International Journal of Multimedia and Ubiquitous Engineering
Vol.10, No.12 (2015), pp.245-254
http://dx.doi.org/10.14257/ijmue.2015.10.12.25

Spectral Domain Scrambling

Gwanggil Jeon

Department of Embedded Systems Engineering, Incheon National University
119 Academy-ro, Yeonsu-gu, Incheon 406-772, Korea
gjeon@inu.ac.kr

Abstract

Video contents may adopt various conditions for one may access a system and this system may adopt pay-per-view. This scrambling method is used in commercial way to protect copyright. As image and video contents are widely released, content protection becomes an important issue. In this paper, we present a scrambling method which uses magnitude and phase decomposition. A given image is transformed into spectral domain to obtain magnitude and phase components. The magnitude component is transferred to unauthorized individual. However phase component is selectively distributed to protect contents because phase component contains important information. Simulation results show that the proposed method gives reliable performance.

Keywords: *Scrambling, video, image, protection*

1. Introduction

A video has various conditional access rules that are adopted for pay per view or subscriber regarded services [1-8]. In many cases, owners of video contents would like to fully control access of subscription. In this paper, we proposed a scrambling method which protects the copyright of the content [9-11].

Recently, the scrambling method is widely used because copyright issue is important [12-16]. The goal of scrambling method is to hide important information and only show desirable or trivial scene, and therefore attracts individuals to subscribe contents. We assume that the proposed video scrambling method may stop undesirable interception and watching of any possible transmitted video. The human visual system is very sensitive at spotting distortions in pictures, poor video decoding is not desired. Thus, it is very important to select the right video scrambling method because the contents still has to attract viewers although it is not fully watchable. There are several approaches concerning video scrambling [17-20].

This paper proposes a new scrambling method which works as follows. We assume a video signal is transmitted. To allow individuals watch contents, authentication process is applied and each individual is allowed or not-allowed watch video. The legal viewers are awarded a correct key to solve phase issue, and the others are given wrong key. The original video is decomposed by magnitude and phase signal, and magnitude signal is transmitted unconditionally. However, as most important information is carried in phase, only legal viewers can watch watchable video.

This paper is organized as follows. Section 2 shows the proposed method. Section 3 explains simulation results. Section 4 shows conclusion remarks and finalize this paper.

2. Proposed Method

The Fourier transform is one of important tools for image processing. It makes us to understand spectral domain image processing quickly. The two dimensional Fourier transform allows one to see the frequency spectrum of the data in both dimensions and

ISSN: 1975-0080 IJMUE

have one visualize filtering operations more easily. The 1D DFT is explained as follows. Let us assume

$$\mathbf{f} = [\, f_0,\ f_1,\ f_2, \ldots,\ f_{N-1}] \,, \tag{1}$$

Where **f** is a sequence of length *N*. Then, we state DFT as

$$\mathbf{F} = [F_0, F_1, F_2, \ldots, F_{N-1}] \,, \tag{2}$$

Where

$$F_u = \frac{1}{N} \sum_{x=0}^{N-1} \exp\left(-2\pi i \frac{xu}{N} \right) f_x \,. \tag{3}$$

The inverse DFT is explained as

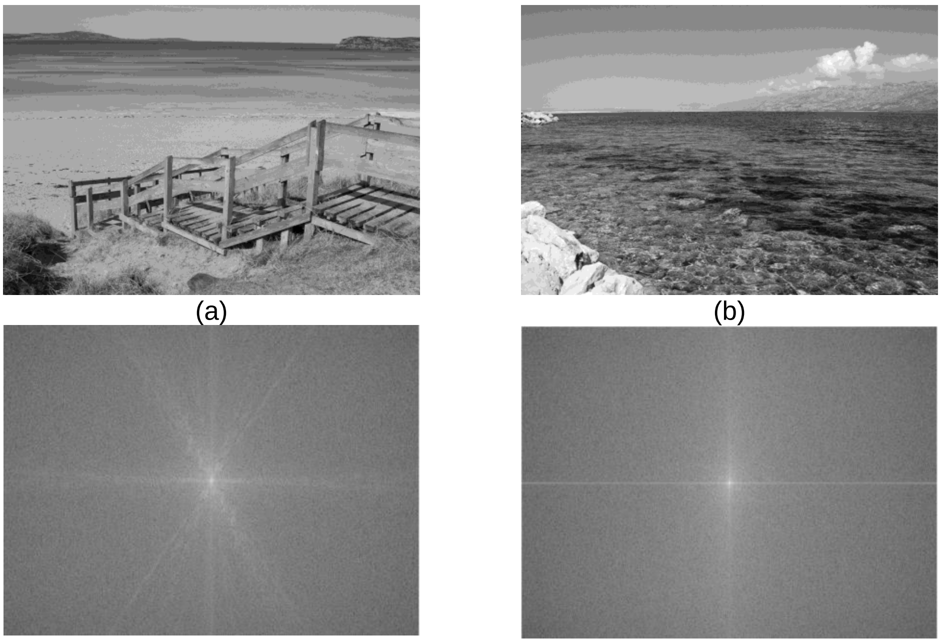
$$x_u = \sum_{x=0}^{N-1} \exp\left(2\pi i \frac{xu}{N} \right) F_u \,. \tag{4}$$

