

Problems and Attempts : CGH

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Abstract

This is a record of the problems I encountered while studying computer-generated holography (CGH) and my attempts to solve them.

1 Hologram Calculation

Q1.1 (2024.07.25) How to calculate a hologram that successfully reconstructs a desired size and resolution 3D image at a desired distance? To display the hologram on a Digital Micromirror Device (DMD), hologram resolution should be fixed to $5\mu m$.

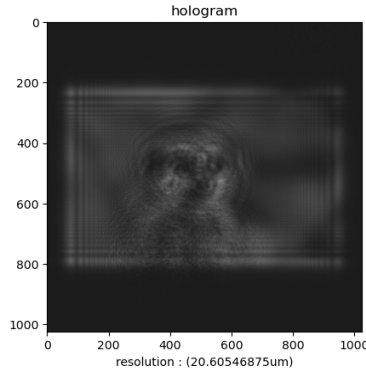


Figure 1: Hologram

(24.07.29) I came up with the idea of adjusting the hologram resolution on the computer to fit the display resolution. For example, I can use the `cv2.resize` method in Python. I did this, but.. what I need to do is create a hologram that displays a 3D image at the desired distance and size. While resizing can fit the hologram pattern to the DMD physically, it does not create the desired pattern.

(24.07.30) `cv2.resize` method works well. When we calculate the Fourier Transform for propagation, the resolution of the resulting array is automatically set to

$du = \frac{1}{N \cdot dx}$ per pixel : which means the array is in a frequency space. Or, equivalently, we can interpret the array as a physical space array with the associated spatial resolution $dx = \lambda z du = \frac{\lambda z}{N \cdot dx}$.

For example, $\lambda = 633nm$, $z = 1m$, $N = 1024$, $dx_s = 5\mu m \rightarrow dx = 123\mu m$. Since the resolution at the destination plane becomes large($dx = 123\mu m$), we need to resize it in order to get an image with desired resolution(for example, $dx' = 5\mu m$).

2 Aliasing

Q2.1 (2024.07.25) When performing a Fourier transform on a hologram, weird aliasing occurs as shown below. Why does this happen, and how can it be fixed?

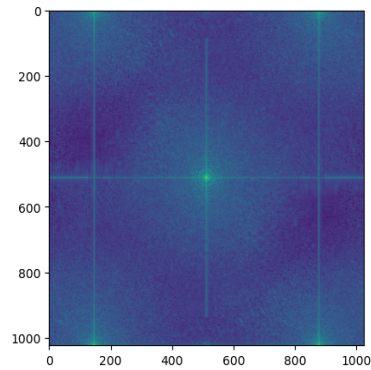


Figure 2: Fourier transform of the hologram

Q2.2 (2024.07.25) When simulating hologram reconstruction on a computer, aliasing occurs. Why does this happen, and how can it be fixed?

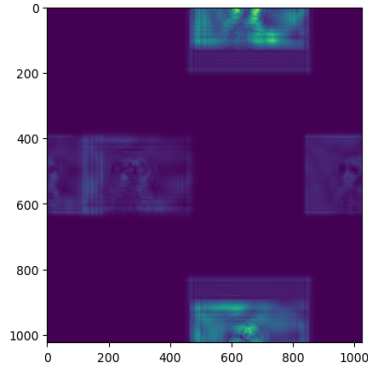


Figure 3: Aliasing in reconstructed image ($\theta = \pi/5$)