An Algorithm for Scaling Parameter Optimization of Watermarking using Random Dot Images

In-Jung Lee* *Regular Member*

랜덤한 점분포를 가진 영상을 사용한 워터마킹에서 스켈링 파라메타의 최적화 알고리즘

정회원 이 인 정*

ABSTRACT

For a digital image watermarking some autostereograms are used such as random dot images. In there, the extraction efficiency is good and the distortion rate is low. In this paper, we shall select an optimized scaling parameter which derives low distortion rate and high extraction efficiency, when we use a random dot images as like as autostereograms into some images except for extremely biased gray level images.

Keyword : Watermarking

I. INTRODUCTION

Digital watermarking is very useful to set up a controlled multimedia data distribution and provides efficient means for copyright protection. For some digital watermarking, Pitas and Kaskalis[1,2] suggested that a picture can be split in two subsets of equal size. The brightness of the pixels of the one is altered by adding a positive integer k. This factor kis calculated using the variances of two subsets. The difference of the means between two subsets can be calculated. Carroni[2,3] suggested a method which embeds a bit stream in the luminance value of an image. Zhao and Koch[2,4] propose a method to embed a bit stream into the DCT which is like JPEG algorithm method. And another method suggested by Cox et. al[2,5,6] is one of the most popular method which is to embed a sequence of real numbers in an N×Nimage by computing the DCT and adding the sequence to the n highest, excluding the DC component. To extract the sequence, the DCT transform of original image is subtracted from the DCT transform of the labeled one and sequence is extracted from highest coefficients. In these cases, watermarking efficiency is good with randomly distributed embeddablewatermarking image. Since the randomly distributed image derives good efficiency, we can get some idea choosing optimal parameter. The ranom dot image is a dotted image in which every pixel is randomly distributed all over. For example, in fig 1., we show an image that is transformed by random number generator from an logo image.

We know that the autostereogram is a random dot image because we can find a random number generator in [7]. In this paper, we propose some watermarking that use autostereograms for embedding watermark. The basic concept of autostereograms that fusing of the two eyes' images to produce the effect of depth (be called stereopsis). Stereopsis occurs naturally when viewing solid objects with both eyes [7]. This is

*호서대학교 컴퓨터공학부(leeij@office.hoseo.ac.kr)
논문번호 : 030323-0801, 접수일자 : 2003년 8월 1일

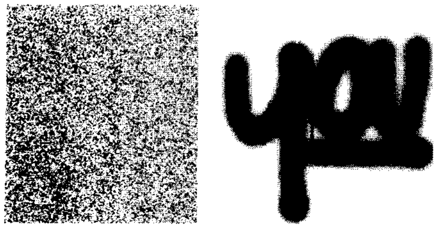


Fig. 1. Randomly distributed image transformed by random number generator from a logo image.

the direct sensing of the distance of an object by comparing the images received by the two eyes. This can be done only when the eyes of a creature look in the same direction, and have overlapping fields. In this way, the placing of the two eyes gives up the opportunity of a wide field of view obtained with eyes on the sides of the head[8]. Predators find it best to have eyes in front, prey to have them on the sides. It is possible with two-dimensional pictures only when each eye receives a separate image, corresponding to the view of the actual 3D object depicted as in Fig.2. In Fig.3, we show an autostereogram of hemisphere with gray level. In this research, we argue that a watermark has to be embedded with partially optimization of scaling parameter in

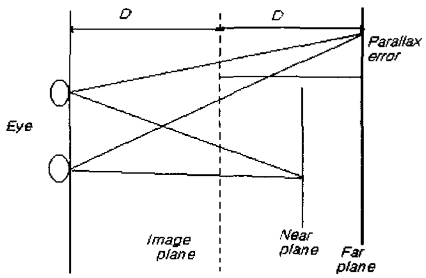


Fig. 2. Principals of Autostreogram

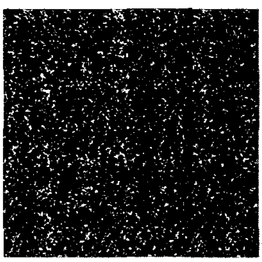


Fig. 3. Autostreogram of hemisphere

order to adjust the quantity of watermark data. In other words, for minimizing the distortion of original images and maximizing extracted watermark, the scaling parameter can be partially adjusted.

II. SCALING PARAMETER

By Cox's method [5,6], when watermark X inserts into image V, a scaling parameter α determines the extent to which X alters V as shown in Eq.1.

$$v_i' = v_i + \alpha x_i \qquad \text{Eq.1}$$

where, $V = \{v_1, v_2, \ldots, v_n\}$ is coefficient set which is a transformed original image by DCT or FFT.

$X = \{x_1, x_2, \ldots, x_n\}$ is watermark sequence.

$V' = \{v_1', v_2', \ldots, v_n'\}$ is adjusted sequence.

In Eq.1, a scaling parameter α may not be applicable for perturbing all of the values v_i, because different spectral components may exhibit more or less tolerance to modification.

In this research, we propose an optimized scaling parameter α adjusting the quantity of watermark data.

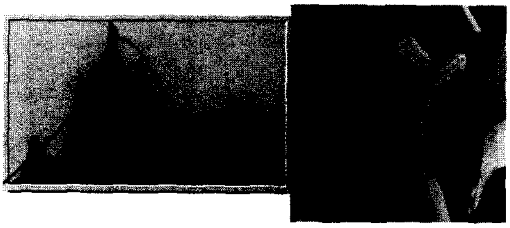
For implementing this method, first, original image is transformed by using DCT, and then generate the watermark by compounding autostereograms make the watermarked image using inverse transformation.

III. OPTIMIZATION OF THE PARAMETER

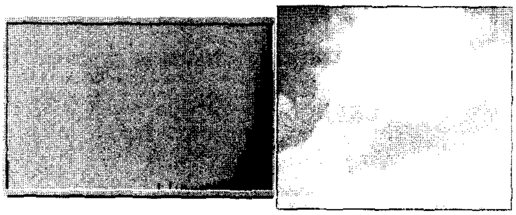
Watermark in order to optimize the scaling parameter in case We consider the maximizing of using autostereograms. In this case, the distortion of original image can be minimized and the detected watermark can be maximized.

In Eq.1, the scaling parameter α determines the quality of watermark images. We want to minimize the distortion of theoriginal image and to maximize detection rate of watermarked images. We assume a general image set such that for every image in this set the gray level is near a Gauss distribution as in Fig.4 in that we show biased image.

Let us define similarity $Sim\ (X, Y)$ of two images X and Y as follows as Cox's method:



a) A sample of general image with gray level in that dashed line is Gauss distribution



b) A sample of not general image

Fig. 4. A sample of general image or not general image with their gray level.

$$Sim(X,Y) = \mathrm{cov}(X,Y)/(\sigma_X \sigma_Y) \quad \text{Eq.2}$$

where σ_X and σ_Y are standard deviation of X and Y respectively, $\mathrm{cov}(X,Y)$ is covariance of Xand Y. We mean the maximizing that the similarity is near one between the extracted autostereogram I' and the original autostereogram I. When any autostreogram is compounded we can encode and decode watermark as follows. Let WY be a watermarked image and OX be an original image.

Then

$$\begin{aligned} WY &= IDCT(DCT(OX) + \alpha DCT(I)) \\ &= IDCT(DCT(OX)) + \alpha IDCT(DCT(I)) \\ &= OX + \alpha I + \varepsilon(OX) + \varepsilon(I) \end{aligned} \quad \text{Eq.3}$$

where $\varepsilon(OX) + \varepsilon(I)$ is error term. We set

$$\begin{aligned} I' &= \frac{1}{\alpha} IDCT(DCT(WY) - DCT(OX)) \\ &= \frac{1}{\alpha}(OX + \alpha I - OX + \varepsilon(\varepsilon(OX) + \varepsilon(I)) + \varepsilon(OX)) \\ &= I + \frac{1}{\alpha}(\varepsilon(\varepsilon(OX) + \varepsilon(I)) + \varepsilon(OX)) \end{aligned} \quad \text{Eq.4}$$

which is the detected watermark. Let $Sim\ (I, I')$ be the extraction efficiency and let $1/|Sim\,(OX, WY)|$ be the degree of distortion. We assume that OX and I are mutually independent, error term is constant and OX is an element of general image set, then standard deviation of OX is bounded. Applying Eq.3,

