

Adaptive Watermarking in Spatial Domain for Still Image

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ABSTRACT

In this paper, watermarking for still image is proposed. Image watermarking is performed in spatial domain that not only easy but also good result. A watermark image as binary image is embedded onto a original image by using method that gray levels of pixels in original image blocks is modified to appropriate a intensity of block. A variation of watermark image bits in order to embed the original image block selected affects to embedded block intensity and also it depends on original image block intensity. The block size is adapted as intensity of original image and capacity of watermark image in order to embed. As method of varying block size proposed, the effect of block size adaptation is good and also watermark image is robust to a number types of degradation. As the proposed method, quality of the original image is at least affected.

Keywords: Watermarking, Spatial Domain.

1. INTRODUCTION

Nowadays, the copyright-protection of digital data that is lawlessly duplicated is more important to verification to owner of data by embedding a number of symbols. Particularly, for symbols being binary image, intensity to show owner is greatly interesting. In case of embedding in spatial domain, the smaller size image, the lower complicated image is embedded. However, both spatial and frequency domain are taken into account three properties, that is, robustness of watermark to disturbance in a number of patterns, perceptual invisibility, and capacity. Recently, several watermarking methods are proposed to trade-off properties as mentioned in both spatial and frequency domain [1], [2] and [3].

Recently, image watermarking based on spatial domain [3] has shown the good result. The cornerstone is adjusting intensity level of pixel's brightness level of block by that let block size of original image, all size of 512×512 pixels, be constant of 4×4 pixels. Any blocks is embedded by binary image of one bit, 0 or 1, by when the binary image is embedded by bit of 1, brightness is

then increased in the block and in opposite directions, brightness is decreased when the binary image is embedded by bit of 0. In procedure of extracting watermark, comparative method of the watermarked image to original image is applied to restore the desired watermark. The disadvantage of the mentioned method is constant block size assignment, 4×4 pixels. The block size is greatly important to robustness property of watermark. The larger block size, the higher robustness. In adjusting brightness the total pixels of each block is adjusted with the same value. If intensity of block is over, brightness is then readjusted both increasingly and decreasingly. In recent method, the extension of block is only applied even though it is more robust but the watermarked image is more changed causing blocking effect certainly. Fig.1 shows the watermarked image from original image of 512×512 pixels and gray levels of 256 with the recent method by that image is equally divided onto a large block of 16×16 sizes.

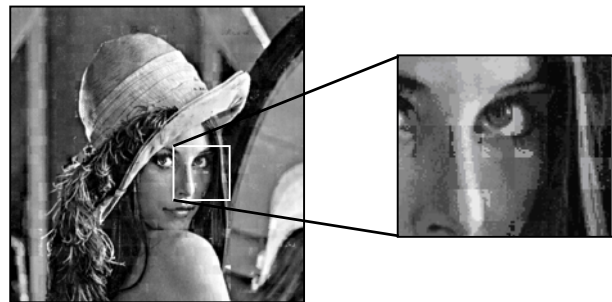


Fig.1: Blocking effect from the large extended block.

2. THE PROPOSED METHOD

From the mentioned disadvantage, we propose a way to improve the watermarking method to better results as the following steps.

Step 1: Original image with size of 512×512 pixels is divided onto several blocks with size of 64×64 , 32×32 , 16×16 and 8×8 pixels. The quadtree method was proposed in [4] by using two condition that is the smallest block size of 8×8 and appropriate threshold -

level assignment comparing with intensity value of block from (1), variance, in procedure of quadtree.

$$A_k = \frac{\sum_{i=1}^n (\mu - x_k(i))^2}{n-1} \quad (1)$$

where A_k is intensity value of the k^{th} block and k varies from 0 to ,less and equal, a number of pixels of watermark to embed, μ is mean of brightness level of the block, $x_k(i)$ is brightness level of the i^{th} pixel of the k^{th} block, and n is a total number of pixels of the k^{th} block. As mentioned, image is divided either large block or small block depending on intensity level following as each of location of original image region. The larger block, the lower intensity level, and the smaller one, the more intensity level. The variable block size being distribution is to have equally approximate robustness of all block. Fig.2 shows dividing the Lena image onto a number of blocks based on intensity of 189.

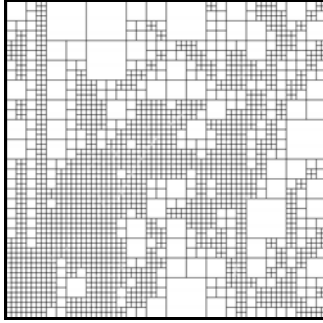


Fig. 2: Several block size from dividing original image.

