ECE 278C **IMAGING SYSTEMS** **Winter 2024**

ASSIGNMENT 1: Fourier Spectrum of Coherent Wavefield

Due: Tuesday, January 30

Objective: The main objective of this homework assignment is to visualize the spectral distribution of *2-D* coherent wavefield patterns. This leads you to

(i) the generation of the coherent wavefield,
(ii) observations of the spectral distributions of coherent wavefield,
(iii) understanding of the concept of phase-only imaging, and
(iv) observations of changes due to the variation of wavelength, sample spacing, and aperture size.

Part A: the wavelength

(1) Consider a point source at the origin, $(x_o, y_o) = (0, 0)$. This centered point source produces a *2-D* coherent wavefield pattern in the form of

$$h(x,y) = (j\lambda_o r)^{-1/2} \exp(j2\pi r/\lambda_o)$$

where $r = (x^2 + y^2)^{1/2}$ and λ_o is the operating wavelength. Generate the resultant *2-D* wavefield pattern for a region within the radius of $30\lambda_o$. For simplicity, sample the *2-D* wavefield uniformly, in both directions, with the sample spacing

$$\Delta x = \Delta y = \lambda_o /4.$$

Evaluate the *2-D* Fourier spectrum of the coherent wave-field with a *512 x 512 FFT*, and plot the amplitude of the *2-D* spectrum. (Remember to zero out the data points around $r = 0$.)

(2) Repeat Part (1) with 3 active point sources, located at (x_n, y_n), $n = 1, 2, .. 3$.

	scatters	*scatter locations*
1	(x_1, y_1)	$(0, +15\,\lambda_o)$
2	(x_2, y_2)	$(-12\,\lambda_o, -9\,\lambda_o)$
3	(x_3, y_3)	$(+12\,\lambda_o, -9\,\lambda_o)$

The resultant wavefield pattern over the aperture region is the superposition of 3 coherent waveform patterns.

(3) Now consider a different case that each of these 3 active sources is generating an independent coherent wavefield pattern, with a different operating wavelength λ_n, where

	scatters	*scatter locations*	*wavelengths*
1	(x_1, y_1)	$(0, +15\,\lambda_o)$	λ_o
2	(x_2, y_2)	$(-12\,\lambda_o, -9\,\lambda_o)$	$\lambda_o/2$
3	(x_3, y_3)	$(+12\,\lambda_o, -9\,\lambda_o)$	$2\,\lambda_o$

Again, the overall wavefield pattern over the aperture is the superposition of 3 waveform patterns. Sample the composite waveform in both directions, with the same sample spacing $\Delta x = \Delta y = \lambda_o/4$. Evaluate the *2-D* Fourier spectrum of the composite waveform with a *512 x 512 FFT*, and plot the amplitude of the spectrum.

Part B: the magnitude

(4) Repeat the exercise by using a modified version of the Green's function

$$h'(x,y) = A\, exp(j2\pi r/\lambda)$$

(This is to replace the amplitude portion of the *Green's function* with a constant *A*, which is known as the *phase-only* version.)

Part C: the sample spacing

(5) The sample spacing was set to $\lambda_o/4$ for simplicity. Now, examine the change of the spectral distribution as you vary the sample spacing of the array.

Part D: the aperture size

(6) The radius of the circular aperture was set to $30\lambda_o$ for simplicity. Examine the change of the spectral distribution as you vary the aperture size.

Report format:

1. Cover page
2. Figures
3. Summary: (comments based on your observations)
4. Appendix: (computer code)