The 2D Fourier transform is extension version of 1D Fourier transform over two axes. The 2D inverse Fourier transform is extension version of Eq. (4). The equations of 2D Fourier transform and inverse Fourier transform are introduced as follows:

$$F(u, v) = \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} f(x, y) \exp\left(-2\pi i \left(\frac{xu}{N} + \frac{yv}{N} \right) \right), \tag{5}$$

$$f(x, y) = \frac{1}{MN} \sum_{u=0}^{M-1} \sum_{v=0}^{N-1} F(u, v) \exp\left(2\pi i \left(\frac{xu}{N} + \frac{yv}{N} \right) \right). \tag{6}$$

The transformed image can be represented in two ways: magnitude and phase content.



(a) (b)

(c) (d)

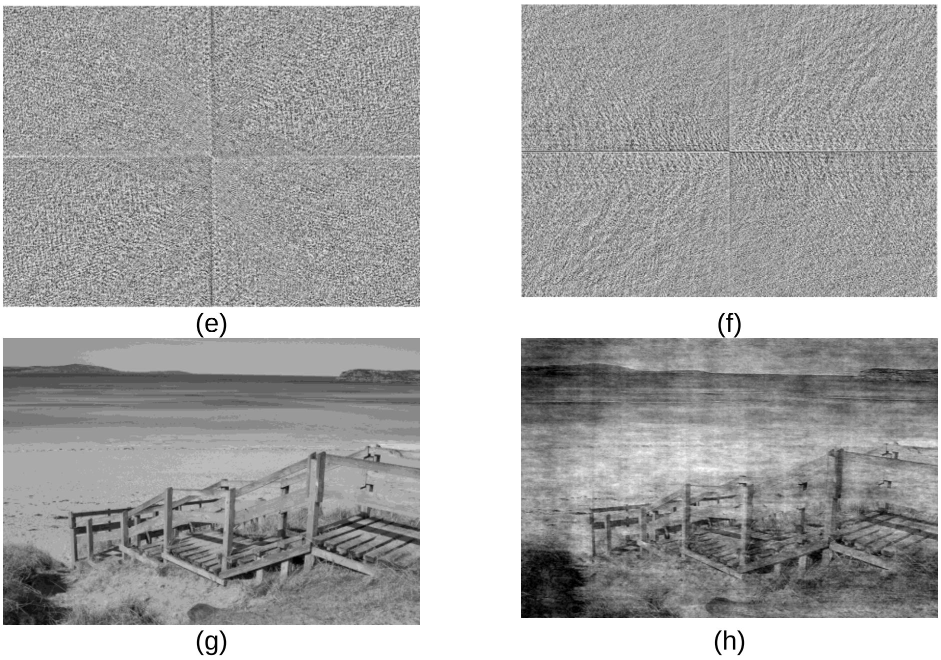


Figure 1. (a) #149 LC Image, (b) #150 LC Image, (c) Magnitude of #149 LC Image, (d) Magnitude of #150 LC Image, (e) Phase of #149 LC Image, (f) Phase of #150 LC Image, (g) Result with Correct Key, and (h) Result with Wrong Key

Figure 1 shows an example. We assume image1 is Figure 1(a) and image2 is Figure 1(b). The magnitudes of Figure 1(a) and Figure 1(c) are shown in Figure 1(c) and Figure 1(d). It is noted that, for display purpose, it is necessary to display the DC component in the center of the spectral matrix. This is possible by multiplying $(-1)^{x+y}$ before the Fourier transform. Similarly, the phase components are shown in Figure 1(e) and Figure 1(f) and. Figure 1(g) is reproduced by using Figures 1(c) and 1(e). On the other hand, Figure 1(h) is reproduced by using Figures 1(c) and X(f). The phase information is hard to understand. However, it is evident that the phase information plays an important role for reproducing image.