Where K is the smallest value of $\frac{\sigma_I}{\sigma_{OX}}$,

$$\begin{aligned} Sim\,(OX, WY) &= \frac{\mathrm{cov}(WX, OX)}{\sigma_{WX}\sigma_{OX}} \\ &= \frac{\sigma_{OX}^2}{\sqrt{\sigma_{OX}^2 + \alpha^2\sigma_I^2}\sqrt{\sigma_{OX}^2}} \\ &\le \frac{1}{\sqrt{1 + \alpha^2 K^2}} \end{aligned} \quad \text{Eq.5}$$

Applying Eq.4, since $\varepsilon(I)$ is very small,

$$\begin{aligned} Sim\,(I, I') &= \frac{\mathrm{cov}(I, I')}{\sigma_I \sigma_{I'}} \\ &= \frac{1 + \frac{rM}{\alpha}}{\sqrt{1 + \frac{rM}{\alpha} + \frac{M^2}{\alpha^2}}} \\ &\approx 1 \end{aligned} \quad \text{Eq.6}$$

where $M = \dfrac{\sigma_{\varepsilon(I)}}{\sigma_I}$, $-1 \le r \le 1$.

Thus the extraction efficiency is almost constant. As α increases, the degree of distortion

$$1 / | Sim(OX, WY) |$$

$$\ge \sqrt{1+\alpha^2 K^2}$$

is increase. When we assume that original image is a general image and watermark image is an autostereogram with gray level as in Fig. 5. Since σ_{OX} is small,then K is about 85 with 5% errors.

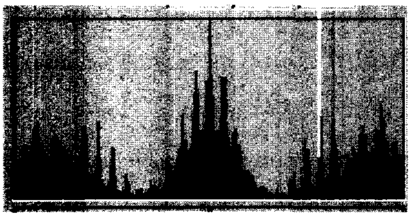


Fig. 5. Gray level of an autostereogram

We can detect a image distortion by two eyes when the absolute value of similarity is less than 0.6. In this case, the distortion limit is 1.7 and we show that the optimal α=0.016 with error 5% from $\sqrt{1+\alpha^2 K^2} \le 1.7^2$

III. EXPERIMENTAL RESULTS AND ROBUSTNESS

The distortion limit is about 1.7, in this situation, the maximum scaling parameter α is about 0.016. If α is less than 0.016, distortion is not occurred, if not, distortion is occurred. In fig. 6, we can see that the extraction efficiency should not be changed extremely, and the degree of distortion should be changed heavily as scaling parameter 0.016. The experimental results are shown in fig. 7, accordingto scaling parameter 0.01 and 0.1. Because human eyes are not accurate, we can find some distortion when scaling parameter has big difference.

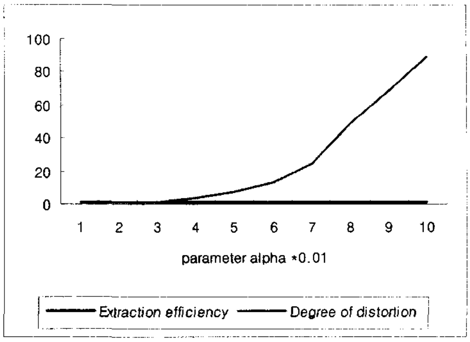
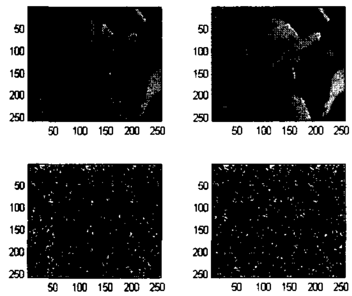
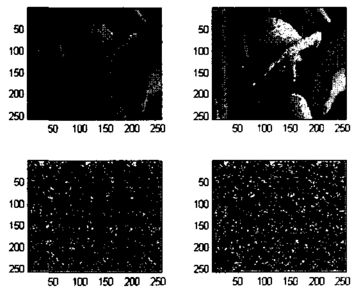


Fig. 6. The change of extraction efficiency and degree of distortion



α =0.01



α =0.1

Fig. 7. The images according to scaling parameter 0.01 and 0.1 in which upper left is original image and upper right is watermarked image lower left is original autostereogram and right is detected autostereogram.

