High Payload Lossless Digital Image Watermarking Using Integer Wavelet Transform

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ABSTRACT

In this paper a high payload lossless digital image watermarking technique based on Integer Wavelet Transform is proposed. Digital watermarking is the process of embedding the watermark image into a host image which is imperceptible by human visual system. The small deviations in data values are not allowed in certain images for obvious reasons and a potential risk of a person misinterpreting an image. After extracting the embedded data, the original image should be recovered from watermarked image. A preprocessing histogram adjustment is used to prevent overflow/underflow. In proposed technique, the data are embedded into one or more bit planes of wavelet coefficients of high frequency sub bands. This technique embeds much more data imperceptibly than the existing techniques. The experimental results have demonstrated the superiority of the proposed method over existing techniques.

Index Terms; Digital watermarking, Integer wavelet transform, Histogram modification.

INTRODUCTION

In today's life Internet is being increasingly used as the platform for distribution of digital multimedia .However many publishers may be unwilling to show their work on the internet due to lack of security. Images can be easily duplicated and distributed without the owner's permission. Digital watermarks came in to picture to avoid this type of issues. A digital watermark is an invisible digital image embedded inside the host image to show ownership. A digital watermark will prevent the obstruction of the original image which is invisible by human visual system[1]. It should be statistically invisible to prevent detection. Digital image watermarking with lossless is of great use in practice.

A lossless high-capacity data embedding for image watermarking based on integer wavelet is proposed. After extracting data embedded, the original image should be reversible from watermarked image. Obviously most of current hiding algorithms are not distortion less. Recently, some distortion less marking techniques have been reported in the literature .The concept of distortion-free data embedding appeared for the first time in an authentication method in a patent owned by Eastman Kodak was published in 1999.This method [2] is carried out in the spatial image domain. These techniques aim at authentication, instead of data embedding. As a result, the amount of hidden data is quite limited. The first distortion less marking technique that is suitable for data embedding was presented in [3]. This amount of hidden data is still not large enough for some medical applications.

INTEGER WAVELET TRANSFORM

The Wavelet Transform produces floating point coefficients even when applied to integer values [4]. The original integer data can be reconstructed perfectly in theory by using these coefficients. However in practice, we usually use the fixed point format for data values because the fixed point systems are easier to implement. The reduced precession arithmetic used in such systems can introduce round off errors in the computations. In practice traditional wavelet transform have some drawbacks such as it is a floating point algorithm, computer finite word length will bring in rounding error and signals can't be reconstructed exactly, the computation is very complicated, computation cost is very high, it requires more storage space and it is not appropriate to hardware implementation[5]. In order to overcome above drawbacks, this paper uses lifting scheme wavelet - integer wavelet transform. It doesn't depend on Fourier transform, but it still inherits , multi resolution properties of traditional wavelet transform and transforming coefficient, calculation speed is more fast, and it doesn't need extra storage cost so it is called second generation wavelet transform. Hence in applications where we need lossless reconstruction, we need transforms which have reversibility properties even when reduced precision is used. It was shown by calderbank et al., [6] that we can build wavelet transforms that map integers to integers by using lifting structure. The reversibility property is obtained by rounding of the predict filter or update filter output before adding or subtracting in each lifting step. Wavelet filters are decomposed into basic modules by integer wavelet transform, that is,

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wavelet transform is completed through splitting, predicting and updating, as Fig 1 displays.

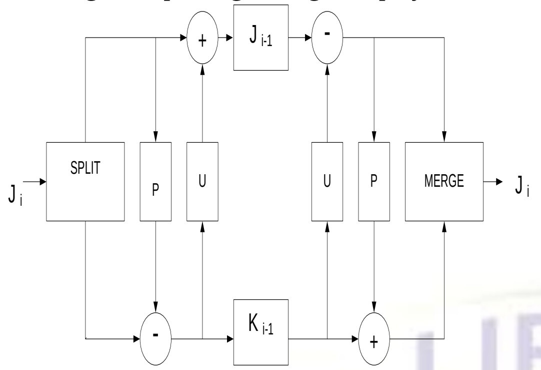


Fig 1. Integer wavelets transform decomposition and Reconstruction diagram

After integer wavelet transform, it has four sub-bands. We will embed the information into three high frequency sub bands. Except that it has advantages of traditional wavelet transform, integer wavelet transform which is applied to digital watermarking technology has following advantages:
(1) It avoids rounding error of floating point in mathematical transformation;
(2) Its transforming speed is fast and it doesn't need extra storage cost.

