Slice-and-cascade Simulation of 3-D Optical Systems

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Understanding the Bragg selectivity requires getting an accurate prediction of the diffraction field of a volume hologram. So far, several methods have been introduced to analyze the diffraction property of volume hologram. One popular method is the Coupled Wave Theory (CWT), which was first applied to holography by Kogelnik. His classic paper presents an elegant expression of the diffraction efficiency by considering coupling of the 0th and 1st diffraction orders. The drawback of CWT is the limitation for complicated fringe shapes. An alternative is the so-called Born approximation theory. Though this method gives an analytic result for the diffraction field and can be applied to arbitrary geometry of hologram, it is valid only under the first-order approximation which means weak refractive index modulation.

In 3-D imaging systems, we usually utilize the spherical wave-recorded holographic element and pursue a maximum efficiency. This requires us to choose the hologram with complicated geometry and strong modulation. To model and optimize such holograms, we have developed a novel numerical method called slice-and-cascade simulation for the problem of diffracting volume holographic. The idea is to decompose the thick element into slices and calculate the propagation slice by slice. Intuitively, we can think the propagation in one slice as following: firstly light is translating in a homogeneous space and then is modulated by a phase grating. Also, based on this assumption, we can get a recursive relation of the fields between two adjacent slices.

Figures 1 and 2 show a very good agreement of our method with the CWT, verifying that the method works well in the well-known plane-wave hologram case. We are currently in the process of extending the slice-and-cascade method to the more complicated geometry of interest, and we are optimizing our system design.

![Figure 1: comparison of slice-and-cascade method with CWT as angular selectivity for plane-to-plane volume hologram](image1.png)

![Figure 2: comparison of slice-and-cascade method with CWT as wavelength selectivity for plane-to-plane volume hologram](image2.png)

REFERENCES: