OPTICAL ILLUMINATION WATERMARKING USING DB WAVELET

Parvinder Singh
Meenakshi Chhikara
Deenbandhu Chhotu Ram University of Science & Technology,
Murthal, Haryana, India

Abstract

We proposed a new technology with which real world object can be prevented from illegal photographing. In optical illumination watermarking we have used Db10 wavelet to make the watermark pattern invisible to human eye and also to have 100% accuracy forreading out embedded data. Various different images have been used for generating watermark pattern of various pixel size viz. 2x2, 4x4, 8x8, 16x16. The result revealed that Db10 is effective technique to be used in optical illumination watermarking.

Keywords: Optical illumination watermarking, DB Wavelet

Introduction

The protection of copyrights of digital data has been the main concern from the time the digital communication developed. The digital data is easily prone to attack including change of data or reproduction of data without the originators permission. Watermarking techniques have been widely recognized as methods of protecting the copyrights of image content [10]-[17].In order to prevent the data many watermarking technologies has been developed which protect the data from malicious handling [3]. The watermark is made invisible for the human visual system so that it can't be detected by the attacker or distributor and later on can be used by the authenticator to detect the authenticity of the data. Recently digital watermarking has also been used in printed images, where watermark is embedded in the digital data before it is printed [4],[5]. This is to prevent illegal use of images copied by digital cameras or scanners. However, printed images that have not been produced from digital data, eg pictures at museums that have been painted by artists, do not contain digital watermarking and thus photographs of these objects can be easily utilized without copyright. Various techniques have been proposed in the recent years to protect such non digital data from unauthorized use. These techniques are named as "optical illumination watermarking",where the illumination contains watermark data.

Optical illumination watermarking is the technique where object is illuminated with the watermark. Thus any photograph of such object also contains the watermark data without the knowledge of photographer and hence the non digital data is protected. By digitalizing this photographic image, watermarking information can be extracted through various processes in the same way as the conventional watermarking technique. Many methods have been proposed in order to make watermark both robust and imperceptible to human visual system.The techniques such as DCT[5], WHT[7] and Haar DWT [8]have been used previously.

This paper proposes a new optical watermarking technique that makes watermark invisible to human. We have used Db DWT technique in order to make watermark more robust and invisible. We have used various block size to generate watermark pattern.

Procedure for producing optical watermark

Fig.1 explains the procedure of producing watermark using DCT[5]. I-DCT is used to produce watermark pattern.

$$f_{i,j}(x,y) = \sum_{u}^{N-1} \sum_{v}^{N-1} C(u)C(v)F_{i,j}(u,v) \cos\left\{\frac{(2x+1)u\pi}{2N}\right\} \cos\left\{\frac{(2y+1)v\pi}{2N}\right\} \quad (1)$$

where fi,j(x,y) is the watermarking image data for pixel (x,y) of the block (i, j), Fi,j(u,v) are the data for pixel (u, v) of block (i, j) in frequency space, N is the number of pixels of the block in the x and y directions.

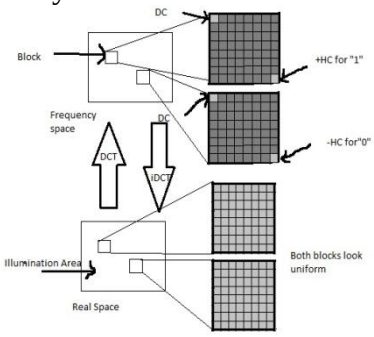

Fig.1: Procedure for DCT

When 2D inverse WHT is used, the equation is expressed by

$$f_{i,j}(x,y) = \frac{1}{N} \sum_{u}^{N-1} \sum_{v}^{N-1} F_{i,j}(u,v) wh(x,u) wh(v,y) \quad (2)$$

Fig.2 illustrate procedure, when wavelet is used to produce watermark images[8].