HISTOGRAM ADJUSTMENT

For a given image, after data embedding in some IWT coefficients, it is possible to cause overflow/underflow, which means that after inverse wavelet transform the gray scale values of some pixels in the water marked image may exceed the upper bound (255 for an eight-bit grayscale image) and/or the lower bound (0 for an eight-bit grayscale image). In order to prevent the overflow/underflow, we adopt histogram modification, which narrows the histogram from both sides as shown in. Fig.2. Please refer to [7],[8] for the detailed algorithm. The bookkeeping information will be embedded into the cover media together with the information data.

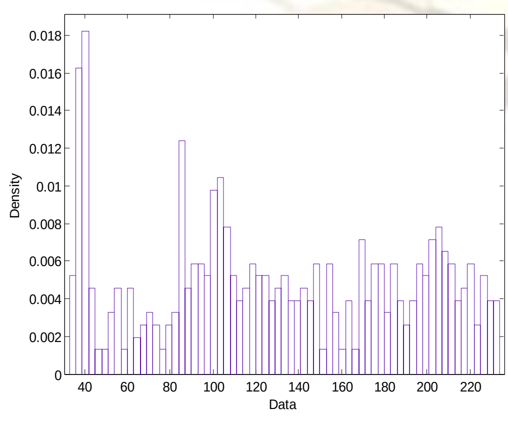


Fig 2(a). Gray scale histogram modification of Original histogram

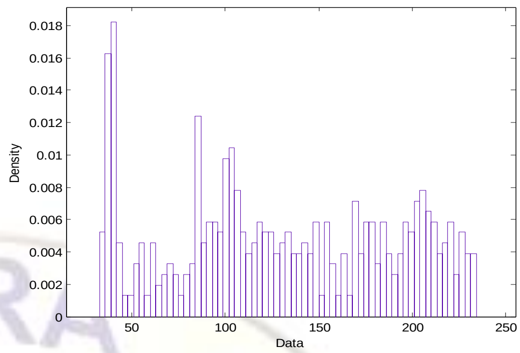


Fig 2(b). Gray scale histogram modification modified histogram

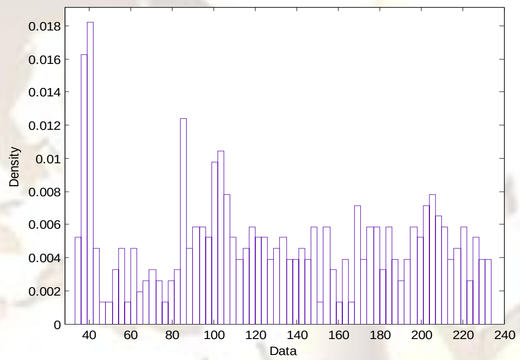


Fig 2(c). Gray scale histogram modification histogram after data embedding.

PROPOSED WATERMARKING SCHEME

1. Data Embedding Process:

The main steps of the embedding procedure developed are presented here and summarized.

a. Histogram modification is applied on original image that prevents possible overflow and underflow.
b. We first apply integer wavelet decomposition to the original image. In our experiments, CDF (2, 2) wavelet filters are used to decompose the original gray scale image into one level. After integer wavelet transform, it has four sub-bands.
c. In order to have the marked image perceptually the same as the original image, we choose to hide data in one (or more than one) "middle" bit-plane(s) in the IDWT domain. To further enhance the visual quality of the marked image, we embed data only in the middle and high frequency sub bands, specifically in the LH1, HL1 and HH1 sub bands.
d. Construct binary images from 5^{th} bit of LH1, HL1 and HH1 wavelet coefficients. For constructing binary image using LH1, the each integer wavelet coefficients in LH1 is converted into 8 bit binary sequence, if 5^{th} bit of each binary sequence is 1 then assign 2 to binary

image otherwise assign 1. For constructing binary image using HL1 and HH1 is same as above.

