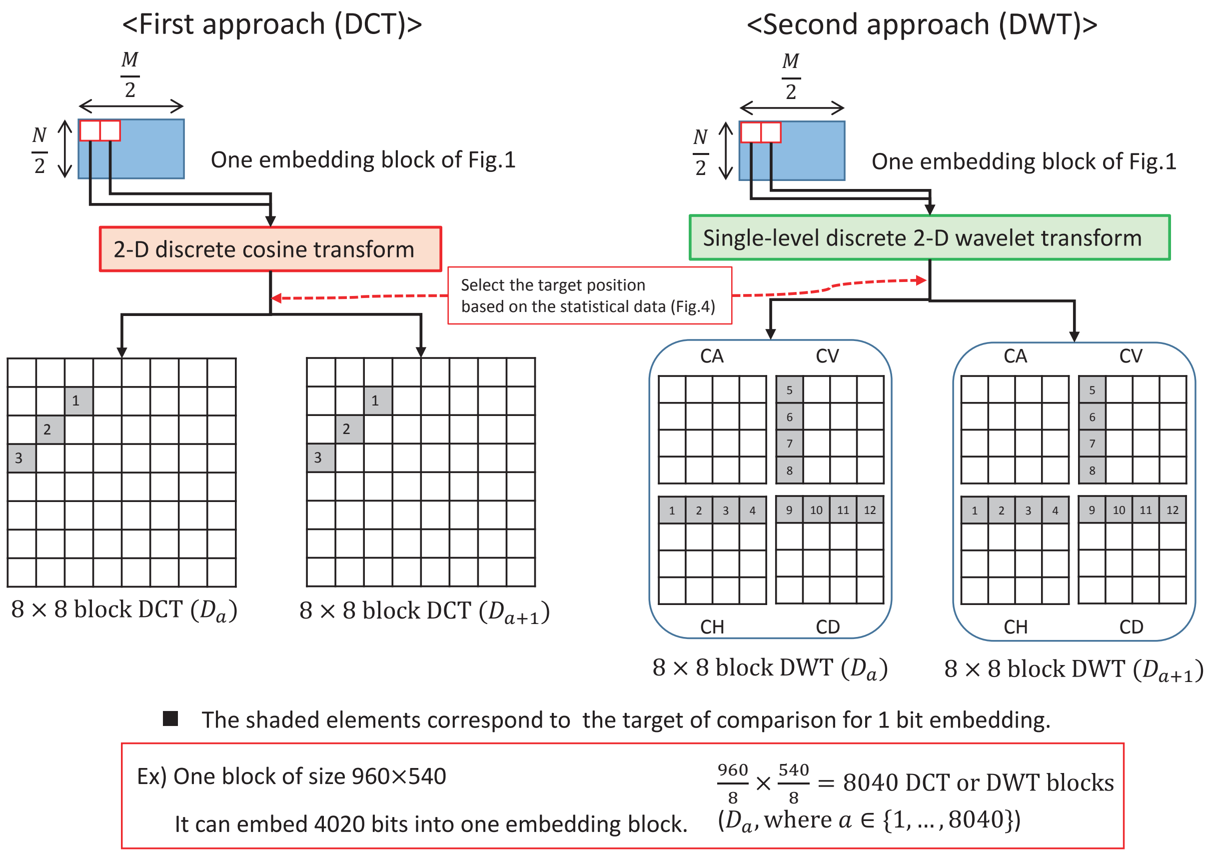
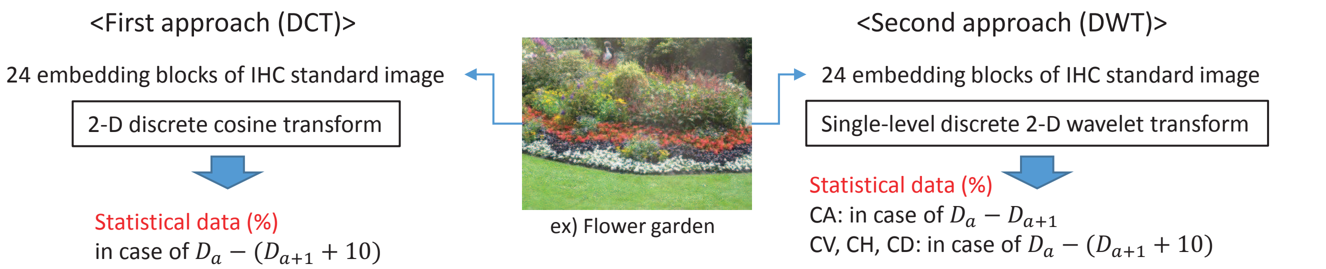


Figure 3. Embedding approach based on the difference of pairwise DCT/DWT coefficients.