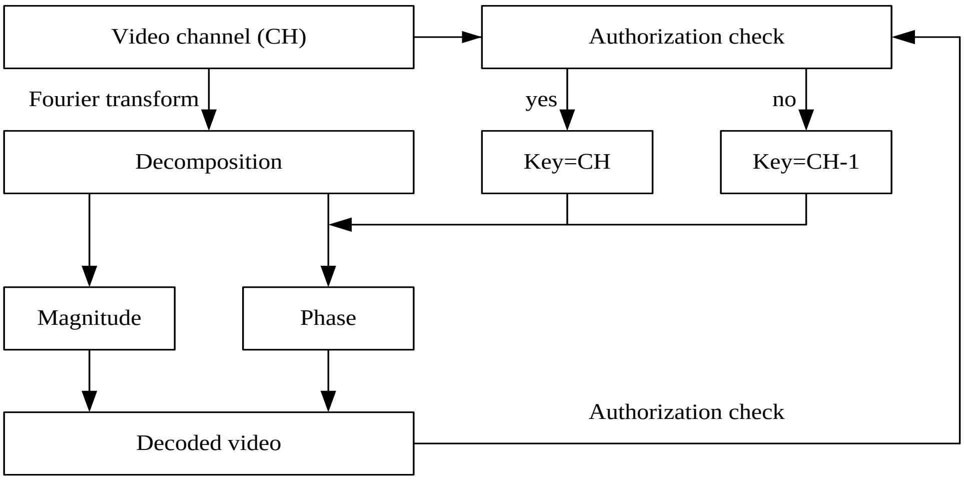
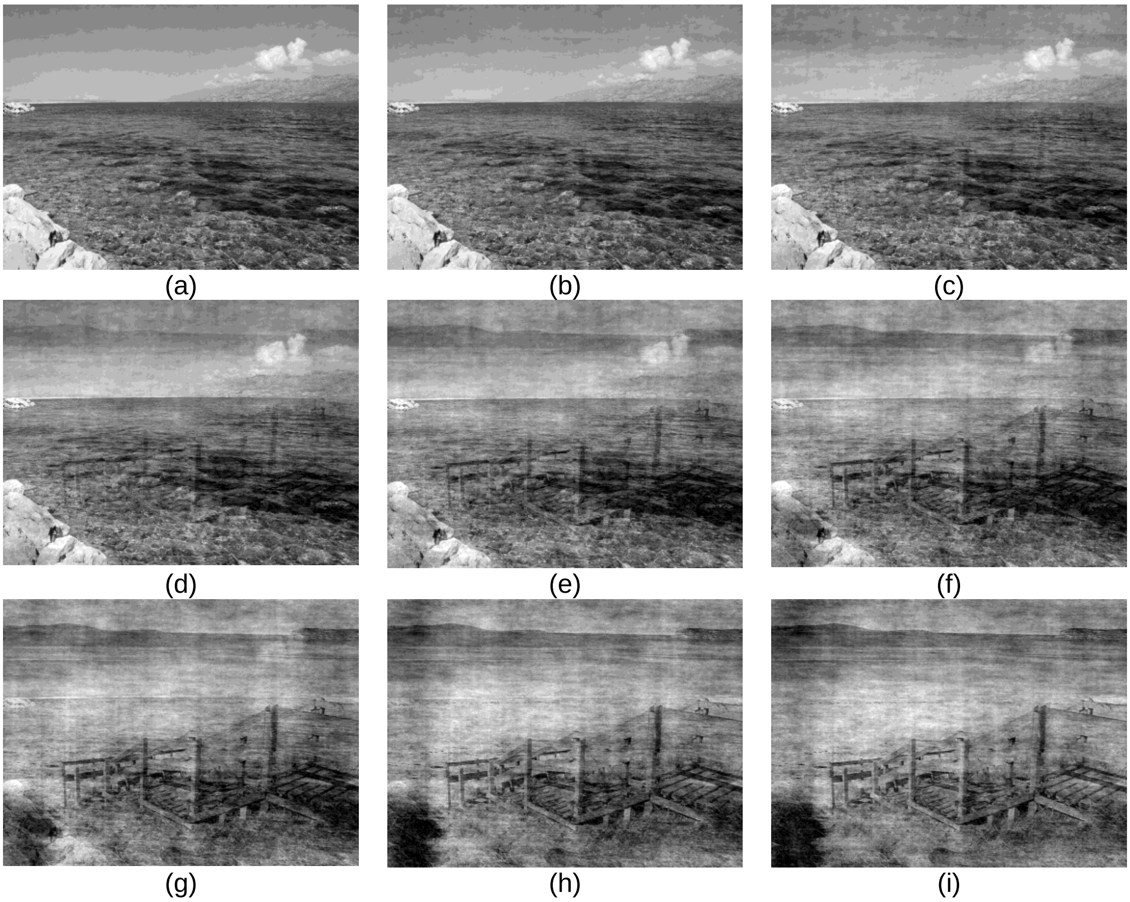


