An Efficient Watermarking Algorithm to Improve Payload and Robustness without Affecting Image Perceptual Quality

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Abstract— Capacity, Robustness, & Perceptual quality of watermark data are very important issues to be considered. A lot of research is going on to increase these parameters for watermarking of the digital images, as there is always a tradeoff among them. In this paper an efficient watermarking algorithm to improve payload and robustness without affecting perceptual quality of image data based on DWT is discussed. The aim of the paper is to employ the nested watermarks in wavelet domain which increases the capacity and ultimately the robustness against attacks and selection of different scaling factor values for LL & HH bands and during embedding not to create the visible artifacts in the original image and therefore the original and watermarked image is similar.

Index Terms—Watermarked, Perceptual, Matlab

1 INTRODUCTION

To increase payload the one watermark is embedded in the other i.e nested watermark is used. Two different visual watermarks are used, nested and thus the resulting watermark is embedded in lower (LL) & high frequency (HH) bands based on the optimal selection of different scaling factors for each band. The DWT coefficients in lower frequency band are larger as compared to the higher frequency bands. Therefore the value of scaling factor is kept larger in lower frequency band and lower in high frequency band. The scaling factors are chosen such invisibility and quality of extracted watermark is maintained. Visual quality of extracted watermarks is measured by the Similarity Ratio (SR) between compared images. In this paper we are giving a new image watermarking method. The embedding and extraction of watermark is based on discrete wavelet transform. Matlab 6 [28] is used to implement all the coding related to digital image processing. It is a non-blind watermarking method.

2 ALGORITHMS

2.1 Algorithm to embed one watermark into other watermark:

Inputs: Primary watermark, secondary watermark image.
Steps:
1) Read the primary visual watermark image.
2) Decompose the primary watermark image into cap1, chp1, cvp1, cdp1 bands using daubachesis filter.
3) Read the secondary visual watermark image.
4) Add the secondary watermark into the horizontal DWT coefficient (chp1) of Primary watermark.
5) Apply the IDWT to get the nested watermark image.
6) Calculate the PSNR & MSE of nested watermark with original primary watermark image.
Output: Nested watermark image

2.2 Algorithm to embed nested watermark into cover image:

Inputs: Cover image, nested watermark image
Steps:
1) Read the cover image & nested watermark image.
2) Apply DWT to cover image to obtain approximation, horizontal, vertical, diagonal DWT coefficients i.e. ca1, ch1, cv1, cd1.
3) Modify the approximation DWT coefficient by adding the nested watermark image as in equation
   a. Ca1(i,j)=ca1(i,j)+α*nested watermark
   b. Where Ca1 & ca1 are the modified & original approximation coefficients and α is a scaling value as set to 0.04.
4) Modify the diagonal DWT coefficient by adding the nested watermark image as in the equation
   a. Cd1(i,j)=cd1(i,j)+α*nested watermark
   b. Where Cd1 & cd1 are the modified & original diagonal coefficients of cover image and α is set to value 0.01.
6) Apply the inverse DWT to obtain the watermarked cover image.
7) Calculate the PSNR & MSE of watermarked cover image with original cover image.

Output: Watermarked cover image.

2.3 Algorithm for Watermark Extraction:

Inputs: Original cover image, Watermarked cover image or Attacked Watermarked cover image.

1) Apply two-dimensional DWT, to obtain the first level decomposition of the watermarked cover image i.e. c1a1, c1h1, c1v1, c1d1
2) Extract the watermark from approximation & diagonal DWT coefficient (c1a1 & c1d1) as per the equation
   \[ LL_w = (c1a1-c1a1)/\alpha; \text{ where } \alpha = 0.04 \]
   \[ HH_w = (c1d1-c1d1)/\alpha; \text{ where } \alpha = 0.01 \]
3) Calculate the visual quality of extracted watermark by the Similarity Ratio (SR) between compared images. \[ SR = \frac{S}{S+D} \]
   where S denotes the number of matching pixel values in compared images, and D denotes the number of different pixel values in compared images.
4) Apply the set of possible attacks to watermarked image to get the attacked image. Calculate for each attack the PSNR of Original and attacked image.
5) Apply two-dimensional DWT, to obtain the first level decomposition of the Attacked image i.e. c2a2, c2h2, c2v2, c2d2.
6) Extract the watermark from approximation & diagonal DWT (i.e. c2a2 & c2d2) coefficient of attacked image as per the equation
   \[ LA_w = (c2a2-c2a1)/\alpha; \text{ where } \alpha = 3 \]
   \[ HA_w = (c2d2-c2d1)/\alpha; \text{ where } \alpha = 1 \]
7) Calculate the visual quality of extracted watermark from attacked image by the Similarity Ratio (SR) between compared images. \[ SR = \frac{S}{S+D} \]