Red channel

46	44	33	22	16	8	2	0
41	38	30	19	13	4	1	0
35	32	24	15	10	3	0	0
27	25	17	11	4	2	0	0
21	19	12	7	1	0	0	0
13	11	4	1	1	0	0	0
6	3	2	0	0	0	0	0
0	0	0	0	0	0	0	0

Green channel

45	44	34	22	16	9	2	0
41	38	30	19	13	4	1	0
35	32	24	15	10	3	0	0
27	25	17	11	4	2	0	0
21	19	12	7	1	0	0	0
13	12	5	1	1	0	0	0
6	3	2	0	0	0	0	0
0	0	0	0	0	0	0	0

Blue channel

46	45	33	22	16	9	2	0
40	38	30	19	13	5	1	0
34	32	24	15	9	3	0	0
27	25	17	11	4	2	0	0
21	19	12	7	1	0	0	0
13	12	5	1	1	0	0	0
6	3	2	0	0	0	0	0
1	0	0	0	0	0	0	0

CA				CV			
51.040	51.209	50.914	50.722	22.413	5.900	5.705	5.775
51.067	51.105	51.021	50.685	22.488	5.903	5.829	5.727
51.053	50.960	50.744	50.822	22.343	5.856	5.733	5.677
51.012	50.964	50.907	50.855	21.193	4.965	5.031	5.017
23.103	23.411	23.324	22.317	7.385	0.458	0.439	0.397
9.743	9.850	9.600	8.578	1.044	0.034	0.024	0.024
9.737	9.851	9.871	8.831	1.145	0.047	0.042	0.057
9.723	9.635	9.581	8.542	1.042	0.027	0.030	0.032
CH				CD			

Figure 4. Statistical analysis based on the difference of pairwise DCT/DWT coefficients.

3.4. Embedding and Extraction

3.4.1. Embedding Process

As shown in Figure 3, let D_a be an 8×8 DCT or DWT block, where $a \in \{1, ..., 8, 040\}$ and $D_a(i)$, $D_{a+1}(i)$ is the comparison target for one-bit embedding, where $i = 1, ..., 4$ or $i = 1, ..., 12$. The insertion method is as follows (see Figure 5).

