

Reviving a Spatial Light Modulator for Digital Holography

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Spatial Light Modulators (SLMs) are optical devices that enable precise control over the amplitude and phase of coherent light beams, playing a pivotal role in controlling beams. In this project, I developed a Python script to generate digital holograms and export them to a Cambridge Correlators SDE1024 SLM.

The SLM pixels operate on a grayscale range of 0-255, where the transition from dark to bright can be used to form a binary phase grating, while using the full pixel depth can produce a digital hologram with finer control over a desired beam, including beam steering. The images cast on the SLM are calculated from the interference pattern expected between two plane waves coincident on the plane of the SLM at specified angles. However, for this specific SLM, the maximum phase shift achievable is only 0.8π for red light, compared to the desired 2π or more. This limited phase shift corresponds to the grayscale values used to control the SLM. The fringe spacing for light with $\lambda=635$ nm is obtained from the above calculation and can be determined as $\Delta x = \lambda / \sin\theta$ where θ is the angle of incidence. The project explored limiting cases for different θ values, with $\theta=0$ resulting in parallel beams, $\theta=\pi/2$ producing perpendicular beams, and $\theta=\pi$ leading to a standing wave. As θ approaches zero, the fringes widen, impacting the interference pattern's resolution. The program was developed to create digital patterns to steer the beam reflected from the SLM to more precisely steer the reflected beam.

Over the summer, I produced a Python code and PyQT GUI that could calculate and control digital holograms to be broadcast on the SLM, setting up the possibility to explore further applications, such as holographic optical tweezers. Future work will focus on refining hologram manipulation techniques to enhance the capabilities of holographic optical tweezing and other applications of digital holography.

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