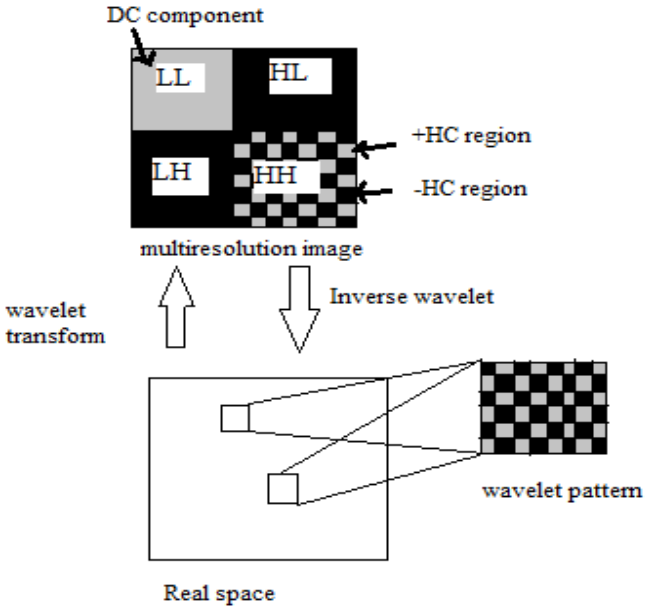

Fig.2: Procedure for wavelet

The DC value is provided to entire LL plane, this gives the average brightness to the entire watermarked area. The HC value for the HH component is provided to every component block which would give the information of watermark pattern. All components of HL and LH are given value 0.

We have used block Db wavelet technique in order to generate watermark pattern. Different block sizes viz. 2x2, 4x4,8x8,16x16have been used to generate different watermark pattern.

Experiment

The key factor in optical illumination watermarking is to keep the watermark pattern both invisible and readable when it contained in light and also when captured using camera. We carried out experiments to evaluate these characteristic in the performance of the proposed technique.

Watermark Pattern

Various images were taken to work as the watermark pattern. Every image underwent the forward block db wavelet transformation, block haar transform and block DCT. All these transformation results various watermarking images. The block size taken was 2x2, 4x4, 8x8, 16x16 pixels per block.

The DC value was kept constant to 150 in the experiment, which gave the average brightness to the entire watermark pattern. The HC value was changed from 0 to 25.

Equipment Used

The experiment utilized a digital projector to project watermark pattern on the object in order to have watermark through light. A digital camera was used to capture the images of object having illuminated watermarking. We have used a wall painting to be our object image in the experiment.

Layout

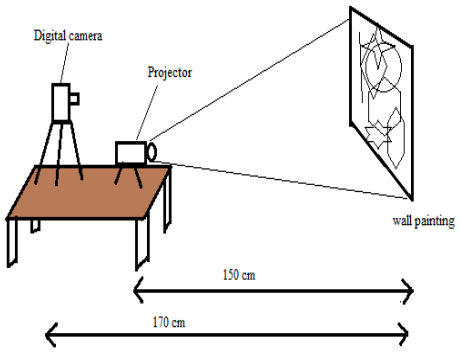

Fig.3: Layout for experiment

Fig.3 explains the layout of the experiment. The projector was kept at approximately 150 cm away from the object to be watermarked. The digital camera was behind the projector in order to capture the images.

Evaluation of Readability

When block DCT was used watermark readability was evaluated by checking the phase of every block of the captured image. The phase was checked by computing forward block DCT of image and then checking the sign of (N-1,N-1) pixel of every block[7].When the wavelet was used for watermarking we got a multiresolution image and therefore DCT readability method cannot be used. For wavelet we took the HH component of the image by using forward block wavelet and then calculate the average of the every block of HH plane. The average value gave us the sign of the phase of that block. For negative average value we term the read out value as "0" and for positive average value we term the read out value to be "1"[8]

The accuracy of the detection of the watermark data read out from the image was evaluated on the basis that readout data gives the check board pattern when blocks with value 0 and 1 are alternatively placed in every technique.

Evaluation of Invisibility

We evaluated the invisibility of test pattern with the subjective test. The watermarking patterns were projected on the object and the viewers were asked to notice the projected image from more than 1m of distance. Under these conditions the viewers were asked to observe the pattern. The patterns with different HC values were projected randomly. Six viewers participated in the invisibility test and all were having correct eyesight.

Result and Discussion

Fig. 4 gives some of the patterns which were projected for readability and invisibility. We have tested around 200 patterns for the experiment. The patterns generated were similar to the check board pattern. The size of every pattern was kept constant. A single painting was used to project different patterns. The patterns were cropped and zoomed in figure, showing only a part of the entire pattern.

