

Abstract

This thesis presents a study on the effectiveness of algorithms implemented in a Spatial Light Modulator (SLM), which is used to generate arbitrary light patterns. SLMs play a crucial role in holography by precisely modulating the phase of light to create interference patterns essential for hologram formation. The quality of the generated holograms heavily depends on the algorithm used to compute the phase pattern necessary for optimal light distribution.

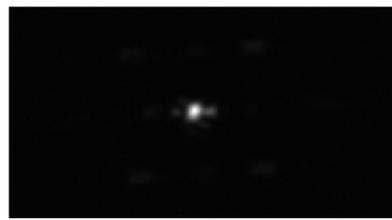
To generating hologram , we use different algorithm create 3x3 images by python code and create hologram form SLM software such as 1) Random Mask (RM) , each pixel has random phase shift, phase will be random between 0 to 2π the technique is very fast and performs remarkably good as far as uniformity is concerned. 2) Superposition (S) this though slower than RM give order one efficiencies but very poor uniformities. 3) Superposition Random (SR) , it improved from S by adding a random phase (θ_m) and results better than S also produce good uniformity. 4) Gerchberg-Saxton (GS) optimize phase by repeating many iterations given result in poor uniformities. To analyze the performance, we extracted images from the SLM and analysis intensity using Python. We then compared the efficiency , uniformity, and standard deviation of the different algorithms used for hologram generation with the SLM. Furthermore, this thesis examines the holograms generated by the SLM, where different algorithms result in vary phase calculations and efficiencies. Understanding this control generation will help improve hologram quality for applications in technology, quantum computing, and other fields.

Introduction

Optical tweezers use highly focused laser beams to trap and manipulate microscopic particles, revolutionizing fields like quantum, biophysics, and nanotechnology. A key advancement is the integration of a spatial light modulator (SLM), which dynamically shapes the laser beam to create multiple traps and complex optical patterns. This enhances precision, flexibility, and efficiency in particle manipulation. Moreover, the quality of the generated hologram directly impacts trapping stability and accuracy. High-quality holograms ensure precise control over optical forces, enabling advanced applications such as parallel manipulation and high-resolution force measurements, driving innovation in optical manipulation technologies. SLMs enable the simultaneous creation of multiple light traps, allowing for the trapping and control of multiple particles at the same time. Additionally, SLMs allow for the adjustment of light trap patterns to suit specific applications.

However, creating high-quality holograms with an SLM requires efficient algorithms to calculate the appropriate phase patterns. These algorithms play a crucial role in determining the quality of holographic images in various aspects, such as efficiency , uniformity, and standard deviation

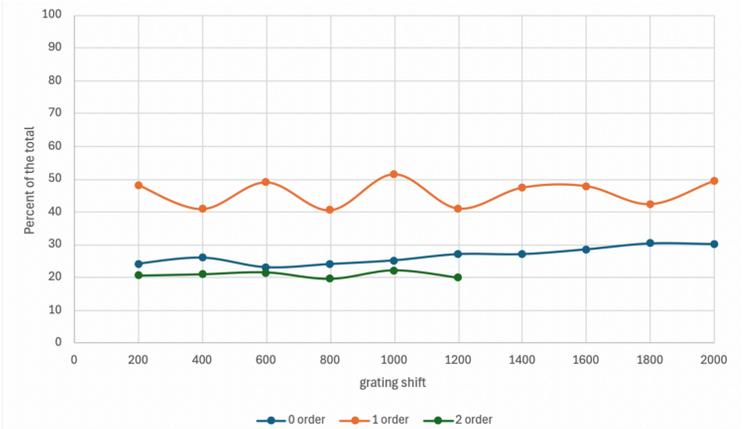
Result



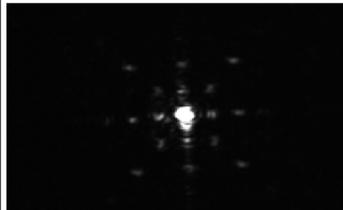
grating shift at 0



grating shift at 1000



We studied SLM diffraction by generating holograms with grating shifts from 0 to 2000. High brightness was observed initially due to overlapping zero and first orders. At a grating shift of 1000, the orders were clearly separated with no interference from other orders.



