International Journal of Image Processing and Vision Science

Volume 1 | Issue 4 Article 8

October 2012

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A CONTOURLET DOMAIN WATERMARKING ALGORITHM

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Abstract:-This paper presents a blind watermarking algorithm for digital images based on contourlet transform. After Contourlet transform, original image is decomposed into a series of multiscale, local and directional sub images. Each blocks of Arnold transformed watermark image, is embedded into suitable blocks of low pass coefficients of the contourlet transformed original image. Watermark is embedded using module arithmetic and odd-even quantization. The retrieving watermark algorithm is a blind detecting process, and it does not need original image. The experimental results show that the proposed watermarking algorithm is able to resist attacks, such as JPEG compression, noising, cropping and other attacks, and the watermarking is invisible and robust.

Keywords:-*Arnold transform, blind watermarking, Contourlet transform, module arithmetic, quantization*

I. INTRODUCTION

URING the past decade, with the development of information digitalization and internet, digital media increasingly predominate over traditional analog media. And also digital data can be shared by multiple users, distributed over network and is managed for longer period of time without any damage. However, as one of the concomitant side-effects, it is also becoming easier for some individual or group to copy and transmit digital products without the permission of the owner. Digital watermarking has been proposed as a solution to illegal copying or reproduction of digital data. The applications like copyright protection and authentication may mostly require the content owner or the authorized buyer to prove the authenticity without reference to the cover work. This creates a demand on blind watermarking techniques over non-blind watermarking techniques. For a watermarking scheme to be effective, it should have certain characters like imperceptibility, robustness, unambiguous. Wavelet based algorithms have been widely chosen for watermarking, since new image coding standards use wavelet domain representation and it models human visual systems as well. Wavelets are good at representing one dimensional signal. Two dimensional wavelet transform is a tensor product of a one dimensional wavelet, so they have limitation in capturing the geometry of image edges. Thus contourlet transform was defined to represent two dimensional signals more efficiently. Contourlet transform provides flexible multi-resolution, local and directional image expansion.[5] Contourlet D transform can also capture the intrinsic geometric structure which is the key in visual information. It is realized efficiently via a double iterated filter bank structure. In this double iterated filter bank structure, at first Laplacian Pyramid is used to capture point discontinuities and is followed by directional filter bank to link point discontinuities into linear structures [3]. Several digital image watermarking methods have been proposed. It includes both spatial and frequency domain techniques. Spatial-domain watermarking technologies change the intensity of original image or gray levels of its pixels. This kind of watrmarking is simple and with low computing complexity, because no frequency transform is needed. Frequency-domain watermarking embeds the watermark into the transformed image. Schyndel et al. [9] proposed a method for inserting information into original image using spatial domain technique. This method involves the embedding of the m-sequence on the LSB of the image data. The original 8 bit gray scale image data is capable of compression to 7 bits. But this method may be easily circumvented. Cox et al. [8] proposed a spread spectrum watermarking based on cosine transform in which watermark is embedded into perceptually most significant components of the data, thus the watermark is robust to signal processing operations. Maity et al. [4] proposed a blind spread spectrum watermarking scheme where watermark information is embedded redundantly in the multilevel wavelet coefficients of the cover image. High resiliency of the scheme is supported by good visual quality of the extracted watermark images from the several distorted watermarked images. Jayalakshmi et al. [2] proposed a relatively simple additive watermarking based on contourlet, the watermark is embedded into the high-pass coefficients of Contourlet transformed image, but the algorithm cannot to combine into the character of the carrier naturally, the visual quality decreased and the robustness are poor. Jingjing et al. [1] proposed a blind contourlet domain watermarking using module arithmetic, in which watermark is embedded into the low-pass coefficients of contourlet transformed, and it provides good robustness and invisibility. In order to increase robustness and invisibility, a new algorithm is proposed here. In this each blocks of watermark is embedded into that blocks of contourlet transformed original image which have optimum distance with the embedding watermark block. The paper is organized as follows. Section II, describes about Contourlet transform. And Section III describes the proposed algorithm. The simulation results of embedding and retrieval are given in Section IV. Conclusions are drawn in Section V.