Step 2: Brightness of pixels in each block is adjusted. Block size of 4×4 pixels from the recent method [3] by that let b be watermark bit is shown in Fig.3. Pixels in block are first ordered from low to high value. Mean g_{mean} in the block is calculated. g_{min} , g_{max} are the minimum and maximum value of one, respectively. m_H , m_L are mean between high and low side block. Additional understanding sees Fig.3. The procedure to embed watermark into block with bit as 1 or 0 where g_{old} is original brightness level and g_{new} is new brightness after the pixels in the changed block is as following.

Watermark as bit of 0

$$\begin{aligned} g_{new} &= g_{min} && \text{if } g_{old} < m_L, \\ g_{new} &= g_{mean} && \text{if } g_{mean} \leq g_{old} < m_H, \\ g_{new} &= g_{old} - C_b && \text{otherwise.} \end{aligned}$$

Watermark as bit of 1

$$\begin{aligned} g_{new} &= g_{max} && \text{if } g_{old} > m_H, \\ g_{new} &= g_{mean} && \text{if } m_L \leq g_{old} < g_{mean}, \\ g_{new} &= g_{old} + C_b && \text{otherwise.} \end{aligned}$$

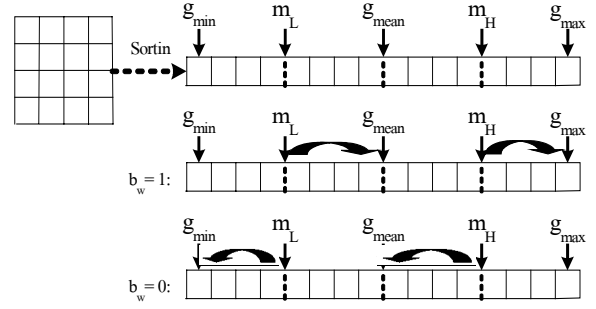


Fig. 3: Improving brightness level of each pixel in block.

Either high or low value of C_b depends on intensity of the block which can calculate from (2).

$$C_b = \max(C_{min}, \alpha(g_{max} - g_{min})) \quad (2)$$

where C_{min} and α are the appropriately assigned value in order to change the watermarked image to differ from the original image in sense of data while preserving the human visual system as the original one. In case of the very low intensity value of block, meaning that brightness level of area is almost equal, for the recent method as mentioned, brightness level of all pixel in the block is adjusted with the same value that can be calculated as step 2. To avoid the mentioned disadvantage, the blocks that have size larger than that of 8×8 pixels are partially divided onto blocks of size of 8×8 pixels. Intensity of each of partially divided block is calculated although the large block is embedded by watermark bit of either 0 or 1. As the above method, the intensity of each of large block is differently adjusted, more or less; it is dependent on intensity of the sub-block. The more intensity, the more adjustment and in opposite directions, the less one, the less adjustment. The effect of above performing to the original image to embed watermark is to the smallest degradation.

The diagram of overview system is shown in Fig.4, seeing that additional component is part of alternation of watermark as linear feedback shift register (LFSR) [5] in order to increase the hardness for restoring the watermark from unauthority.

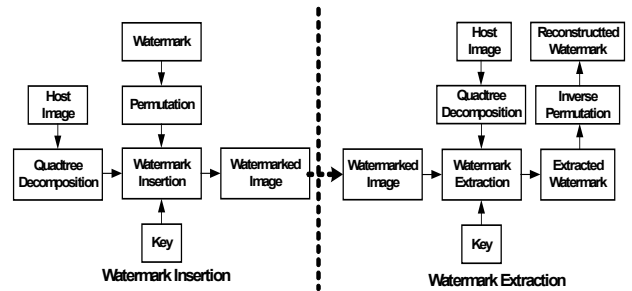


Fig. 4: Experiment of insertion and extraction watermark by the proposed method.

For procedure of extracting watermark, we use the original image to process the procedure of dividing block that the same as the embedding procedure to compare intensity of block for different size with the block of watermarked image. Let S_o and S_{new} be total of all pixel brightness in comparatively desired block of original image and in watermarked image, respectively. Result of extracting watermark bit of each one can be calculated as

$$\begin{aligned} b &= 1 && \text{if } S_{new} > S_o \\ b &= 0 && \text{otherwise} \end{aligned} \quad (3)$$

3. EXPERIMENTAL RESULTS

In the experiments, the host image is of size 512×512 pixels with 256 gray levels. The watermark as character image of size of 46×46 pixels is employed to embed for the proposed method. Following as Fig.4, the original image is embedded by watermark and the watermarked image is transmitted via disturbed environment such as low-pass filter, median filter, JPEG data compression as several bit rates, scaling and rotating. Normalized cross correlation (NC) and peak signal to noise ratio (PSNR) are used to evaluate the quality or nearness to original watermark as (4) and (5), respectively.

$$NC = \frac{\sum_i \sum_j p_{ij} p_{ij}^*}{\sum_i \sum_j (p_{ij})^2} \quad (4)$$

where p_{ij} and p_{ij}^* are $(i, j)^{\text{th}}$ pixel position of the original watermark and the extracted one by that $1 \leq (i, j) \leq 46$, respectively.

$$PSNR = 10 \log_{10} \frac{255^2}{MSE} \quad (5)$$

where MSE is mean square error.



