Despite many years of development in Computer-generated holography, perfect phase-only holograms for most target images are still yet possible to compute. All computational phase retrieval algorithms end up with some error between the reconstructed field and the target image, except for specific targets, leading to noise in holographic projections. This research focuses on the fundamental limits of phase-only computer-generated holograms quantized to limited bit depths levels, from the information theory point of view, quantifying how difficult a target image is for phase-only hologram computation.

Under the real-world constraint, current spatial light modulators (SLM) can only achieve either amplitude or phase modulation, instead of a full complex modulation. In Computer-Generated Holography (CGH), phase modulators are more often used due to their higher energy efficiency and lower zero order in the reconstruction. Despite many years of development in CGH perfect phase-only holograms are still yet possible to compute for most target images. The 50-year-old Gerchberg-Saxton algorithm is still in the leaderboard among phase retrieval algorithms, and all algorithms including Gerchberg-Saxton will end up with an error between the reconstructed field and the target image, except for some specific targets, leading to noise in holographic projections.

Taking the novel point of view from information theory, this research focuses on the fundamental limits of phase-only computer-generated holograms, including practical phase holograms quantized to limited bit depths levels given the real-world SLM constraints. This research quantifies how complex a target image is for phase-only hologram computation, and evaluates the effect of hologram bit depth and target image entropy in hologram generation performance for phase-only CGH displays. Iterative phase retrieval algorithms including the Gerchberg-Saxton algorithm and optimization methods have been implemented to generate quantized phase-only holograms for thousands of real-life images, using several initial holograms and bit depth limits. Then the final normalised mean squared errors (NMSE) between target images and reconstructions are plotted against the bit depth of hologram and target image entropies. A statistical result is then achieved to illustrate the correlation between the NMSE and the bit depth of hologram, demonstrating the information capacity of phase-only holograms, making prediction on the projection noise level given any combination of target image and phase hologram bit depth.