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Print-Resilient Binary Image Watermarking Based on Grayscale Conversion and DCT Transformation

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Abstract

Current binary image watermarking methods are mainly spatial domain methods, and most of them cannot resist printing and scanning. Based on this consideration, this paper introduces a new print-resilient watermarking method tailored for binary images. For data embedding, by dividing the cover binary image into disjoint regions and counting the black pixels in each region, it is first converted into a form similar to a grayscale image. Then, by applying DCT to the transformed image, two DCT coefficients are selected and modified to embed the watermark. Next, after modification, the transformed image is converted back to the spatial domain to identify the number of pixels that need to be changed in the original binary image. Finally, for the cover binary image, edge detection is employed to select and modify its pixels (white to black, or black to white) without reducing the image quality, effectively realizing the watermark embedding. Experimental results show that the proposed method can well preserve the visual quality while resists the print-scan attack.

Motivation

- The increasing demand for digital copyright protection necessitates more effective solutions. This need has propelled the development of digital watermarking, positioning it as a central focus in information security. The main objective of digital watermarking is to embed watermark information into digital media while maintaining both imperceptibility and robustness. Despite the proliferation of digital data, a considerable portion of image data still relies on paper for information dissemination. In some cases, the printed data demands even stricter security and confidentiality than digital data, making it more challenging to ensure their protection, and giving rise to the necessity for watermarking tailored for paper-based image data.
- Current image watermarking methods are mainly centered on color or grayscale images, while relatively few techniques have been developed for binary images. Additionally, the methods tailored for color or grayscale images are often incompatible with binary images. Compared with color or grayscale images, embedding watermarks into binary images is inherently more demanding and involves more complex processes.

Methodology

Grayscale conversion

In our approach, the watermark information sequence is initially encoded using Bose-Chaudhuri-Hocquenghem (BCH) coding, which provides error correction and improves the overall robustness of the method.

Since binary images only contain 0s (white pixel) and 1s (black pixel), most watermarking techniques designed for grayscale images do not work with binary images. The proposed method addresses this challenge by converting a binary image into an approximate grayscale image. This conversion is achieved by dividing the binary image into disjoint regions and counting the number of black pixels in each region, making it possible to apply watermarking techniques for grayscale images.

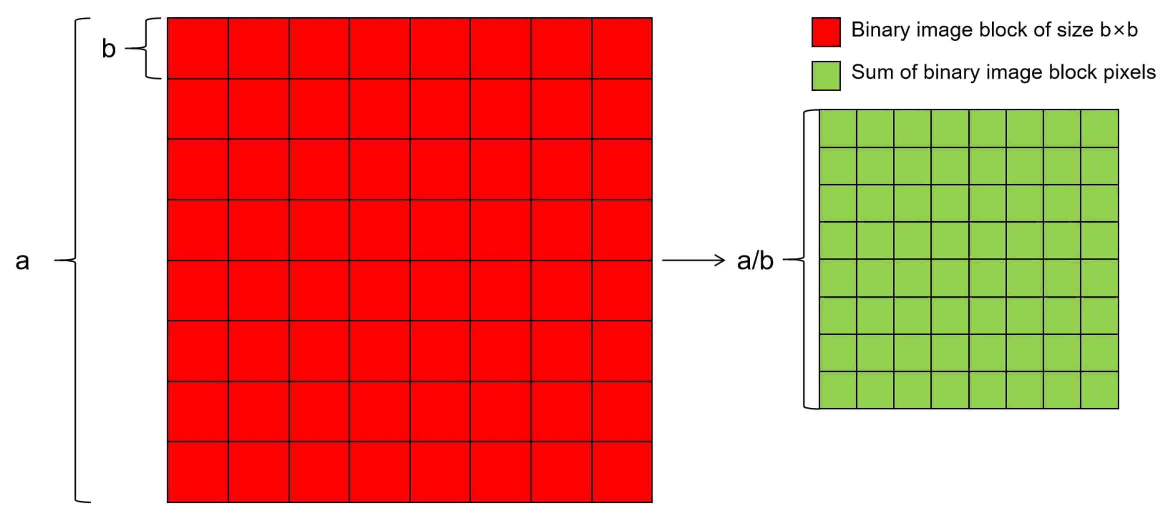

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Figure 1 The image ofl grayscale conversion.

Watermark embedding

1.DCT domain embedding position:

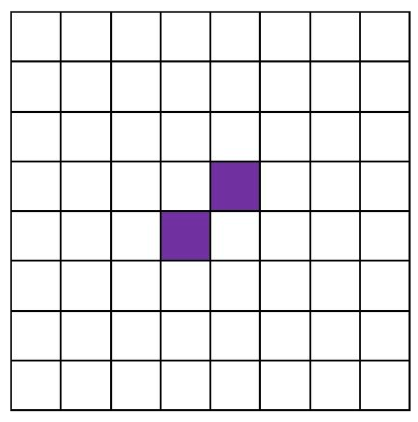

Figure 2 Two selected DCT frequency bands that will be used for data embedding..