Fig. 5: Illustrates the proposed method
(a) Watermarked image (b) Extracted watermark.



Fig. 6: Result of Low-pass filtering
(a) Watermarked image (b) Extracted watermark.

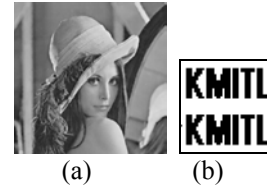


Fig. 7: Result of Median filtering
(a) Watermarked image (b) Extracted watermark.

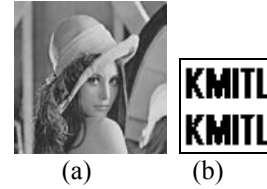


Fig. 8: Result of JPEG 75% compression
(a) Watermarked image (b) Extracted watermark.



Fig. 9: Result of scaling image
(a) Watermarked image (b) Extracted watermark.

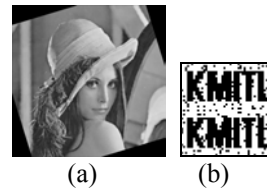


Fig. 10: Result of rotation image
(a) Watermarked image (b) Extracted watermark.

Fig.5(a) shows the watermarked image with intensity of 189 to be used to divide block. This intensity is changed as size of desired watermark to embed. In order to adjust a number of blocks being more than or equal a number of data to be embedded, the larger a number of bits require to embed, the less intensity used to divide block is. Fig.5(b) shows the extracted watermark from Fig. 5(a).

Table 1: Numerical results of PSNR and NC from Image.

Image	Lena	Peppers	boat	Baboon
PSNR	32.21	32.32	31.07	27.16
3×3 LPF	0.9467	0.9344	0.9500	0.9939
3×3 Med	0.9990	1.0000	0.9909	1.0000
JPEG 75%	0.9980	0.9990	0.9990	1.0000
Rotating	0.8490	0.8142	0.8651	0.8547
Scaling	0.9447	0.9298	0.9241	0.9939

To show the robustness of the proposed method under common image processing operations, we have processed the watermarked image using the following operation: low-pass filtering, median filter, JPEG compression, scaling and rotating. Fig.6(a) shows the result of applying low-pass filtering to the watermarked image. The filter is a neighborhood averaging operation with a mask of 3×3 size. Fig.6(b) shows the extracted watermark from Fig.6(a). The NC between the extracted watermark and original one is of 0.9467. Fig.7(a) shows the result of applying 3×3 neighborhood median filtering to the watermarked image. The extracted watermark is shown in Fig.7(b). The NC between the extracted watermark and original one is of 0.9990. We can easily verify the existence of the watermark although there is some distortion in the extracted watermark.

To show the robustness of the proposed method under lossy JPEG compression, we first compress the watermarked image and then extract the watermark from the compressed image. Fig. 8(a) shows the compressed image with a quality factor of 75%. The extracted watermark is shown in Fig.8(b). The NC between the extracted watermark and original one is of 0.9980.

Fig.9(a) shows the result of applied scaling the watermarked image reduced to one quarter of its original size (256×256) and rescaled back to 512×512 . The extracted watermark is shown in Fig. 9(b). The NC between the extracted watermark and original one is of 0.9447. Fig.10(a) show the result of applying the rotated watermarked image. It is rotated by 12 degrees to the right and then rotated back to its original position. The extracted watermark is shown in Fig.10(b). The NC between the extracted watermark and original one is of 0.8490. The experiments with other host image standard. Numerical results to evaluate PSNR and NC criteria are shown in Table 1.

4. CONCLUSIONS AND DISCUSSIONS

In this paper, we have discussed embedding the binary image as watermark into original image in spatial domain. Taking into account a basic requirement is the perceptual invisibility, robustness and capacity. The proposed method requires the smallest capacity because implementation of small image watermarking is popular such as company symbol or signature. Method of embedding watermark is adjusting brightness of block by dividing the original image into different size block from the largest size into the smallest size being of 8×8 pixels, alternatively. The block size depends on intensity of the area and a number of blocks can be changed as a number of the desired watermark to embed. Experimental results show that moreover adjusting block size and increasing or decreasing brightness take into account sub-area in block giving better results. However, the cropped degradation is still a problem for this technique.

5. REFERENCES

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