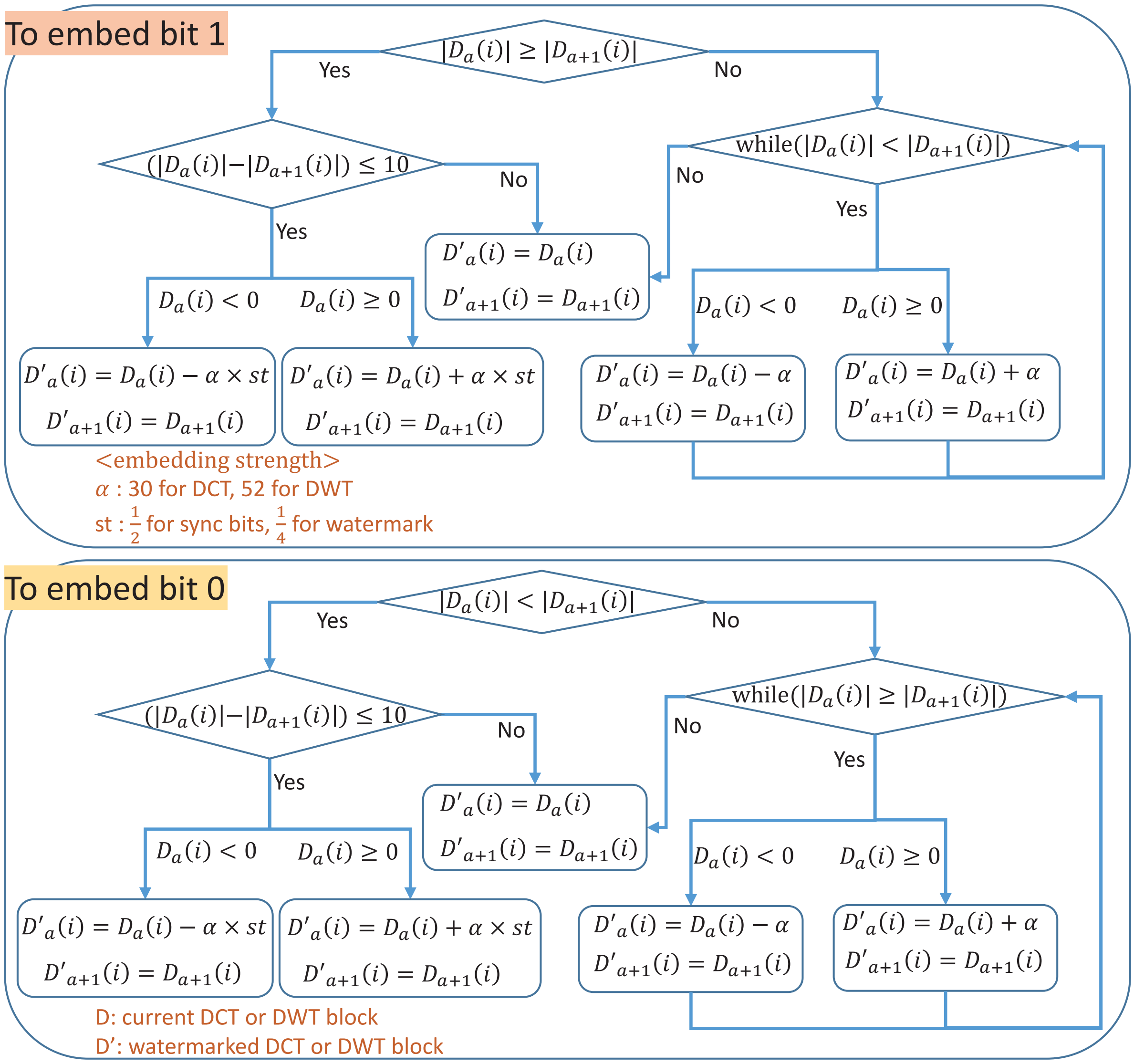


Figure 5. Block diagram showing the embedding process.

(1) The original image is separated into color channels and subdivided into 8×8 pixel blocks. Before insertion, each 8×8 pixel block is processed using the DCT or DWT.

(2) Let $b_w \in \{0, 1\}$ be the embedded value. Modify the DCT or DWT coefficient values in block D_a according to the following rules.

To embed $b_w = 1$:

$$
\begin{aligned}
&\text{if } |D_a(i)| \geq |D_{a+1}(i)| \\
&\quad \text{if } (|D_a(i)| - |D_{a+1}(i)) \leq 10| \\
&\qquad D'_a(i) = D_a(i) - \alpha \times st \quad (\text{if} \quad D_a(i) < 0) \\
&\qquad D'_a(i) = D_a(i) + \alpha \times st \quad (\text{if} \quad D_a(i) \geq 0) \\
&\text{else} \\
&\quad \text{while } (|D_a(i)| < |D_{a+1}(i)|)\{ \\
&\qquad D'_a(i) = D_a(i) - \alpha \quad (\text{if} \quad D_a(i) < 0) \\
&\qquad D'_a(i) = D_a(i) + \alpha \quad (\text{if} \quad D_a(i) \geq 0)\}
\end{aligned}
$$

To embed b_w = 0:

$$
\begin{aligned}
&\text{if } |D_a(i)| < |D_{a+1}(i)| \\
&\quad \text{if } (|D_a(i)| - |D_{a+1}(i)) \leq 10| \\
&\qquad D'_a(i) = D_a(i) - \alpha \times st \quad (\text{if} \quad D_a(i) < 0) \\
&\qquad D'_a(i) = D_a(i) + \alpha \times st \quad (\text{if} \quad D_a(i) \geq 0) \\
&\text{else} \\
&\quad \text{while } (|D_a(i)| \geq |D_{a+1}(i)|)\{ \\
&\qquad D'_a(i) = D_a(i) - \alpha \quad (\text{if} \quad D_a(i) < 0) \\
&\qquad D'_a(i) = D_a(i) + \alpha \quad (\text{if} \quad D_a(i) \geq 0)\},
\end{aligned}
$$

where D is the current DCT or DWT block, D' is the watermarked DCT or DWT block, α is the embedding strength and st is $\frac{1}{2}$ for the sync bits and $\frac{1}{4}$ for the watermark.

3.4.2. Extraction Process

The one-bit extraction method is as follows (see Figure 6).