II. CONTOURLET TRANSFORM

Contourlet transform gives flexible multi-resolution, local and directional image expansion. It is realized using Pyramidal Directional Filter Bank. Pyramidal Directional Filter Bank combines Laplacian Pyramid with Directional Filter Bank. Laplacian Pyramid captures the point discontinuities, and the directional filter bank links these discontinuities into linear structures [3]. Contourlet transform provides multi-scale decomposition of the image, which is obtained by using Laplacian Pyramid. Laplacian Pyramid at each level generates a down sampled low-pass version of the original and the difference between the original and prediction result in a band pass image [10]. The directional filter banks (DFB) are used to derive the high frequency sub bands with diverse directionality [7]. The DFB can be efficiently implemented via l-level binary tree decomposition that leads to 2l sub bands with wedge-shaped frequency supports[6]. Contourlet transform extends to the different scales, orientation and height-width ratio support, which makes it approach to the image. In the frequency domain, Contourlet provides a multiscale decomposition, but it has a redundancy by 33%, the redundancy is generated by the LP. Contourlet transform is unique since the number of directional bands could be specified by the user at any resolution. Fig 1 shows the contourlet filter bank.

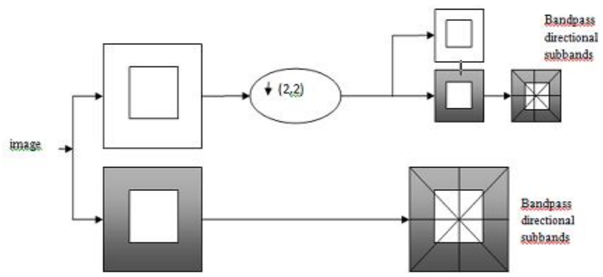

Figure 1.The contourlet filter bank: first, a multiscale decomposition by the Laplacian pyramid is computed, and then a directional filter bank is applied to each bandpass channel.

III. PROPOSED ALGORITHM

A. Watermark Embedding

Each blocks of watermark image is embedded into suitable blocks of original image, and save the block mappings on a table. Before embedding, each block of watermark image is scrambled using Arnold transform. Andon each blocks of original image, perform two times of contour let transform, and then make module arithmetic on it, and choose the result of it as the location to embed watermark. The steps of the embedding process of the watermark are as follows:

1) Perform Arnold transform on the watermark image, then save the number K of the scrambling as a key.
2) Divide transformed watermark image into blocks.
3) Divide original image into blocks.
4) Consider one block from the watermark image and each block in original image one by one, then do the following steps. a)On the original image block, perform Contourlet transform of one layer, then perform a second transform the same as the first to the low-frequency of the last transform, then select the sub band for watermark embedding (Dm)

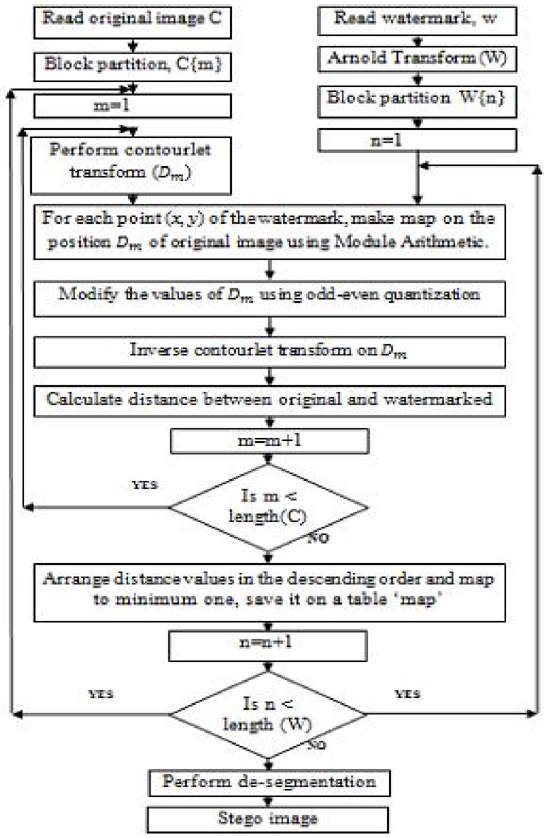

Figure 2.Watermark Embedding Algorithm

b) Perform module arithmetic in the embedding domain, for each point (x, y)of the watermark, make a map on the position Dm, the map as follows:

$$i = double(x + 2 * y) mod(Mc / 4) ,$$

$$j = double(3 * x + 7 * y) mod(Nc / 4) ,$$

where Mc, Nc is the size of the original image. c) Modify the value of each Dm using the quantization method of odd-even, the rules are as follows:

$$D_m{}'(i,j) = \begin{cases} D_m(i,j) & \text{if } Mod(r(i,j),2) = w(i,j) \\ [r(i,j)+1] * delta & \text{If } Mod(r(i,j),2) \neq w(i,j) \text{ and } w(i,j) = 1 \\ [r(i,j)-1] * delta & \text{If } Mod(r(i,j),2) \neq w(i,j) \text{ and } w(i,j) = 0 \end{cases}$$

$$r(i,j) = round(D_m(i,j) / \Delta)$$

Where, Dm (i,j), Dm'(i,j) are the values of the embedded points before and after the embedding respectively, W(i,j) means the relative (x, y) according to the map, round (•) represents the rounding operation, Δ represents the step size of the quantization.

d) Perform 2 times of inverse contourlet transform.

5) After this, calculate the distance between original and watermarked image, and map watermark into that position of original image which have minimum distance, and also save the block mappings on a table.

6) Repeat steps 4&5 untill all blocks of watermark image is considered

7) Perform de-segmentation on the blocks and result will be the watermarked image.

$$i = double(x + 2* y)mod(Mc / 4),$$

$$j = double(3* x + 7 * y)mod(Nc / 4),$$

where Mc , Nc are the size of the original image.

5) Modify the value of each D_m'' using the odd-even quantization method, the rules are as follows:

$$Ws_n(i,j) = \begin{cases} 0 \text{ if } Mod(r(i,j),2) = 0 \\ 1 \text{ if } Mod(r(i,j),2) = 1 \end{cases}$$

Where r (i, j) =round(D_m'' (i, j) /Δ) and D_m'' (i, j) is the value of the extraction points having been found, Ws_n(i,j) means the relative (x, y) according to the map.

6) Perform de-segmentation on the blocks of extracted

Watermarks

7) Perform Arnold anti-scrambling on Ws, the scrambling number is K, and the result W is the extracted watermark.

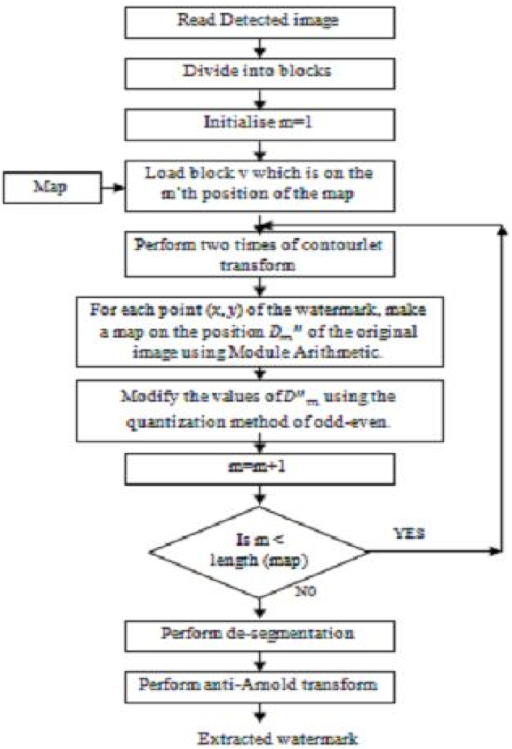

Figure 3.Watermark Extraction Algorithm

IV. RESULTS AND ANALYSIS

Simulation results with 400 x 400 Lena image and 48 x48 binary watermark are included here. In this imulation experiment, use a "9-7"pyramid filter of the LP, and use "pkva" orientation filter of DFB in the Contour let transform. To measure the quality of embedded method and extracted watermark, we use Signal-to-noise ratio (PSNR) and Normalized Correlation (NC) respectively. They can be defined as follows.

$$PSNR = 10log((255^2/MSE))$$

$$\text{Where } MSE = \frac{1}{M\times N}\sum_{i=1}^{M}\sum_{j=1}^{N}(I(i,j) - I'(i,j))$$

I(i,j) is the original image and I'(i,j) is the watermarked image.