Figure 2. Flowchart of the Proposed Method

As one can see, when phase information is switched with other, quality of image becomes poor. Our proposed scrambling method switches phase information with other one, normally the phase of previous image. Figure 2 shows the flowchart of the proposed method.

The proposed method performs as follows. First of all, authorization process is applied to check the validity of the subscription. Once the subscription is valid, correct key is informed to viewer, and the viewer can watch watchable signal by inverse Fourier transforming with correct phase information. However, if the subscription is not valid, the wrong key is informed which makes result images are unpleasant. As the most important information is carried in phase, only legal viewers can watch watchable video.



(a) (b) (c) (d) (e) (f) (g) (h) (i)

Figure 3. The Weight Effect of Phase Information: (a) *w*=0.1, (b) *w*=0.2, (c) *w*=0.3, (d) *w*=0.4, (e) *w*=0.5, (f) *w*=0.6, (g) *w*=0.7, (h) *w*=0.8, and (i) *w*=0.9.

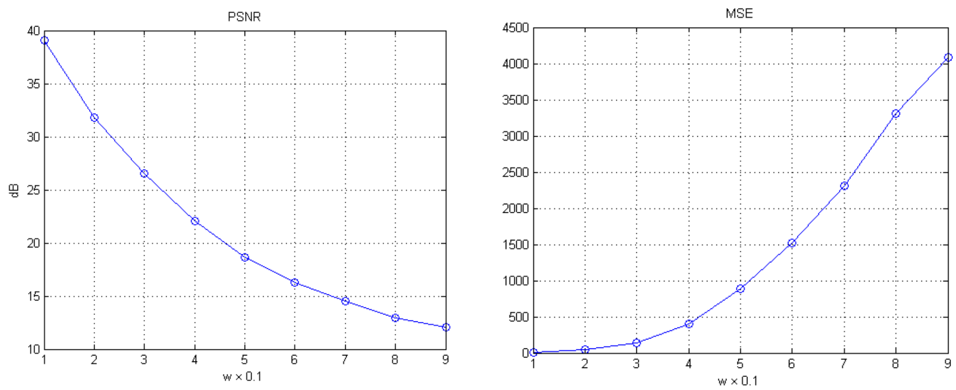
Figure 3 describe the effect of correct phase information. There are nine result images in Figure 3, and the weight of correct phase information is given 0.1 to 0.9, with the increment of 0.1. It can be seen from Figure 3, result images are unacceptable as wrong phase is getting more used.

Table 1. Objective Performance Comparison with PSNR Metric for Different *w*

W	PSNR (dB)
0.1	39.0816
0.2	31.7876
0.3	26.5368
0.4	22.0588
0.5	18.6499
0.6	16.2944
0.7	14.4838
0.8	12.9387
0.9	12.0248

The objective performance of images in Figure 3 is described in Table 1, where PSNR results are shown in dB for nine weights, *w*.

Table 1 can be recast in figure, which is shown in Figure 4(a). As can be seen in Figure 4(a), PSNR performance decreases as *w* increases. Similarly, we calculated MSE results in Figure 4(b).