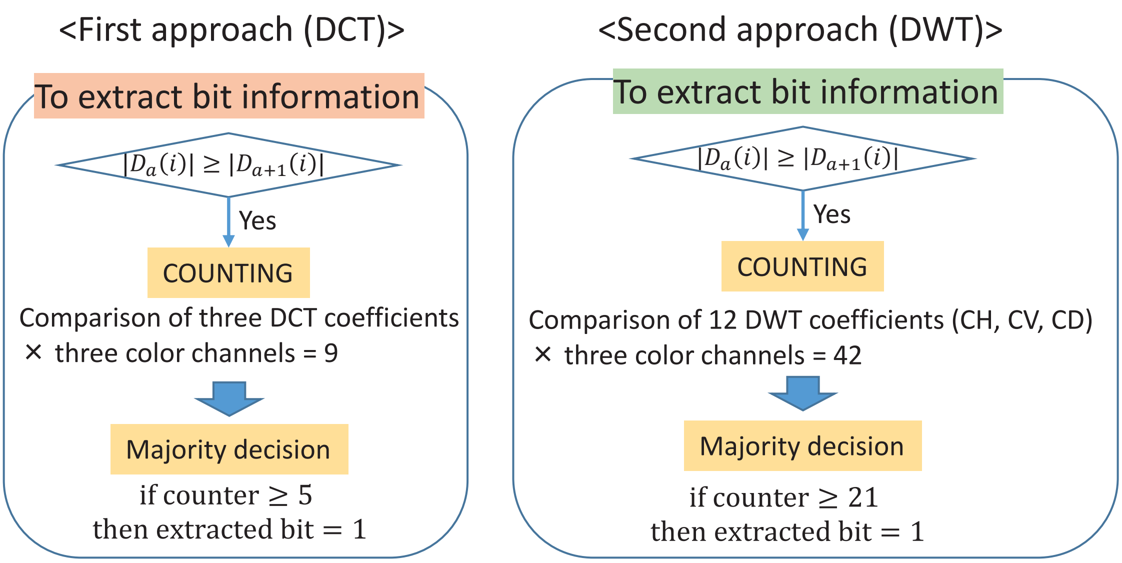


Figure 6. Block diagram showing the extraction process.

(1) Select two pairwise DCT or DWT coefficients in the watermarked block (D_a and D_{a+1}). Count the state according to:

$$Cnt \leftarrow Cnt + 1 \;\; (if\ |D_a(i)| \geq |D_{a+1}(i)|),$$

where Cnt is a count state variable with an initial value of zero.

(2) The total comparison number is $3 \times 3 = 9$ (comparison of three DCT coefficients $\times$ three color channels). In the case of DWT, $12 \times 3 = 42$ are compared from the selected detail wavelet coefficients (comparison of 12 DWT coefficients $\times$ three color channels).

(3) The total counter is assigned a majority decision rule to extract one bit.

3.5. Decoding the Extracted Bits

As mentioned in Section 3.2, the watermark is encoded using a BCH encoder, and the decoding process is shown in Figure 7.

