# Deep neural network-based complex amplitude reconstruction from spatial-domain phase shifting digital holograms

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Digital holography is a technology in which an interferogram, or a digital hologram, is recorded by 2D image sensor and is reconstructed by a computer. As one of the recording methods of a digital hologram, a phase-shift interferometry (PSI) in which multiple digital holograms are captured, and the complex amplitude of the object light can be reconstructed from them is widely known [1]. There are mainly two implementation methods of PSI: a time- and spatial-domain PSI. In the time-domain PSI, the multiple digital holograms are obtained at different time by the step-by-step change of the phase of the reference light. On the other hand, in the spatial-domain PSI, they are obtained at once by spatially changing the phase of the reference light [2]. The time-domain PSI can utilize the full spatial resolution of an image sensor while it limits the temporal resolution of the imager. On the other hand, spatial-domain PSI can utilize the full temporal resolution of an image sensor while it limits the spatial resolution of the imager. To overcome the trade-off in PSI, we have worked on a deep neural network (DNN)-based reconstruction of digital holograms which are captured by spatial-domain PSI. In this paper, we compare the qualities of several reconstruction methods: a reconstruction method using an algorithmic interpolation method such as nearest neighbor and bicubic methods, that using DNN-based interpolation method, and direct reconstruction method using DNN.

In this work, as shown in Fig. 1(a), we assumed that an object light that both amplitude and phase of light is modulated by the object placed 10 cm away from an imager and the reference light having checkerboard-like phase pattern are coaxially interfered. In the reconstruction process, to interpolate the lack pixels in the captured digital hologram, we used two interpolation methods, nearest neighbor and bicubic methods, and two DNN-based super-resolution methods using U-net and eHoloNet [3,4]. In these methods, the free-space Fresnel propagation is co-used to obtain the complex amplitude on the object plane. Also, we modified and used the eHoloNet which can reconstruct not intensity or phase distribution on the object plane but complex amplitude distribution directly from the digital holograms. Figure 1(b) shows the structural similarity (SSIM) of the complex amplitude on the object plane which is reconstructed by each method. It is shown that the direct reconstruction method based on DNN achieve the higher reconstruction quality than the case with time-domain PSI whereas the DNN-based super-resolution methods deteriorates the quality compared to the case without DNN.

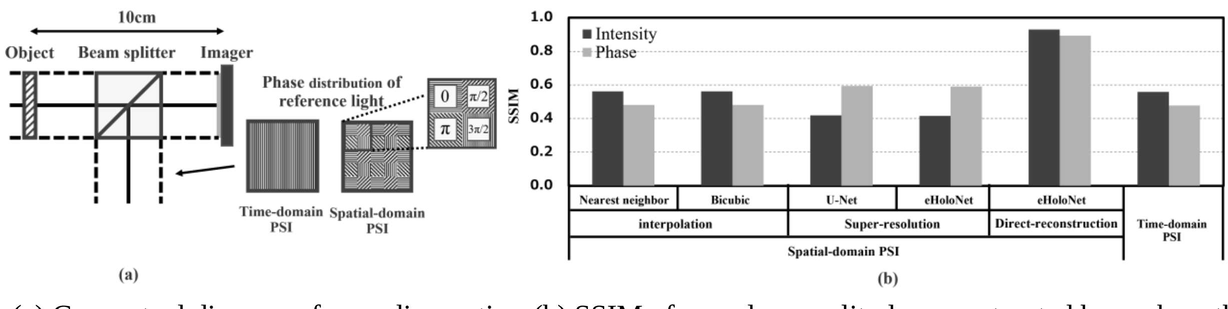


Fig. 1 (a) Conceptual diagram of recording optics. (b) SSIM of complex amplitude reconstructed by each method.

## References

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