(a) (b)

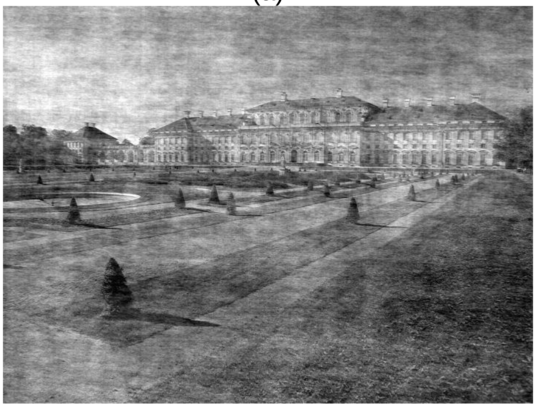
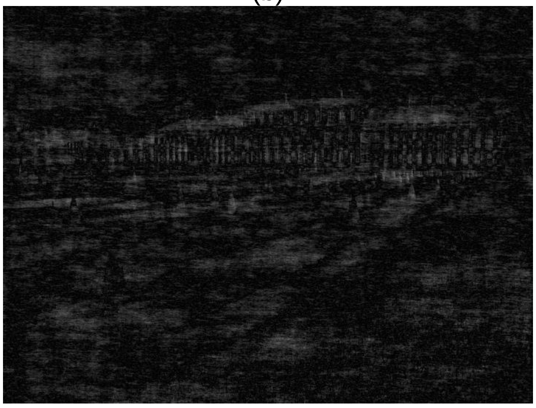
Figure 4. Objective Performance Comparison with PSNR and MSE Metrics for Different *w*

3. Experimental Results

In this section, we provide experimental results on LC dataset, 768×512, 24-bits/pixel high color images. The dataset has 150 images, while we only adopted #21 to #40 images. Four figures display visual performance comparison on #31, #32, #33, and #34. These images are shown in Figures 5 to 8.

Figure 5(a) shows a gray scale image which is obtained rgb2gray command. Figure 5(b) shows a reconstructed image which uses correct magnitude and phase information. Figure 5(c) shows a reconstructed image, however, wrong phase information was used and result image quality is bad accordingly. Finally, Figure 5(d) shows the difference between Figure 5(a) and Figure 5(c). When one has correct key for phase component, the restored images are watchable.

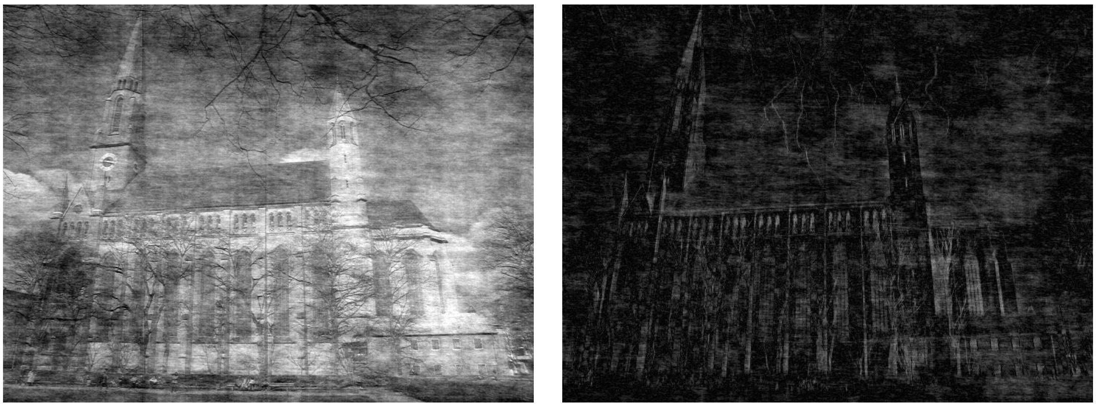

(a) (b)

(c) (d)