2.Watermark embedding formula:

$$Y_k(i,j) = X_k(i,j) - \alpha \bar{X}_k$$
$$Y_k(i,j) = X_k(i,j) + \alpha \bar{X}_k.$$

where Xk is the mean value of the k-th pixel block and α > 0 is a parameter indicating the watermarking strength.

Experiments

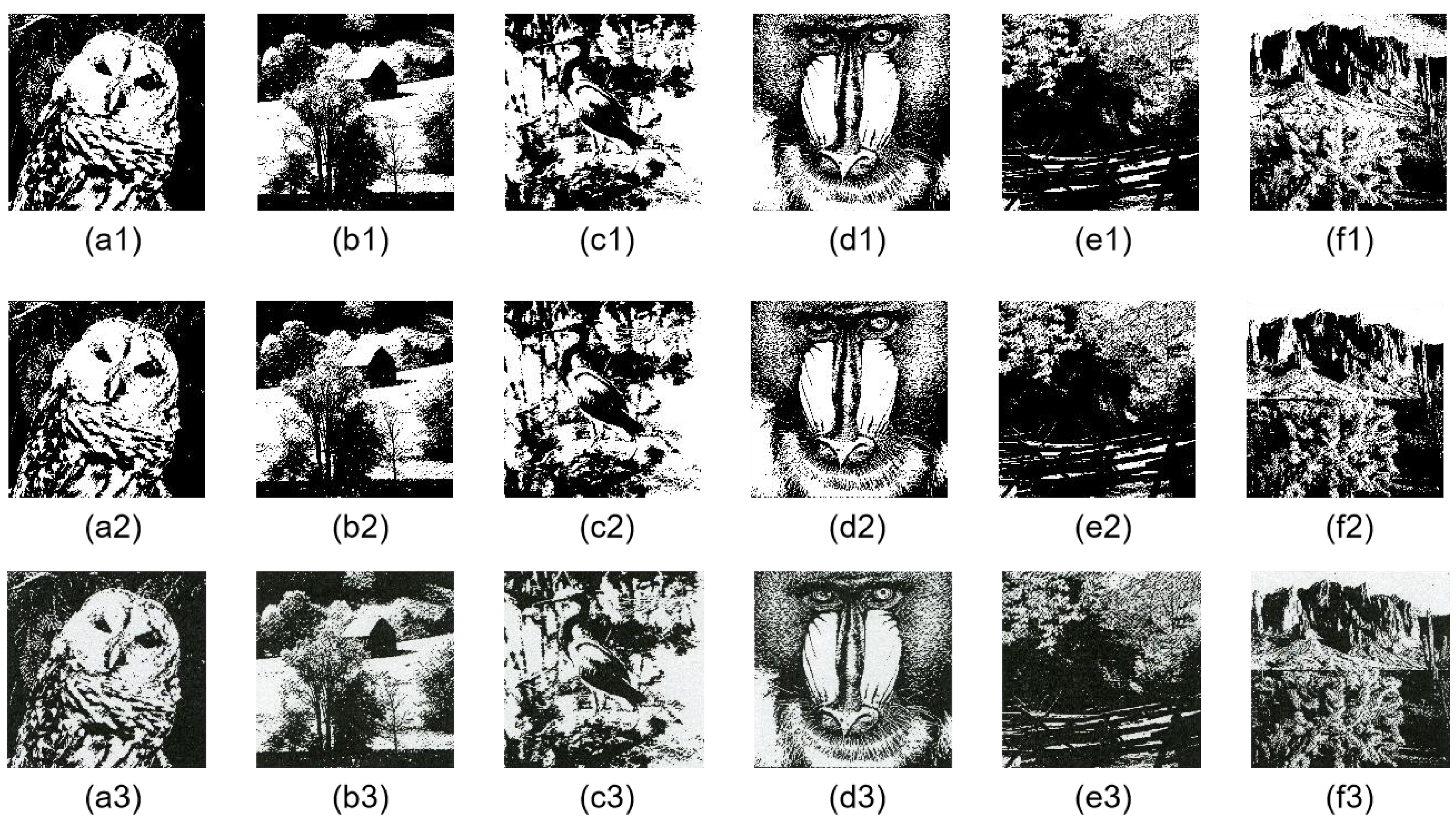

Figure 3 The cover binary images (upper), the watermarked images (middle), and the scanned watermarked images (bottom).

	Number of wrong bits	Extract results
a2	5	success
b2	2	success
c2	2	success
d2	0	success
e2	3	success
f2	0	success

Table 1 W atermark detection results

	Number of wrong bits	Extract results
a3	5	success
b3	4	success
c3	5	success
d3	4	success
e3	4	success
f3	3	success

Table 2 W atermark detection results for the scanned watermarked image sized 5cm*5cm