PSNR Characteristics of Quantum Ghost Imaging with Multiple Positions Illumination

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Abstract. We evaluate the PSNR performance of quantum ghost imaging depending on illuminated positions N. As a result, when the attenuation is severe, large N shows better performance than small N, but when the attenuation is low, too large N degrades the performance.

Keywords: Quantum ghost imaging, Quantum protocol, PSNR

1 Introduction

One of the protocols using entanglement[1] is quantum ghost imaging (QGI)[2]. The essential components of GI include a light source correlated spatially, a detector DA with no spatial resolution, a detector DB with spatial resolution, and a correlator to correlate the outputs from detectors. In addition, an object is placed between DA and the source. Then, repeating the illumination to DA and DB, the image is constructed from the object information by DA and the position information by DB. We devised a QGI analysis using the product states and showed error performance[3]. In this study, focusing long acquisition time, we consider a protocol to illuminate multiple positions and compare PSNR depending on the number of illuminated positions.

2 Protocol

The specific procedure in this study is as follows. First, the light correlated spatially is illuminated on DA and DB. Then, by detecting the light with DA and DB, information on the object is obtained with DA and information on the illuminated position is obtained with DB. Repeating these processes, the image is constructed by linearly normalizing the correlations of the outputs from DA and DB.

Let Ap (Bp) be the mode illuminating the position p of DA (DB), and we use the following state,

$$|\Psi_p\rangle = \bigotimes_{p \in P} |1\rangle_{A_p} |1\rangle_{B_p} \bigotimes_{p \notin P} |0\rangle_{A_p} |0\rangle_{B_p},$$

(1)

where P is a set of N positions and |0⟩ and |1⟩ are the vacuum and single photon states, respectively.

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Figure 1: Average PSNR calculated for 100 trials with η = 0.3, 0.9, and N = 1, 5, 9.

3 Simulation results

The input state for DA is considered to be an η-attenuated photon number state with the number of photons through the slit. On the other hand, we assume DB obtains P without errors. Then, Figure 1 shows the average PSNR for 100 calculations, with η = 0.3, 0.9 and N = 1, 5, 9. A high PSNR means that the imaging results are accurate.

When η = 0.3, only the protocol with N = 9 can obtain a clear image. However, when η = 0.9, the protocol with N = 9 shows lower performance than others. This is because a large N increases the count of photons in the non-slit part.

4 Conclusion

We evaluated the PSNR of QGI depending on N. As a result, the protocol with N = 9 performed better than the others under the severe attenuation and worse under the low attenuation. The presentation will include an explanation for the performance.

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References