e. Compress data in binary image obtained from LH1, HL1 and HH1 by using arithmetic coding because of its high coding efficiency. This compressed data is also embedding along with watermark data; this can be used later for inverting the watermarked image into original one.
f. The watermark signal is chosen to be a binary image or logo consisting of 0's and 1's.
g. Insert the header information, compressed data and watermark together, the embed signal consists of these three. If embedded bit is 1or (0) then convert first integer wavelet coefficient in LH1 sub band into 8 bit binary sequence and replace 1or (0) to the 5th bit plane of that binary sequence and convert back to integer. In this way all the embedded bits hide in "5th" bit-plane in the LH1, HL1 and HH1 coefficients.
h. The way of accessing each wavelet coefficient for embedding depends on secret key.
i. A secret key function that keeps the hidden data secret even after the algorithm is known to public.
j. Take the Inverse integer wavelet transform to reconstruct the watermarked image.
k. Perform histogram modification on watermarked image.
l. The invisibility of the watermarked image

We use the formula (1) to compare the difference between the original image and the watermarked image, Figure 5 demonstrates that the watermark embedded with the proposed algorithm is invisible, where (a) is the original image, and (b) is the watermarked image with PSNR=36.57 db.

$$PSNR = \frac{255^2}{\frac{1}{M \times N}\sum_{i=1}^{M}\sum_{j=1}^{N}(H(i,j)-W(i,j))^2} \quad (1)$$

Where

$H(i,j)$ Is Original cover image

$W(i,j)$ Is Watermarked image

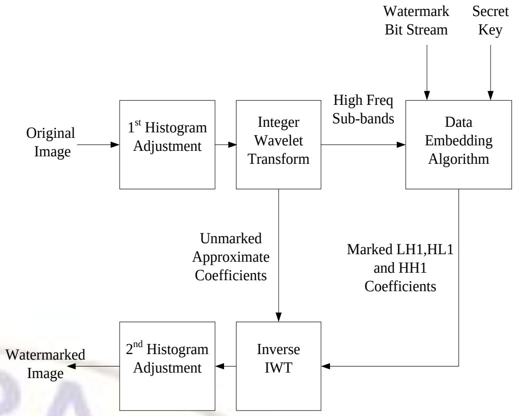


Fig.3 Embedding Method

2. Extraction Process

Extraction of watermark image and inverting of watermarked image into original one is reverse process of embedding.

a. Perform histogram modification on watermarked image.
b. Perform one level integer wavelet decomposition on watermarked image.
c. Extract the embed signal from 5th bit of LH1, HL1 and HH1 wavelet coefficients.

For extracting embed signal with using LH1, the each integer wavelet coefficient in LH1 is converted into 8 bit binary sequence and if 5th bit of each binary sequence is 1, then embed bit is 1 otherwise embed bit is 0.

The sample code given below:

```
Index=1
for i=1: size (LH1, 1)
for j=1:size(LH1,2)
binSeq = dec2bin (abs (LH1(i, j)),8);
if binSeq (5) == '1'
embed Signal (index, 1) = 1;
else
embed Signal(index,1) = 0;
end
index = index + 1;
end
end
```

For extracting embedded signal with using HL1 and HH1 same as above.

(a) Based on header information extract binary watermark image from embed signal.
(b) Extract the respective binary images of LH1, HL1 and HH1 from embed signal based on header information.
(c) Decompress to get the original sequence.
(d) Remove the watermark and insert the uncompressed 5th bit data back into LH1, HL1 and HH1.
(e) Take the Inverse integer wavelet transform to reconstruct the original image.

(f) Perform histogram adjustment on original image.