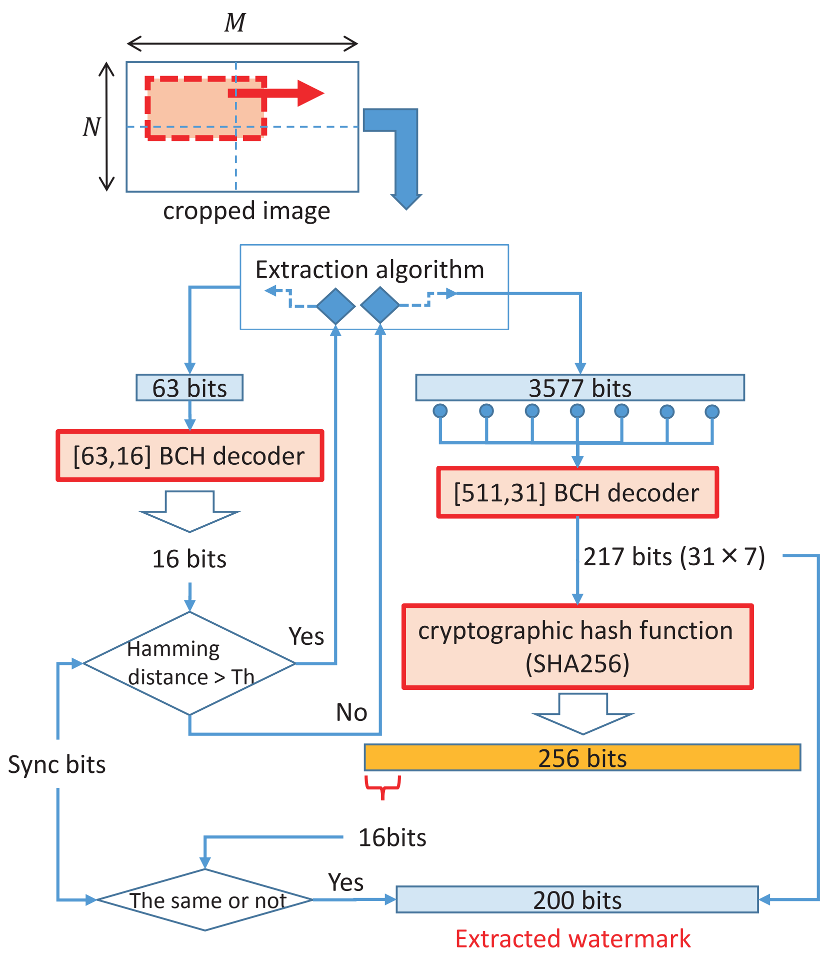


Figure 7. Overall watermark extractor.

The BCH decoder can correct up to a certain number of errors. Thus, the [511,31,109] BCH code can correct errors of up to 109 bits, which is referred to as a 109-ECC. We also used the [63,16,11] BCH code to correct the sync errors at the front of the selected embedding block.

The overall watermark extractor is as follows.

(1) Extract 63 bits from a selected embedding block and obtain 16 bits using the BCH decoder.

(2) Compare the Hamming distance (HD) between the extracted bits and the original sync bits using a threshold (Th). This threshold can be set based on a consideration of the system's performance (where zero is the default value).

(3) Extract 3577 bits from the remaining area of a selected embedding block, and obtain 217 bits using the BCH decoder (in the case where the HD is less than the threshold).

(4) Finally, we can obtain the extracted watermark (200 bits after excluding 17 bits) after applying an authentication process using a cryptographic hash function (e.g., SHA256).

3.6. Data Hiding Capacity

According to the IHC criteria, the watermark should be sufficiently tolerant, such that it can be detected in no less than 200 bits in each cropped image. In this study, the number of embedding blocks was 24, and one block measured 960×540. The actual number of embedded bits in one block was 3640 bits because of the error correcting code. Thus, the overall hiding capacity for each IHC standard image (4608 $\times$ 3456) was 87,360 bits (3640 $\times$ 24). However, it should be noted that the amount of watermark information that needs to be embedded was 200 bits.

As mentioned in the Introduction, the highest image quality test included tolerance, *i.e.*, JPEG compression and cropping tests. We need a robust watermarking scheme that has a good tradeoff of robustness and imperceptibility. Thus, we described how the BCH code can be used to satisfy the IHC criteria based on a specific example. For the IHC standard image, we selected ECC parameters with good balance (quality and tolerance).

4. Experimental Results

In total, six IHC standard images that each comprised 4608 $\times$ 3456 pixels were used in the experiment. We used the [511,31] BCH code for the watermark and the [63,16] BCH code for the sync data, which obtained suitable error correction performance levels with 109 bits and 11 bits, respectively.

The 2D lifting-based discrete wavelet transform leads to a speed-up when compared to the standard implementation. Therefore, in this paper, we choose db2 (Daubechies wavelet of order 2) to use the Daubechies 4-tap filter.

According to the IHC evaluation criteria, there are two competition categories: highest tolerance and highest image quality. However, we focus on obtaining a solution to the highest image quality problem.

The image quality was evaluated in terms of the PSNR and the mean structural similarity (MSSIM) [25]. The PSNR is a parameter that is used widely for evaluating image quality. The MSSIM is based on the characteristics of the human visual system, and it measures the structural similarity between two images. The MSSIM is equal to one if two images are identical. In the present study, the MSSIM measure used the following parameter settings: K_1 = 0.01, K_2 = 0.03. Table 3 shows the results for the highest image quality obtained by the DCT and DWT approaches, including the average compression ratio, PSNR value and MSSIM value. As shown in Table 3, the DCT approach using the best position performed best, although all of the approaches satisfied the criteria.

Table 3. Average compression ratio, peak signal-to-noise ratio (PSNR) and mean structural similarity (MSSIM) value for the highest image quality. The term "DCT(old)" refers to our previous method [22]. The terms "DCT(new)" and "DWT" refer to the methods using the best positions in the frequency domains.

