Homework set

Diffraction tomography & Compressive holography - Backpropagation

(Off-axis holograms: Assume that you can filter out the squared field (a.k.a. autocorrelation) and the conjuate (a.k.a twin image) terms with no errors)

Assume that the detector pixel resolution is 3.0 um, the wavelength is 600 nm, and the lens has unit magnification. The NA is defined in the codes. Use the axial resolution 5 mm in the propagation direction. The incident field is assumed to propagate along the propagation axis, in which case the incident field angle is defined to be 0 degree. Assume that the front surface of the 3D objects created in part a is focused at the detector plane (i.e., the distance between the object front plane and the detector plane is 0).

a. Synthesize two 64 x 64 x 64 3D objects: one relatively simple in the sense that the Fourier transform contains (a lot) more low frequency components than high frequency components, and the other (more complicated) one with more high frequency components than low frequency components.

b. Simulate 7 holograms with 7 wavelengths. Use two sets of the wavelengths [300:1:306] and [100:100:700] all in nm. Also, simulate 7 holograms with 7 incident field angles. Use two angle combinations [0.01:0.03:0.23] and [0:0.8:0.48] degrees. Discuss the effects of the choice of angles and/or wavelengths on the reconstructions. Draw on a piece of paper the frequency sample map consisting of semicircular arcs as discussed in class) using the Fourier diffraction theorem. Estimate quantitatively the resolution of the reconstructions. ([a:b:c] denotes a sequence of numbers from a to c with increment b.)

c. Simulate compressive holography with the objects in part a with the simulated measurements in part b. Compare and discuss the effects of the choice of angles and wavelengths on the backpropagation reconstruction and the compressive holography reconstruction. Discuss their resolution qualitatively.

d. Add independent noise (i.e., Gaussian) with noise level 30 dB to the holograms created in b and c, and repeat parts b and c. Describe the effect of noise in the two reconstructions.

(Gabor hologram: Now you add the autocorrelation and twin image to your holograms)

Use the same parameters as those used in the off-axis case.

e. Generate a single Gabor hologram measurement with one of the objects you simulated in part a for wavelength 533 nm and incident angle 1.5 degrees. Assume that the object front surface is 6 cm away from the detector plane. Find the backpropagation and the compressive holography reconstructions. What is the effect of the autocorrelation and the twin image in both reconstructions (backpropagation and compresive holography reconstruction)? Add 30 dB additive noise and repeat the reconstruction. Discuss the effects of noise. What is the effective NA in the object space and the resolution associated with the object reconstruction?

* Note: there is no interpolation involved in this homework problem because the objects are defined in the discrete domain. You will need interpolation in practical problems dealing with continuous objects though.