Readability

Table 1 gives the result of accuracy of the data readout from the watermarked images of the experiment. The accuracy is indicated by the percentage of the data to be read out correctly from the entire data.

Invisibility

Table 2 summarises the result of invisibility of the projected watermark pattern. Six viewers took part in the visibility test. They were made to observe the object from a fairly distance. With the result it is clear that the pattern become invisible when db10 is used in any watermark pattern.

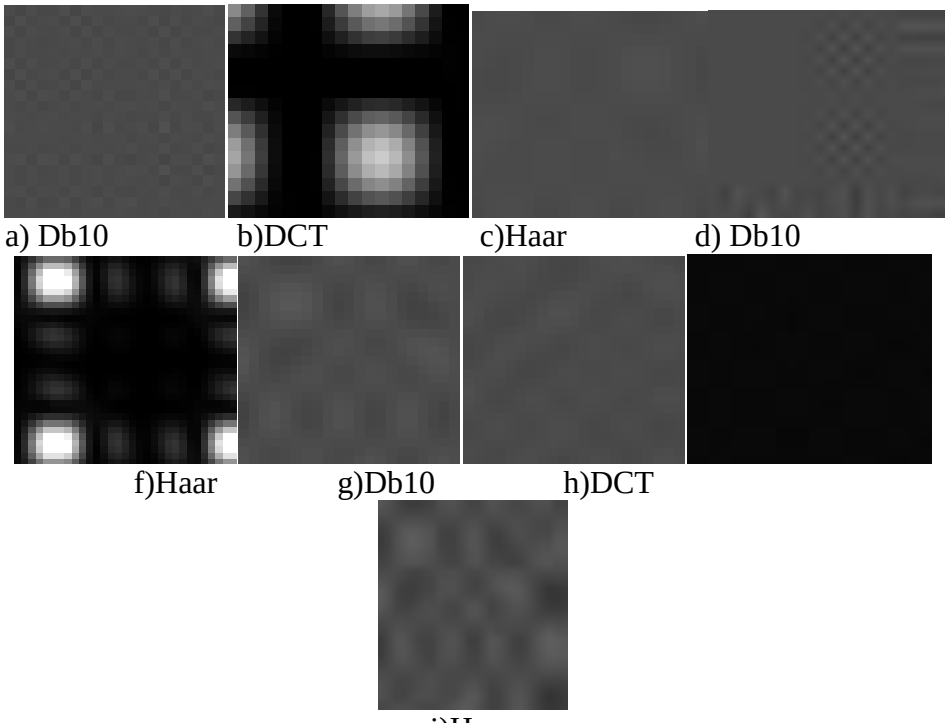

Fig.4. (a) to (c) block size 4, HC value 5, (d) to (f) block size 8, HC value15, (g) to (i) block size 16, HC value 25

Table 1 Accuracy of reading out watermarked data

Experimental condition			Accuracy(%)			
Techniques	DC	HC	2x2	4x4	8x8	16x16
Db10	150	0	92	95	97	99
		5	93	97	98	99
		10	100	100	100	100
		15	100	100	100	100
		20	100	100	100	100
		25	100	100	100	100
DCT	150	0	96	97	97.5	100
		5	97	98	99	100
		10	98	100	100	100
		15	100	100	100	100
		20	100	100	100	100
		25	100	100	100	100
Haar	150	0	94	95	97	98
		5	96	97	100	100
		10	100	100	100	100
		15	100	100	100	100
		20	100	100	100	100
		25	100	100	100	100

Table 2: Results of invisibility of projected watermarking pattern based on subjective test

Experimental condition			Invisibility			
Techniques	DC	HC	2x2	4x4	8x8	16x16
Db10	150	0	Y	Y	Y	Y
		5	Y	Y	Y	Y
		10	Y	Y	Y	Y
		15	Y	Y	Y	Y
		20	Y	Y	N	Y
		25	Y	Y	N	Y
DCT	150	0	Y	N	N	N
		5	Y	N	N	N
		10	Y	N	N	N
		15	Y	N	N	N
		20	N	Y	Y	Y
		25	N	Y	Y	Y
Haar	150	0	Y	Y	Y	Y
		5	Y	Y	Y	Y
		10	Y	Y	Y	Y
		15	Y	Y	Y	Y
		20	N	N	N	N
		25	N	N	N	N

Watermarking Pattern

We have carried out histogram analysis in order to check the difference in the pattern generated. The analysis revealed that block Haar technique gives the same pattern irrespective of image and the experimental conditions. Thus we can conclude that Haar patterns are not robust and can be easily forged whereas Db10 and DCT gave fairly different patterns.