		Compression ratio		PSNR		MSSIM	
		1st coding	2nd coding	1st coding	2nd coding	1st coding	2nd coding
Image1	DCT(old)	0.0663	0.0379	34.0452	34.0505	0.9998	0.9996
	DCT(new)	0.0667	0.0382	37.4422	36.7424	0.9999	0.9998
	DWT	0.0652	0.0340	29.3411	32.3522	0.9994	0.9988
Image2	DCT(old)	0.0665	0.0399	34.0364	33.9966	0.9998	0.9995
	DCT(new)	0.0644	0.0389	37.6280	37.1333	0.9999	0.9998
	DWT	0.0665	0.0398	29.1324	31.1637	0.9989	0.9985
Image3	DCT(old)	0.0658	0.0398	34.1061	34.3482	0.9998	0.9995
	DCT(new)	0.0642	0.0385	37.8325	37.2284	0.9999	0.9997
	DWT	0.0665	0.0344	29.1950	32.1529	0.9991	0.9983
Image4	DCT(old)	0.0665	0.0386	34.5838	34.8446	0.9996	0.9992
	DCT(new)	0.0662	0.0335	38.9399	38.1649	0.9998	0.9994
	DWT	0.0663	0.0363	28.8398	31.7642	0.9981	0.9961
Image5	DCT(old)	0.0660	0.0397	34.4361	34.6095	0.9999	0.9997
	DCT(new)	0.0662	0.0376	38.3797	37.8953	0.9999	0.9998
	DWT	0.0653	0.0397	29.0399	30.6679	0.9992	0.9985
Image6	DCT(old)	0.0657	0.0367	33.5861	33.6193	0.9998	0.9996
	DCT(new)	0.0662	0.0388	36.0543	35.3568	0.9999	0.9998
	DWT	0.0664	0.0347	29.4339	31.9051	0.9990	0.9985
Average	DCT(old)	0.0661	0.0388	34.1323	34.2448	0.9998	0.9995
	DCT(new)	0.0656	0.0376	37.7128	**37.0869**	0.9999	0.9997
	DWT	0.0660	0.0365	29.1637	31.6677	0.9989	0.9981

Table 4 shows the average error rates for 10 HDTV-size areas after the second decompression. The watermarks should be sufficiently tolerant, such that they can be detected in no less than 200 bits in each cropped image. Table 5 shows the cropping positions used in this experiment.

According to the IHC evaluation criteria, the compression ratio should be less than $\frac{1}{15}$ (=0.0667) after the first coding and $\frac{1}{25}$ (=0.04) after the second coding. The PSNR should be higher than 30 dB for the luminance signal.

The results shown in Table 4 demonstrate that these criteria were satisfied. The highest average PSNR was 37.0869 for the highest image quality after the second compression. In particular, the MSSIM indicated that we obtained a high level of structural similarity.

Table 4. Average error rates for 10 HDTV-sized areas after the second decompression (%) of the highest image quality.

	Position									
	1	2	3	4	5	6	7	8	9	10
Image1	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Image2	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Image3	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Image4	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Image5	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Image6	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Table 5. Cropping positions used in the IHC evaluation criteria.

Position	(x_1,y_1)	(x_2,y_2)	(x_3,y_3)	(x_4,y_4)
1	(16,16)	(1935,16)	(1935,1095)	(16,1095)
2	(1500,16)	(3419,16)	(3419,1095)	(1500,1095)
3	(2617,16)	(4536,16)	(4536,1095)	(2617,1095)
4	(16,770)	(1935,770)	(1935,1849)	(16,1849)
5	(1500,770)	(3419,770)	(3419,1849)	(1500,1849)
6	(2617,770)	(4536,770)	(4536,1849)	(2617,1849)
7	(1344,768)	(3263,768)	(3263,1847)	(1344,1847)
8	(161,520)	(1935,1520)	(1935,2599)	(16,2599)
9	(1500,1520)	(3419,1520)	(3419,2599)	(1500,2599)
10	(2617,1520)	(4536,1520)	(4536,2599)	(2617,2599)

In addition, Figures 8–13 show the watermarked image obtained from the highest image quality category using the first watermark's initial value of "10101010".

Original image after the first compression

Watermarked image after the first compression
(Compression ratio: 0.0667, PSNR: 37.4422, MSSIM: 0.9999)

Original image after the second compression

Watermarked image after the second compression
(Compression ratio: 0.0382, PSNR: 36.7424, MSSIM: 0.9998)

Figure 8. Original and watermarked images of a flower garden.

Original image after the first compression

Watermarked image after the first compression
(Compression ratio: 0.0644, PSNR: 37.6280, MSSIM: 0.9999)

Original image after the second compression

Watermarked image after the second compression
(Compression ratio: 0.0389, PSNR: 37.1333, MSSIM: 0.9998)

Figure 9. Original and watermarked images of a street view.