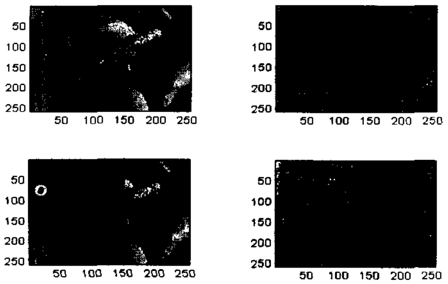


Fig. 8. Upper two images is showing robustness as adding noise in which left image is noised and right image is detected autostreogram and lower two images is showing robustness as damaging in which left is damaged and right is detected image.

The robustness is showing when some noise is added in watermarked image and as cropping in Fig. 8 in which autostereogram is used. We show the similarity is good between original autostereogram and detected one whennoise and cropping is occurred. We know that, in Table 1., robustness is good when the cropping and the noise is added and robustness nearly do not depend scale parameter.

IV. CONCLUSIONS

The digital image watermarking method using autostreograms is good for searching scaling parameter which is a optimum value. In this paper, we find that a watermark using autostreograms as random dot image can be embedded with properly selected scaling parameter in order to adjust the quantity of watermark data. If an embeddable image is not a general image, we cannot obtain a adjusted parameter. Therefore we assume a general image set such that for every image in this set the gray level is near a Gauss distribution. We show the similarity is good between original autostereograms and detected image when noise and cropping is occurred. Consequently, the optimized scaling parameter can be extracted for general embeddable image using autostreograms to watermark.

Table 1. Similarity as Robustness and Distortion Change in RENNA

α	Degree of Distortion	Similarity after Cropping	Similarity after Noising
0.01	1.042	0.59	0.54
0.02	1.67	0.78	0.75
0.03	2.31	0.93	0.87
0.04	3.73	0.91	0.84
0.05	7.86	0.56	0.57
0.06	13.87	0.87	0.82
0.07	24.32	0.82	0.76
0.08	48.92	0.64	0.63
0.09	68.45	0.89	0.86
0.10	88.43	0.94	0.87

REFERENCES

[1] G.C. Langelaar, J.C.A. van der Lubbe, J. Biemond, "Copy Protection for Multimedia Data based on Labeling Techniques,": http://wwwit.et.tudelft.nl/html/research/smash/public/beneluxcr.html

[2] I. Pitas, T. Kaskalis, "Signature Casting on Digital Image," Proc. of IEEE Workshop on Nonlinear signal and Image Processing, Neos Marmaras, Jun., 1995.

[3] Talisman:http://www.tele.ucl.ac.be/IMAGES/ACTS/talisman.html

[4] J. Zhao, E. Koch, "Embedding Robust Labels into Images for Copyright Protection," Proc. of the International Congress on Intellectual Property Rights for Specialize Information, Knowledge and New Technologies, Vienna, Austria, Aug. 1995.

[5] I.J. Cox, J. Kilian, T. Leighton, T. Shamoon, "Secure Spread Spectrum Watermarking for Multimedia," IEEE Trans. on Image Processing, Vol. 6, No. 12, pp.1673-1687, 1997.

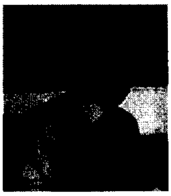
[6] I.J. Cox, J. Kalian, T. Leighton, T. Shamoon, "A Secure, Robust Watermark for

Multimedia," Workshop on Information Hiding, Newton Institute, Univ. of Cambridge, May, 1996.

[7] Harold W. Thimbleby, S. Inglis., Ian H. Witten "Displaying 3D Images: Algorithms for Single-Image Random-Dot Stereograms," Proc. of IEEE Computers, Oct. 1994, pp.38-48.

[8] R. W. Burnham, R. M. Haynes and C. J. Bartleson, Color: A Guide to Basic Facts and Concepts (New York: John Wiley & Sons, 1963).

이 인 정(In-Jung Lee) 정회원



1981년 : 전남대학교 수학과 이학사

1984년 : 중앙대학교 수학과 이학석사

1990년 : 중앙대학교 수학과 이학박사

2002년 : 아주대학교 전자공학과 공학박사

1992년 - 현재 : 호서대학교 컴퓨터공학부 부교수

<주관심분야> 영상신호처리, 수치해석, 인공지능