A Novel Pragmatic RRW Framework to Resist on Unintentional Attacks

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Abstract
Robust reversible watermarking (RVW) is used to protect the copyright and providing robustness against unintentional attacks. In the past histogram rotation-based method suffers from extremely poor invisibility for watermarked images and limited robustness in extracting watermarks from the watermarked images destroyed by different unintentional attacks. In this paper proposed wavelet-domain statistical quantity histogram shifting and clustering (WSQH-SC) method and enhanced pixel-wise masking (EPWM). This method embedded a new watermark image and extraction procedures by histogram shifting and clustering, which are important for improving robustness and reducing run-time complexity. It is possible reversibility and invisibility. The experimental result shows that the comprehensive performance in terms of reversibility, robustness, invisibility, capacity and run-time complexity and widely applicable to different kinds of images.

Index Terms
Integer wavelet transform, k-means clustering, masking, robust reversible watermarking (RRW).

1. Introduction

The concept of reversible watermark firstly appeared in the patent owned by Eastman Kodak[1]. Honsinger et al. [1] utilised a robust spatial additive watermark combined with modulo additions to achieve reversible data embedding. Goljan et al.[2] proposed a two cycles flipping permutation to assign a watermarking bit in each pixel group. Celik et al. [3] presented a high capacity, reversible data-embedding algorithm with low distortion by compressing quantization residues. Tian [4] presented a reversible data embedding approach based on expanding the pixel value difference between neighboring pixels, which will not overflow or underflow after expansion. Thodi and Rodrguez exploited the inherent correlation among the neighboring pixels in an image region using a predictor. Xuan et al. [5] embedded data into high-frequency coefficients of integer wavelet transforms with the commanding technique, and utilized histogram modification as a preprocessing step to prevent overflow or underflow caused by the modification of wavelet coefficients.

Reversible watermarking has found a huge surge of experimentation in its domain in past decade as the need of recovering the original work image after extracting the watermark arises in various applications such as the law enforcement, medical and military image system, it is crucial to restore the original image without any distortions [6]. In traditional watermarking techniques, our main concern is to embed and recover the watermark with minimum loss. The quality of original work image we get after extraction is highly degraded and not restorable. But in applications like law enforcement, medical and military, in which superior quality of image is needed, we cannot use these algorithms. In medical images, some prerequisite information about the patient is watermarked in it while transmitting and at reception we need to have both, the original image and that information to be recovered lossless. This type of result is achievable by making use of any reversible watermarking algorithm out of a pool of algorithms [7].

Ii. Proposed Method

The following steps are used to embedded the watermark image into image.

- Decompose image using 5/3 IWT and divide the sub-band HL into n non overlapping blocks with the size of h × w.
- Compute the mean of wavelet coefficients (MWC) histogram of all of the blocks and obtain Sk.
- Perform EPWM to compute the watermark strength
- **For k = 1to m do**
- 7 Embed the kth watermark bit bk with Sw
- k = Sk + βλbk ;
- **End for**
- Reconstruct the watermarked image I with inverse 5/3 IWT.

The block diagram of proposed method as shown in fig.1.

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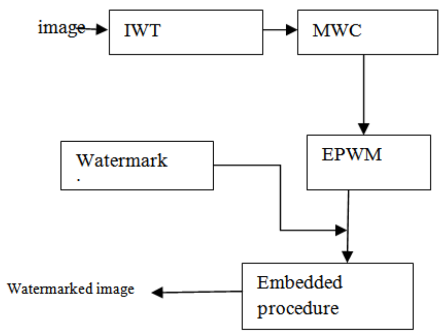

Fig.1. block diagram of proposed method

A. inverse wavelet transforms (IWT)

The wavelet transform transforms the image into a multi-scale representation with both spatial and frequency characteristics. This allows for effective multi-scale image analysis with lower computational cost. Using the IWT, the texture image is decomposed into four sub images, as low-low, low-high, high-low and high-high sub-bands.