Figure 10. Original and watermarked images of a library.

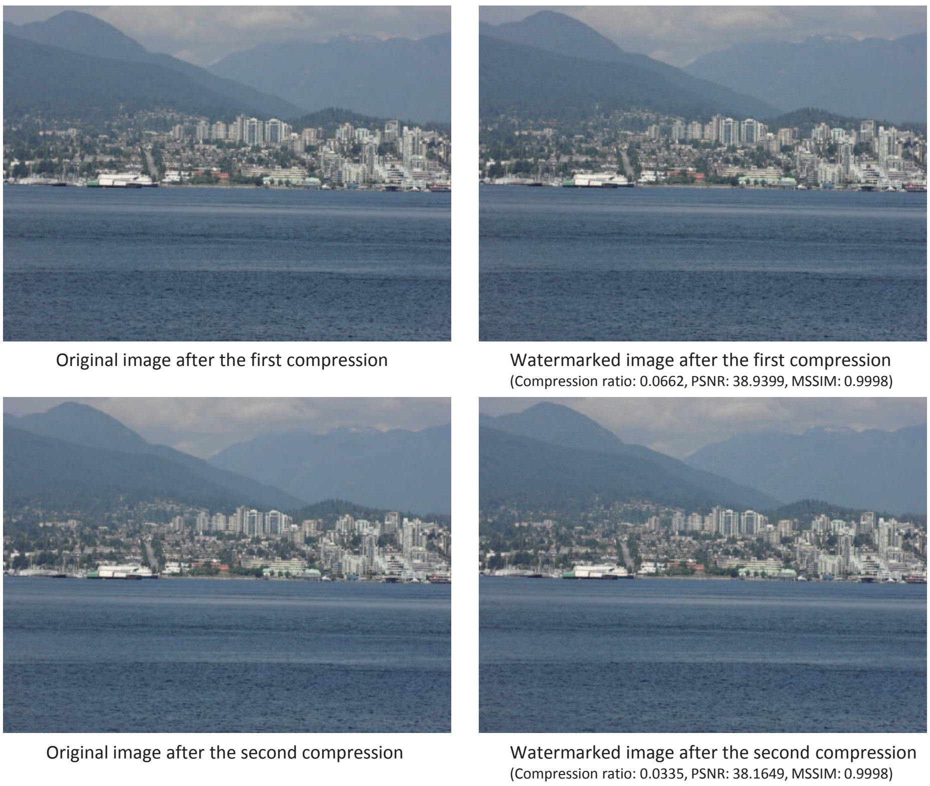
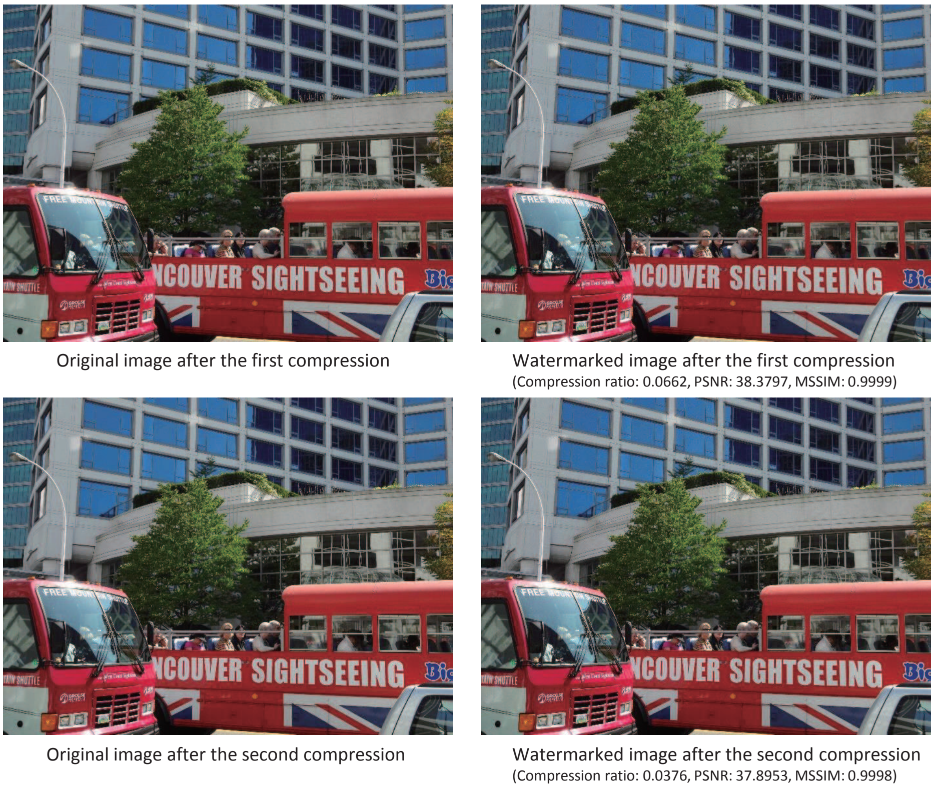


Figure 11. Original and watermarked images of a port view.