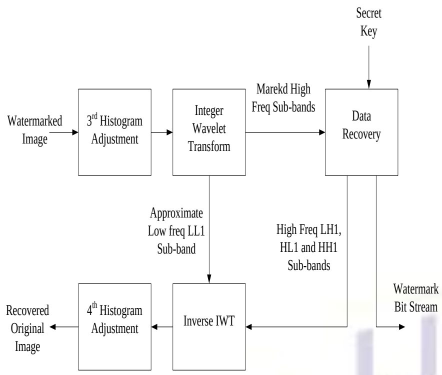


Fig.4 Extraction method

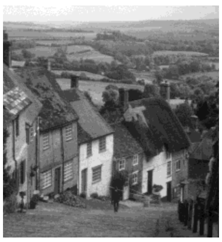
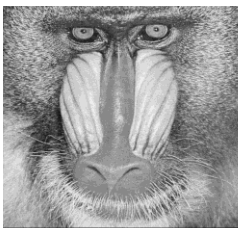
IMPLEMENTATION

The program code is written in 'MATLAB'. Test images of 'Airplane', 'Lena', 'Baboon', 'Gold hill', and 'Barbara' are used as input images for validation of developed algorithms. The wavelet decomposition of image is done by using CDF (2,2) wavelet filter.

The watermark logo is binary image created and embedded as per algorithm discussed. The embedding is done for the visible watermark logo. The resultant coefficients were inverse transformed to obtain the watermarked image. Several test gray scale images of size 512×512 are used in experiments. The original and marked Airplane images are shown in fig.5. The picture signal to noise ratio (PSNR) value of Airplane image after watermark embedding is measured as 36.57 db. It is observed that imperceptibility requirement is met. The same experiment is conducted on other four images. Fig.6 contains other four watermarked images. Table I shows some experimental results.


(a) (b)

Fig.5 Airplane image : (a) Original Airplane image (b) Watermarked image (PSNR=36.57 db)

(a) (b)


(c) (d)

Fig.6 Watermarked images (a) Watermarked Goldhill image (PSNR 35.57 db), (b) Watermarked Baboon image (PSNR 33.99 db), (c) Watermarked Barbara image (PSNR 35.52 db), (d) Watermarked Lena image (PSNR 36.81 db)

Table I The PSNR value after watermark embedding

Host Image 512×512	PSNR of marked Image (db)	Pay-load (Bits)
Lena	36.81	119716
Baboon	33.99	17689
Goldhill	35.37	77284
Airplane	36.57	196152
Barbara	35.52	72900

Table I show that Airplane image has a better embedding capacity than the other images in the experiment. It also shows it has a better visual quality as far as peak signal to noise ratio is concerned.

Table II shows image quality tested for different payloads on the same image using different wavelets. Among various wavelet filters, CDF(2,2) performs better than others for the same payloads. Image quality quickly changes when different wavelets are used. Performance in embedding measured using peak signal to noise ratio shows that db2 has the minimum quality. The embedding capacity also varies when using different wavelets when the image is decomposed using db2 embedding stops in about 75,000 bits whereas CDF(2,2) continues to embedded over one lakh bits.

Table II Comparison of performance of various wavelet families on Airplane image for different payload size

Payload bits	cdf(2,2) PSNR (db)	db2 PSNR (db)	Sym4 PSNR (db)	bior3.3 PSNR (db)	bior6.8 PSNR (db)	rbio3.3 PSNR (db)
10000	37.78	35.84	36.37	36.31	36.31	36.24
15129	37.73	35.78	36.25	36.28	36.23	36.29
20164	37.67	35.73	36.26	36.24	36.26	36.16
25281	37.60	35.69	36.11	36.16	36.00	35.99
50176	37.11	35.708	35.89	35.76	35.85	35.58
75076	36.84	35.67	35.90	35.71	36.00	34.67
100489	36.74	**	35.86	35.51	35.05	33.86