L_1L_1	L_1L_2	L_1H_1	L_1H_2
L_2L_1	L_2L_2	L_2H_1	L_2H_2
H_1L_1	H_1L_2	H_1H_1	H_1H_2
H_2L_1	H_2L_2	H_2L_1	H_2L_2

Fig.2. Image decomposition after a two level scaling for IWT

B. means of wavelet coefficients (MWC) histogram

It is designed in high-pass sub-bands of wavelet decomposition, to which HVS is less sensitive, leading to high invisibility of watermarked images and it has almost a zero-mean and Laplacian-like distribution based on the experimental study of wavelet high-pass sub-bands from 300 test images.
Considering a given host image I , we first decompose I using 2 level IWT to obtain the sub-band and then divide HL into n non overlapping blocks. Let S = [S1,..., Sk ,..., Sn] be the MWCs in the sub-band, then the MWC of the kth block, Sk ,is defined as

$$S_k = \frac{1}{(h-2)\times(w-2)}\sum_{i=2}^{h-1}\sum_{j=2}^{w-1} P_k^{(i,j)}$$

Where $P^{(i,j)}_k$ represents the wavelet coefficient at (i, j) in the k^{th} block

C. Embedded Pixel Wise Masking (EPWM)

It has been well acknowledged that a balance between invisibility and robustness is important for robust watermarking methods. Although many efforts have been made to design lossless embedding models, little progress has been made in this trade-off. Therefore, we develop EPWM to tackle this problem by utilizing the JND thresholds of wavelet coefficients to optimize watermark strength. To compute the watermark strength as shown below

$$\lambda = \frac{\alpha}{M \times N}\sum_{i=1}^{M}\sum_{j=1}^{N} \mathrm{JND}_{\rho}^{\omega}(i, j)$$

where α is a global parameter and M × N is the sub-band size.

D. Embedded procedure

We use the obtained JND thresholds to control watermark strength during the embedding process. To be specific, given the MWC of the kth block of interest, i.e., Sk the watermark embedding is given by
k = Sk + βλbk ;
Here k is the obtained MWC after the kth watermark bit bk ∈ {0, 1} is embedded, β is a factor defined as

$$\beta = (S_k - S^*)\,/\mathrm{abs}\,(S_k - S^*)$$

III. Quality Measurement

PSNR is most commonly used to measure the quality of reconstruction of lossy compression codecs. PSNR is most easily defined via the mean squared error (MSE). Given a noise-free m×n monochrome image I and its noisy approximation K, MSE is defined as:

$$MSE = \frac{1}{m\,n}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I(i,j) - K(i,j)]^2$$

The PSNR is defined as:

$$\begin{aligned} PSNR &= 10 \cdot \log_{10}\left(\frac{MAX_I^2}{MSE}\right) \\ &= 20 \cdot \log_{10}\left(\frac{MAX_I}{\sqrt{MSE}}\right) \\ &= 20 \cdot \log_{10}(MAX_I) - 10 \cdot \log_{10}(MSE) \end{aligned}$$

IV. Experimental Results

Fig.3 shows the lena image

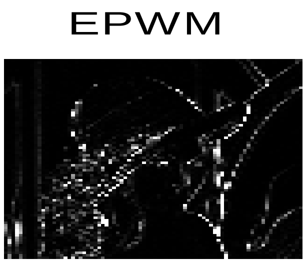

Fig.4. JND thresholds of EPWM method

Fig.5. shows the watermark image

Fig.6. shows the final output (watermarked image)

V. Conclusion

In this paper, developed a WSQH-SC method and enhanced pixel-wise masking EPWM. EPWM precisely estimates the local sensitivity of HVS and adaptively optimizes the watermark strength for a trade-off between robustness and invisibility. This techniques improving robustness, reducing run-time complexity and invisibility for watermarked images. It is widely applicable to different kinds of images.

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