Peak Signal-to-Noise Ratio

We have used Peak Signal-to-Noise ratio for the objective evaluation. The PSNR was obtained from the original image i.e. image without watermark and watermarked image. The PSNR was calculated using (3).

$$PSNR = 20\log_{10}\frac{2552}{\sum_{i,j}\{xo(i,j)-xw(i,j)\}2} \quad (3)$$

Where xo(i,j) is the pixel value of original image data, xw(i,j) is the pixel value of the watermark image data. Fig 5 shows PSNR values of the experiment. From these graph we conclude that Db10 technique has high PSNR value and thus is effective to use for optical illuminationwatermarking.

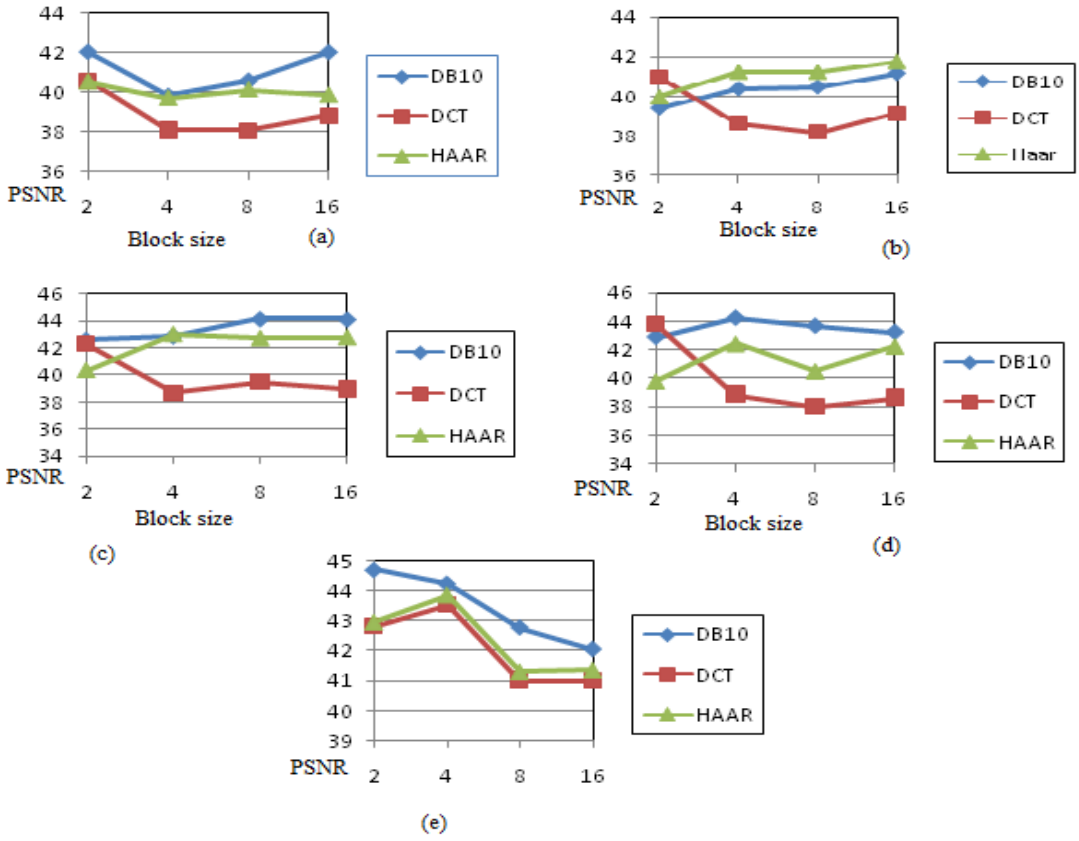

Fig. 5: (a) HC value 0, (b) HC value 5, (c) HC value 10, (d) HC value 15 (e) HC value 25

Conclusion

We have proposed a new method of watermarking using illumination which contains watermark information. It can prevent the illegal use of the captured images of the object that are difficult to protect otherwise. We have used db10 as the orthogonal transform to produce watermark pattern. We have conducted experiment where patterns were developed using various pixels per block and have used 200 different patterns in order to gain objective. The experimental result revealed that the accuracy with which embedded data is read out using Db10 is nearly 100%. The pattern generated using Db10 are all different from each other thus providing security against forging. PSNR value has also given positive results. DCT and Haar were also used in the experiment which resulted that the watermark pattern generated by Db10 are more invisible, robust and secure than the pattern generated by Haar and DCT. The technique can be further evaluated under varying environmental conditions.

