Improved visualization of three-dimensional photon counting integral imaging using background noise removal

Ki-Ok Cho[1], Donghak Shin[2], Min-Chul Lee[3], and Myungjin Cho [1]

[1] Dept. of Electric, Electronic, and Control Eng, Hankyong National University, Kyonggi-do 456-749, Korea

[2]Institute of Ambient Intelligence, Donseo University, Busan 617-716, Korea

[3] Dept. of Computer Science and Electronics, Kyushu Institute of Technology, Fukuoka 820-8502, Japan

Tel.:82-31-670-5298, E-mail: mjcho@hknu.ac.kr

Three-dimensional (3D) photon counting imaging under photon-starved conditions has been investigated [1-2]. However, its visual quality is worse due to lack of the number of photons or background noise. Although the visual quality of the photon counting image can be improved by using advanced statistical estimation methods such as Bayesian approach [2], it is very complex and cannot remove background noise.

In this paper, we propose an improved visualization of 3D photon counting integral imaging. We remove background noise in the image by maximum likelihood estimation (MLE). Therefore, photons can be generated in the only object region of the image. That is, the visual quality of the photon counting image can be enhanced. To prove our method, we implemented optical experiments.

Figure 1 shows the object image, conventional photon counting image, proposed photon counting image with Np=10,000, and proposed photon counting image with Np=20,000, respectively. As shown in Fig. 1, photons are generated in the only object region. Using computational reconstruction of integral imaging [3], 3D reconstructed images can be obtained as depicted in Fig. 2. In conventional photon counting reconstruction as shown in Fig. 2(a), since all of region has photons, the visual quality of the reconstructed image is worse than our result as shown in Fig. 2(b). Therefore, using our proposed method, the visual quality of 3D photon counting integral imaging can be improved under the same photon-starved conditions.

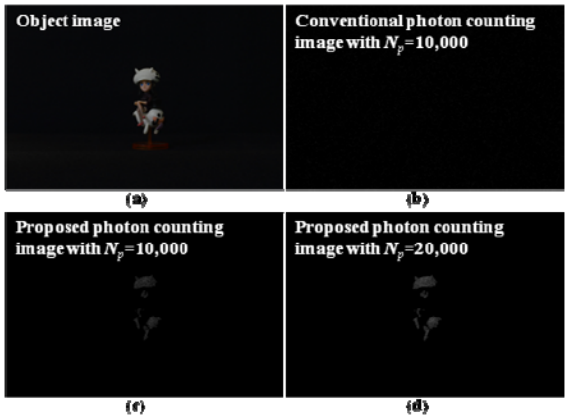

Fig. 1 Images used in experiments
(a) Object image, (b) conventional photon counting image, (c) proposed photon counting image with Np=100,000, (d) proposed photon counting image with Np=200,000.

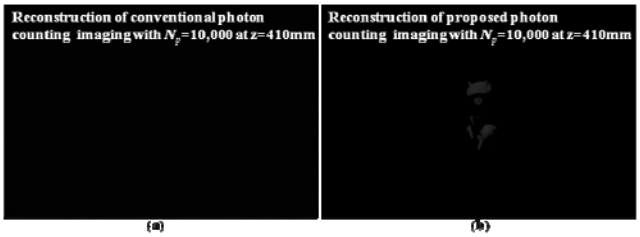

Fig. 2 Reconstruction results for (a) conventional photon counting integral imaging, (b) proposed photon counting integral imaging.

Acknowledgment

This research was supported by Basic Science Research Program through the National Research Foundation of Korea(NRF) funded by the Ministry of Education(NRF-2013R1A1A2057549).

References

1. B. Tavakoli, B. Javidi, and E. Watson, *Opt. Exp.*, 16, 4426 (2008).
2. J. Jung, M. Cho, D. K. Dey, and B. Javidi, *Opt. Lett.*, 35, 1825 (2010).
3. S.-H. Hong, J.-S. Jang, and B. Javidi, *Opt. Exp.*, 12, 483 (2004).