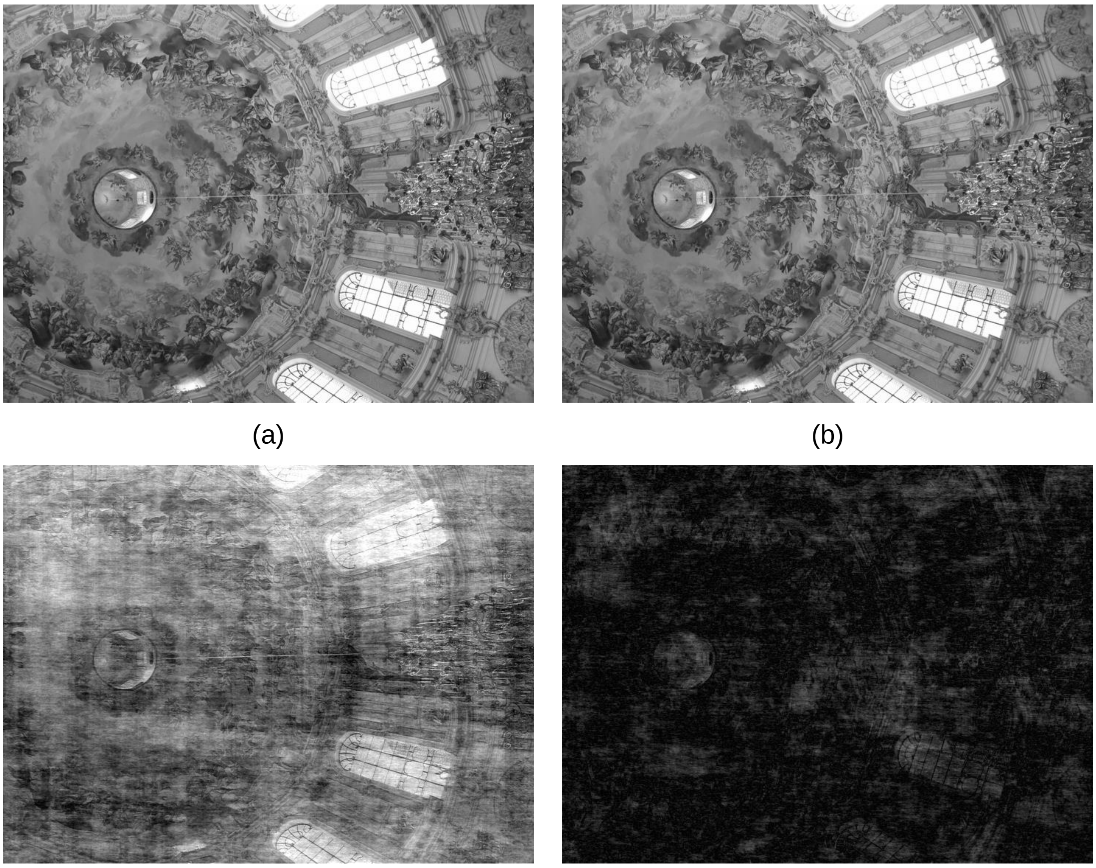
Figure 5. Scrambling Results on #31 Image: (a) Original, (b) Decoded with Correct Key, (c) Scrambled, and (d) Difference between Original and Scrambled Result


(a) (b)



(c) (d)

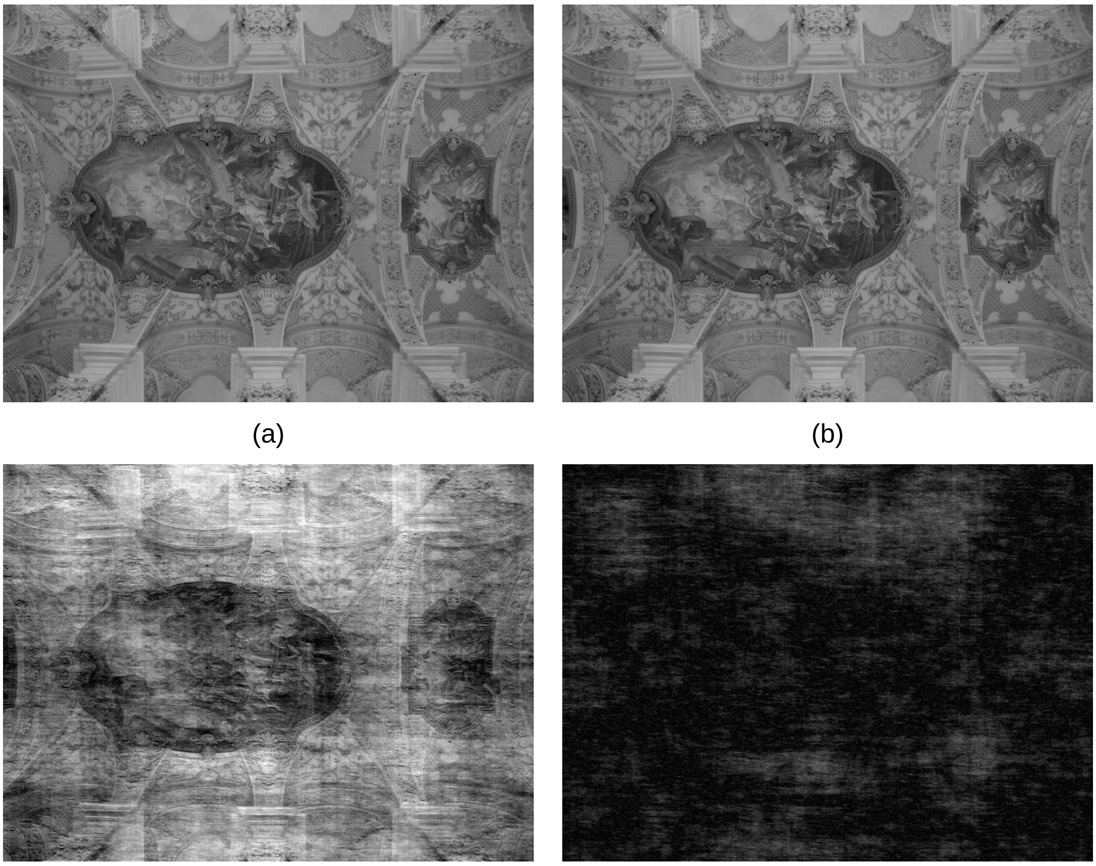
Figure 6. Scrambling Results on #32 Image: (a) Original, (b) Decoded with Correct Key, (c) Scrambled, and (d) Difference between Original and Scrambled Result