References:

Kazutake Uehira and Masahiro Suzuki,“Digital watermarking technique using brightness-modulated light", ICME, pp. 257–260, 2008.

T. Yi-zhou, L. Hai-bo, H. Shui-hua, S. Ben-jian, and P. Zhong-ming, "An Optical Watermarking Solution for Color Personal Identification Pictures," Proceedings of the SPIE vol. 7512, pp. 1–6, 2009.
D. Mistry, "Comparison of Digital Water Marking methods," IJCSE, vol. 02, no. 09, pp. 2905–2909, 2010.
T. Mizumoto and K. Matsui, "Robustness investigation of DCT digital watermark for printing and scanning", Trans, IEICE (A), Vol.J85-A, No.4; pp.451-459 (2002).
M.Ejima and A. Miyazaki, "Digital watermark technique for hard copy image" , Trans, IEICE (A), Vol. J82-A, No.7; pp.1156- 1159 (1999).
V. Solachidis, I. Pitas, "Circularly Symmetric Watermark Embedding in 2-D DFT Domain," Proceedings of the 1999 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP 1999), Vol. 6, Phoenix, AZ, March 15-19, 3469-3472(1999).
Y. Ishikawa, K. Uehira, and K. Yanaka, "Practical Evaluation Technique Using Orthogonal Transforms," journal of display technology., vol. 6, no. 9, pp. 351–358, 2010.
Y. Ishikawa, K. Uehira, and K. Yanaka, "Optimization of Size of Pixel Blocks for Orthogonal Transform in Optical Watermarking Technique," J. Disp. Technol., vol. 8, no. 9, pp. 505–510, Sep. 2012.
U. K., Komori Mizuho, "Optical watermarking technology for protecting portrait rights of three- dimensional shaped real objects using one-dimensional high-frequency patterns," J. Electron. Imaging, Vol. 22(3),Jul.-Sep. 2013.
J. Cox, J. Kilian, F. T. Leighton, and T. Shamoon, "Secure spread spectrum watermarking for multimedia," IEEE Trans. Image Process., vol. 6, no. 12, pp. 1673–1687, Dec. 1997.
M. D. Swanson, M. Kobayashi, and A. H. Tewfik, "Multimedia data- embedding and watermarking technologies," Proc. IEEE, vol. 86, no. 6, pp. 1064–1087, Jun. 1998.
M. Hartung and M. Kutter, "Multimedia watermarking techniques," Proc IEEE, vol. 87, no. 7, pp. 1079–1107, Jul. 1999.
G. C. Langelaar, I. Setyawan, and R. L. Lagendij, "Watermarking digital image and video data," IEEE Signal Process. Mag., vol. 17, no. 5, pp. 20–46, 2000.
Parvinder Singh, Sudhir Batra, HR Sharma, "Evaluating the Performance of Message Hidden in 1st and 2nd Bit Plane", WSEAS Transactions on Information Science and Applications, issue 8, vol 2, August 2005, pp 1220-1227.
Jasvinder Kaur, Manoj Duhan, Ashok Kumar, Raj Kumar Yadav, Matrix Matching Method for Secret Communication using Image Steganography, Annals of Faculty Enginnering, Hunedoara, International Journal of Engineering, Tome X, Fascicule 3, pp. 45-48, 2012
Parvinder Singh, Sudhir Batra, H R Sharma, "Steganographic Methods Based on Digital Logic", 6th International Conference on Signal Processing, Dallas, USA, March 22-24,2007.
K. Okihara, Y. Inazumi, and H. Kinoshita, "A watermark method that improve the relationship between of the number of embedded bits and image degradation," J. IEIJ, vol. 58, no. 10, pp. 1465–1467,2004.