Outputs: Extracted Watermarks from approximation & diagonal coefficients of watermarked cover image & Attacked cover image

3 EXPERIMENTAL RESULTS

In our experimental results Lena cover image of 512*512 size, Primary and Secondary watermark of 64*64 size is used. Cover image is subjected to the watermark embedding and extraction. We measure the quality of watermarked images in terms of PSNR (Peak Signal to Noise Ratio) and MSE (Mean Square Error). In ideal case PSNR should be infinite and MSE should be zero. But it is not possible for watermarked image. So, large PSNR and small MSE is desirable.

\[ PSNR_{db} = 10 \log_{10} \left( \frac{MAX^2}{MSE} \right) \]

The subjective evaluation of extracted watermark is based on Similarity Ratio SR.

\[ SR = \frac{S}{S+D} \]

Where S denotes the number of matching pixel values in compared images, and D denotes the number of different pixel values in compared images.
Table 1: PSNR1 & PSNR2

| Cover Image | Primary Watermark | Secondary Watermark | PSNR1 | MSE1 | PSNR2 | MSE2 |
|-------------|-------------------|---------------------|-------|------|-------|------|
| Lena 512x512 | dmg2.tif (64*64)  | dmg1.tif (64*64)   | 42.14 | 6.10e-005 | 54.18 | 3.81e-006 |

PSNR1 – PSNR of Nested watermark with original Primary Watermark.

MSE1 – MSE of Nested watermark with original Primary Watermark.

PSNR2 – PSNR of gray scale cover image after embedding Nested watermark.

MSE2 – MSE of gray scale cover image after embedding Nested watermark.

3.1 Capacity Increase Results

In our Watermarking technique the embedding capacity is more than normal Watermarking because here watermark nesting is used.

Table 2: Capacity Increase Results

| Cover Image | Capacity of bits without watermarking | Capacity of bits with watermark |
|-------------|---------------------------------------|-------------------------------|
| Lena        | 4096                                  | 8192                          |

Table 3: Robustness Improve Results

| Type of attack | PSNR | SR | Extracted band |
|----------------|------|----|----------------|
| Intensity Adjustement | 29.57 | 0.8749 | HH |
| Gamma Correction | 23.30 | 0.8680 | HH |
| Histogram Equalization | 30.66 | 0.7269 | HH |
| Low Pass Filter/Blur | 21.31 | 0.8803 | LL |
| Resizing | 54.18 | 0.7440 | LL |
| Gaussian Noise | 54.18 | 0.7707 | LL |
| High Pass Filter/Sharp | 19.22 | 0.7582 | LL |
| JPEG Compression | 42.14 | 0.9226 | LL |
5. Future Work

Most of the research is going in watermarking the text, audio, video data for copyright protection and authentication of electronic documents and media. Watermarking is the necessity for digital images as these are available at Internet without any cost, which needs to be protected. The watermarking technique that is given in this paper can be further improved to increase the hiding capacity and Robustness for RGB and the Indexed images.

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4. CONCLUSION

This paper presents a non-blind watermarking technique that uses watermark nesting at level 1 DWT decomposition. Nesting means it embeds an extra watermark into the main watermark and then embeds the main watermark into the cover image. Proposed watermarking technique has following advantages:

1. Proposed watermarking embeds more no of bits into cover image and thereby improves the payload as compared to single watermark embedding.

2. Watermark embedding in the LL band is most resistant to JPEG compression, blurring, Sharpening, adding Gaussian noise and Resizing.

3. Watermark embedding in the HH band is most resistant to histogram equalization, intensity adjustment, Gamma Correction.

4. Recovered watermarks quality under the above attacks is assessed based on subjective evaluation of similarity Ratio(SR). In all attacked cases the SR value is more than 0.7.

5. Robustness is improved in all the attacked watermarked images as PSNR shows a good value against the original watermarked image.

6. The scaling factors are chosen such as invisibility and quality of extracted watermark is maintained.
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