(a) (b)

(c) (d)

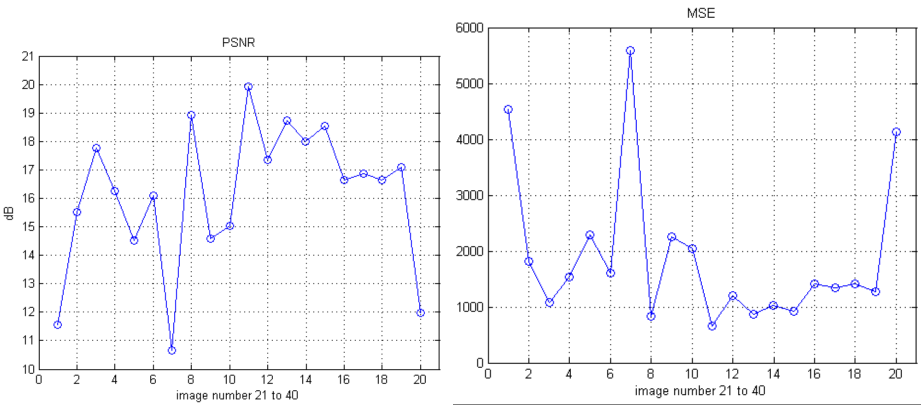
Figure 7. Scrambling Results on #33 Image: (a) Original, (b) Decoded with Correct Key, (c) Scrambled, and (d) Difference between Original and Scrambled Result



(a) (b) (c) (d)

Figure 8. Scrambling Results on #34 Image: (a) Original, (b) Decoded with Correct Key, (c) Scrambled, and (d) Difference between Original and Scrambled Result

Figure 9 shows objective performance comparison with PSNR and MSE metrics for 20 test images.



(a) (b)

Figure 9. Objective Performance Comparison for 20 Test Images: (a) PSNR, (b) MSE

4. Conclusion

A scrambling method is presented in this paper. The proposed method uses magnitude and phase decomposition. As phase component contains important information, by switching phase information scrambling can be performed. Experimental results show that the proposed method gives reliable performance.

Acknowledgments

This work was supported under the framework of international cooperation program managed by National Research Foundation of Korea(2014000756).

This paper is a revised and expanded version of a paper entitled “Scrambling Using Phase Information” presented at ITCS2015.