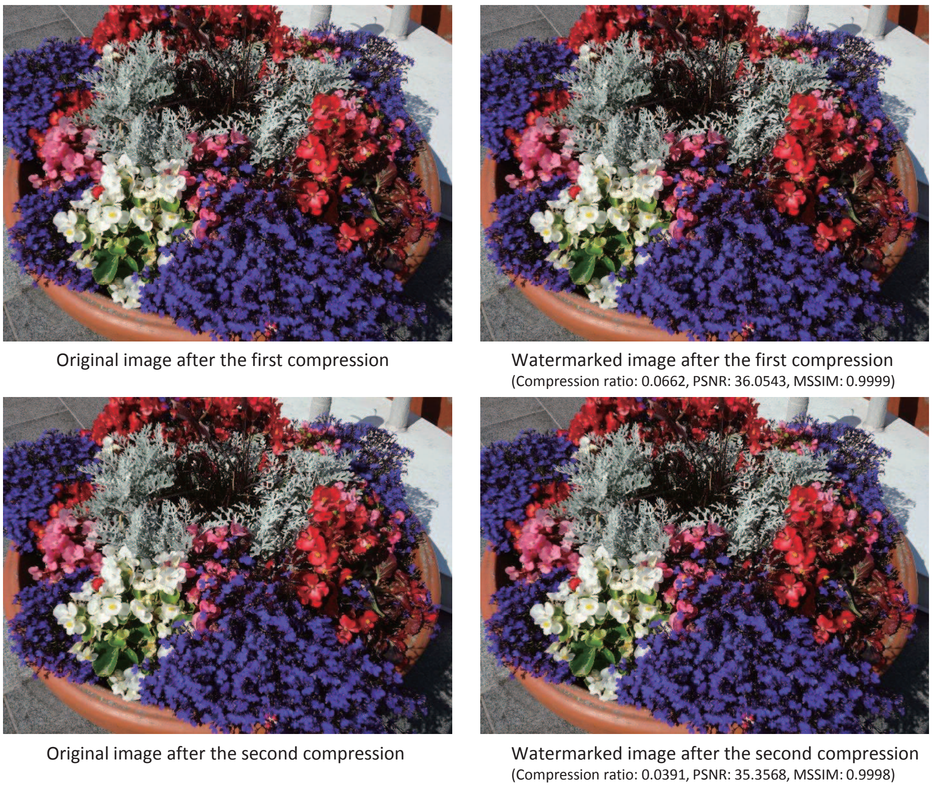
Original image after the first compression

Watermarked image after the first compression
(Compression ratio: 0.0662, PSNR: 38.3797, MSSIM: 0.9999)

Original image after the second compression

Watermarked image after the second compression
(Compression ratio: 0.0376, PSNR: 37.8953, MSSIM: 0.9998)

Figure 12. Original and watermarked images of a bus.



Original image after the first compression

Watermarked image after the first compression
(Compression ratio: 0.0662, PSNR: 36.0543, MSSIM: 0.9999)

Original image after the second compression

Watermarked image after the second compression
(Compression ratio: 0.0391, PSNR: 35.3568, MSSIM: 0.9998)

Figure 13. Original and watermarked images of a flower pot.

5. Conclusions

In this study, we developed a novel and simple digital image watermarking method that satisfies the requirements of the IHC evaluation criteria. This method is based on the difference of the frequency coefficients derived from a DCT or a DWT and on an ECC. This simple approach is suitable for robust watermarking optimization when the evaluation items are predetermined.

It should be noted that the second international watermarking competition based on the IHC evaluation criteria, IWDW2015 (International Workshop on Digital Watermarking 2015) (http://iwdw2015.tokyo/), will be held in Tokyo, Japan.

Author Contributions

Hyunho Kang was responsible for the planning, design, experiments and writing of the manuscript. Keiichi Iwamura reviewed the manuscript. Both authors have read and approved the final manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

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