$$NC(w,w') = \frac{\sum_{i=1}^{M}\sum_{j=1}^{N}A(i,j)A'(i,j)}{\sqrt{\sum_{i=1}^{N}\sum_{j=1}^{N}A(i,j)^2}\sqrt{\sum_{i=1}^{N}\sum_{j=1}^{N}A'(i,j)^2}}$$

A(i,j) is the pixel value of the original watermark, A"(i,j) is the pixel value of the extracted watermark. In this work, the step size of the quantization is selected as 40. If we increase step size of quantisation, the image is robust although we got more distorted image. The variation of PSNR with step size of quantisation, Δ is shown in Fig 4. The watermark selected in this experiment is shown in Fig 3b. Watermarked image of Lena is shown in Fig 3c. The retrieved watermark from this image is also shown in Fig 3d. Figure indicates that after the watermark is embedded, the distortion of the image is small. When the image is not attacked, the value of PSNR is 39.40.

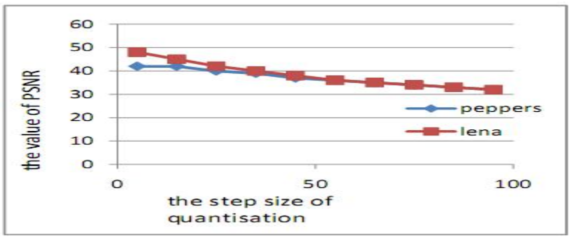

Figure 4. The relationship between PSNR and step size of quantisation

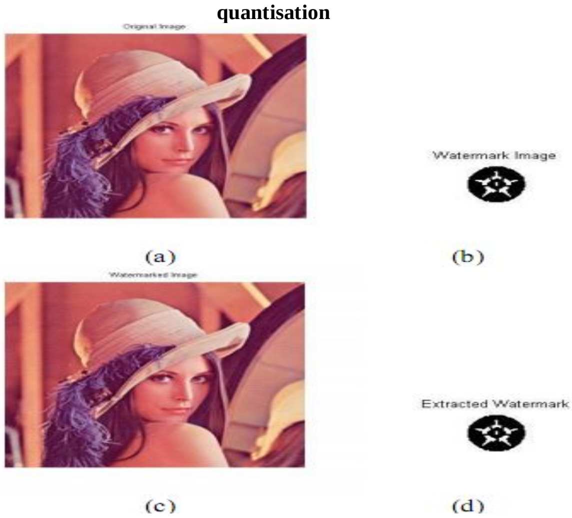

Figure 5. (a)original image, (b)Watermark, (c)watermarked images, (d)extracted watermark

Table 1 shows the PSNR of different images. Step size of quantisation is taken as 40 in both algorithms. From
this we can see that our algorithm will get a good visibility. Table II gives different NC under different attacks on Lena image, it also shows the comparison between our algorithm and reference [1] which uses the same original image and watermark, as shown in the table, our algorithm can resist a variety of attacks, and it has a better robustness.

TABLE I
THE PSNR OF DIFFERENT IMAGES

PSNR / Image	Reference[1]	Our algorithm
Lena	38.45	39.40
Barbara	37.63	39.11
Boat	36.00	39.14
Peppers	34.89	38.63

TABLE II
THE COMPARISON BETWEEN OUR ALGORITHM AND REFERENCE 1

Attacks	Our algorithm	Reference[1]
JPEG compressed (50%)	1.0000	1.0000
Gaussian low pass filter	1.0000	1.0000
Gaussian noise (0.1%)	1.0000	1.0000
Salt and pepper noise (0.1%)	.9970	0.9900
Median filter	1.0000	1.0000
Wiener filter	1.0000	.9900

V. CONCLUSION

In this paper, we proposed a contourlet domain blind watermarking using module arithmetic and odd even quantisation with the help of distance method. This will give better performance in terms of PSNR. Since the contourlet transform used here can also capture contour information, the extracted watermark should be in a good visible pattern. This watermarking algorithm has good perceptual invisibility, since watermark is embedded using optimum mapping. Block based transform is used here, so robustness would be increased. From the experimental results, we can see that the proposed method is superior to the conventional methods in perceptual invisibility. The robustness of our algorithm is tested against various attacks and the results prove that the proposed algorithm is better than existing algorithm. By varying the value of delta, the step size of quantisation, we can change the value of PSNR. Different factors like the number of scrambling times, the level of decomposition selected and the table representing optimum mapping determine the security of the algorithm.

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