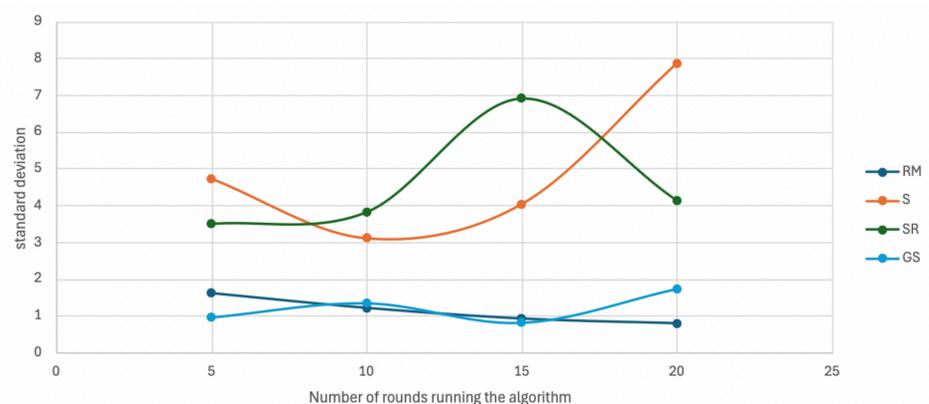
The image shows a grating shift hologram at 0



The image shows a grating shift hologram at 500



The image shows a grating shift hologram at 1000



It can be observed that there is still interference from the 1st order and 2nd order, preventing us from capturing a clear image. When we shifted the grating shift to 500, there was still overlap from other orders. We then shifted the grating shift to 1000, where it was clearly seen that the orders were distinctly separated. Therefore, we chose to capture the data at a grating shift of 1000.

Conclusion

The objective of this study is to analyze and compare the performance of various algorithms used to create holograms using a Spatial Light Modulator (SLM). Emphasis is placed on evaluating factors that affect the quality of holographic images, such as diffraction efficiency, intensity distribution, and uniformity. when the higher the standard deviation, the greater the data dispersion, indicating excessive variation. The lower standard deviation indicates better consistency and stability of the algorithm. In other words, a lower value means that the data is less dispersed around the mean, which is a better result for measuring accuracy and reliability. From the graph, it is clear that GS has a significantly lower standard deviation than RM across all the number of rounds the algorithm is run. Therefore, GS demonstrates better performance and stability than RM.

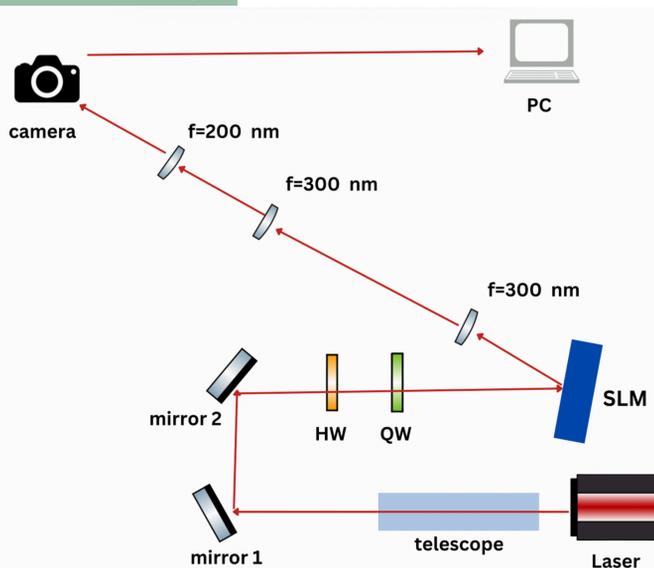
References

- 1.Meadowlark Optics, Inc. (n.d.). PCIe User Manual: XY Phase Series Spatial Light Modulators With PCIe Controller. Meadowlark Optics.
- 2.de Leseleuc, S. (2018). Quantum simulation of spin models with assembled arrays of Rydberg atoms (Doctoral dissertation, Universite Paris-Saclay, Institut d'Optique Graduate School).
- 3.Di Leonardo, R., Ianni, F., & Ruocco, G. (2007). Computer generation of optimal holograms for optical trap arrays. Optics Express, 15(4), 1913-1922

Objective

- . To understand the setup and configuration of the Spatial Light Modulator (SLM).
- . To learn how the software works for different algorithms to generating holograms.
- . To compare and analyze various hologram generation algorithms based on performance metrics such as diffraction efficiency, intensity distribution, and uniformity.

Methodology



at wavelength 820nm, diameter 1m