References

[1] G. L. Hobbs, “Video Scrambling”, U.S Patent, 5815572, **(1998)** September 29.
[2] G. Jeon, M. Anisetti and S. Kang, “A rank-ordered marginal filter for deinterlacing”, Sensors, vol. 3, no. 3, March **(2013)**, pp. 3056-3065.
[3] G. Jeon, M. Anisetti, J. Lee, V. Bellandi, E. Damiani and J. Jeong, “Concept of linguistic variable-based fuzzy ensemble approach: application to interlaced HDTV sequences”, IEEE Trans. Fuzzy Systems, vol. 17, no. 6, December **(2009)**, pp. 1245-1258.
[4] G. Jeon, M. Y. Jung, M. Anisetti, V. Bellandi, E. Damiani and J. Jeong, “Specification of the geometric regularity model for fuzzy if-then rule based deinterlacing”, IEEE/OSA Journal of Display Technology, vol. 6, no. 6, June **(2010)**, pp. 235-243.
[5] J. C. Zou, R. K. W and D. X. Qi, “The generalized Fibonacci transformation and application to image scrambling”, Proceedings of IEEE International Conference on Acoustic, Speech and Signal Processing, Montreal, Canada, **(2004)**, pp. 385-388.
[6] C. Wang, H.-B. Yu and M. Zheng, “A DCT-based MPEG-2 transparent scrambling algorithm”, IEEE Transactions on Customer Electronics, vol. 49, November **(2003)**, pp. 1208-1213.
[7] M. R. Zhang and G. C. Shao, “T-matrix and its applications in image Processing”, IEEE electronics letters, vol. 40, no.25, **(2004)**, pp. 1583-1584.
[8] L. Tong, F. Dai, Y. Zhang and J. Li, “Prediction restricted H.264/AVC video scrambling for privacy protection”, Electron. Lett., vol. 46, no. 1, January 7, **(2010)**, pp. 47-49.
[9] M. S. Kankanhalli and T. Guan, “Compressed-domain scrambler/descrambler for digital video”, IEEE Trans. Consumer Electronics, vol. 48, no. 2, May **(2002)**, pp. 356-365.
[10] G. Ye, “Image scrambling encryption algorithm of pixel bit based on chaos map”, Pattern Recognition letters, vol.31, November **(2009)**, pp. 347-354.
[11] A. M. Del Ray, “A Novel Cryptosystem for Binary Images”, Studies in Informatics and Control, vol. 13, **(2004)**, pp. 5-14.
[12] M. S. Baptista, “Cryptography with chaos”, Phys. Lett. A 240, **(1999)**, pp. 50-54.
[13] S. N. Elaydi, “Discrete Chaos”, Chapman & Hall/CRC, **(1999)**, pp. 117.
[14] “Data Encryption Standard”, FIPS PUB 46, January **(1977)**.
[15] I. Agi and L. Gong, “An empirical study of secure MPEG video transmissions”, in Proc. of The Internet Society Symposium on Network and Distributed System Security, February **(1996)**.
[16] T. Maples and G. Spanos, “Performance study of a selective encryption scheme for the security of networked, realtime video”, in Proc. 4th Int. Conf. Computer Communications and Networks, Las Vegas, NV, September **(1995)**.
[17] Y. Sadourny and V. Conan, “A proposal for supporting selective encryption in JPSEC”, In IEEE Trans. on Consumer Electronics, vol. 49, no. 4, November **(2003)**, pp. 846-849.
[18] B. Macq and J. Quisquater, “Cryptology for digital TV broadcasting”, Proc. of IEEE, vol. 83, no. 6, **(1995)**, pp. 944-957.
[19] W. Zeng and S. Lei., “Efficient frequency domain selective scrambling of digital video”, IEEE Transactions on Multimedia, vol. 5, March **(2003)**, pp. 118-129.
[20] F. Defaux and T. Ebrahimi, “Scrambling for privacy protection in video surveillance systems”, IEEE Trans. Circuits Syst. Video Technol., vol. 18, no. 8, **(2008)**, pp. 1168-1174.

Author

Gwanggil Jeon received the BS, MS, and PhD (summa cum laude) degrees in Department of Electronics and Computer Engineering from Hanyang University, Seoul, Korea, in 2003, 2005, and 2008, respectively.

From 2008 to 2009, he was with the Department of Electronics and Computer Engineering, Hanyang University, from 2009 to 2011, he was with the School of Information Technology and Engineering (SITE), University of Ottawa, as a postdoctoral fellow, and from 2011 to 2012, he was with the Graduate School of Science & Technology, Niigata University, as an assistant professor. He is currently an assistant professor with the Department of Embedded Systems Engineering, Incheon National University, Incheon, Korea. His research interests fall under the umbrella of image processing, particularly image compression, motion estimation, demosaicking, and image enhancement as well as computational intelligence such as fuzzy and rough sets theories.

He was the recipient of the IEEE Chester Sall Award in 2007 and the 2008 ETRI Journal Paper Award.