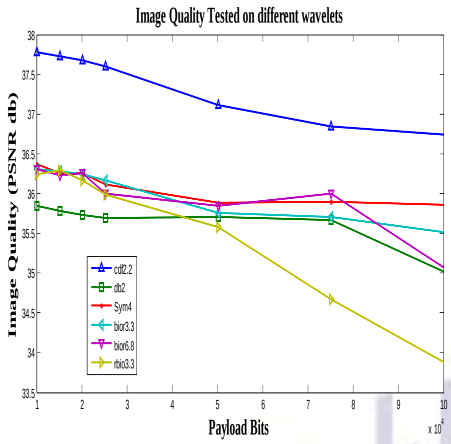


Fig.7 Image Quality Tested on Different Wavelets

Table III shows the comparison between existing methods in literature and proposed method. The proposed method is able to embed up to 196k bits into image of 512 by 512 imperceptibly.

Table III Comparison between existing methods and proposed method

Methods	The amount of data embedded in a 512 × 512 image
Goljan's	3,000-24,000 bits
Guorong	15,000-94,000 bits
Proposed	10000-1,96152 bits

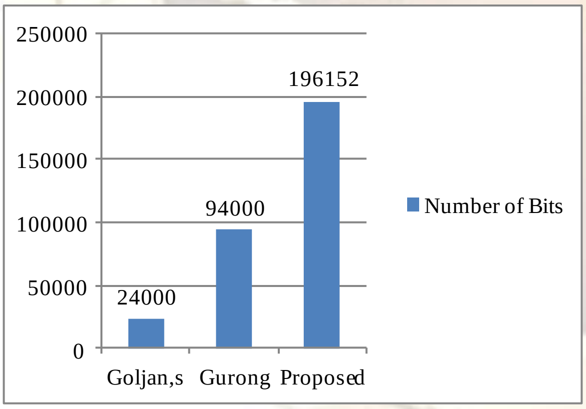


Fig.8 Comparison between proposed and existing methods

CONCLUSION

Simulation experiments on the digital watermarking of images have been performed using two standard images: Lena and Airplane. In proposed method instead of data embedding into single bit plane, the data embedded into multiple bit planes of middle frequency sub band coefficients of host image with sacrificing quality of the watermarked image. The proposed lossless high-capacity digital watermarking algorithm based on integer wavelet transform is able to embed up to 196k bits into image of 512 by 512 imperceptibly and extracts the embedded data and original image from watermarked image without loss of information. The performance of proposed lossless watermarking algorithm verified by various wavelet filters. Among various wavelet filters, CDF (2,2) performs better than others for the same payloads.

REFERENCES

[1] W. Sweden's, "The lifting scheme: A custom-design construction of biorthogonal wavelets," Appl. Computer. Harmon. Anal., vol. 3, no. 2, pp. 186–200, 1996.

[2] Fridrich, J.,Goljan, M., Du, R., "Invertible Authentication", In: Proc. SPIE, Security and Watermarking of Multimedia Contents, San Jose, California January 2001

[3] Jiang Zhu. M., Guorong Xuan., Jidong Chen., "Distortion less data hiding based on integer wavelet transform ", Vol.38, No.25, Electronics Letters 5th December 2002.

[4] I. Daubechies and W. Sweldens, "Factoring wavelet Transforms into lifting steps," J. Fourier Anal. Appl.,vol. 4, no. 3, pp. 245–267, 1998.

[5] M. D. Adams and F. Kossentini, "Performance evaluation of reversible integer-to-integer wavelettransforms for image compression," in IEEE Data Compression Conference, now bird, UT, USA, March 1999, pp. 514–524, IEEE.

[6] A. R. Calderbank, I. Daubechies, W. Sweldens and B. Yeo, "Wavelet transforms that map integers to integers," Applied and Computational Harmonic Analysis, vol.5, no.3, pp.332-369, 1998.

[7] G. Xuan, C. Yang, Y. Q. Shi and Z. Ni: High Capacity Lossless Data Hiding Algorithms. IEEE International Symposium on Circuits and Systems (ISCAS04), Vancouver, Canada, May 2004.

[8] D. Kundur, D.Hatzinakos, "Digital watermarking using multi resolution wavelet decomposition", Proceedings of the IEEE international conference on acoustics, speech and signal processing, Seattle, 1998.

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