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

ASSIGNMENT 5: Multi-Frequency Backward Propagation

Due: Tuesday, February 27

Objective: The objective of this programming assignment is to experience image formation by multi-frequency backward propagation and to observe the effects on image resolution in the form of *aperture size*.

The system configuration is the same as that in *Assignment 2*, with *3* point sources at the same locations. The *receiver aperture* is a centered linear receiver array with a span of $60\lambda_0$ (from $x = -30\lambda_0$ to $x = +30\lambda_0$), located along $y = y_o = +60\lambda_0$, with quarter-wavelength ($\lambda_0/4$) spacing. For each coherent frequency, there are *241* wavefield samples in total over the $60\lambda_0$ - long aperture.

In *Assignment 2*, one single wavelength was applied. As we move up to the multi-frequency (wideband) operating mode, we collect wavefield samples over a wide range of spectrum corresponding to *64* different wavelengths, in the form

$$\lambda_n = 64\,\lambda_0/(n+32) \qquad n = 1, 2, \ldots 64$$

Thus, this imaging modality operates with a sequence of wavelengths, from $0.67\lambda_0$ to $2\lambda_0$, corresponding to the spatial-frequency band from $0.5(1/\lambda_0)$ to $1.5(1/\lambda_0)$ resulting a spatial-frequency bandwidth of $(1/\lambda_0)$.

The complete data set is a *(64 x 241)* array, corresponding to *64* wavelengths and *241* receiver positions.

Superposition of range profiles:

This is to perform range estimation *241* times at the *241* receiver positions, with the same receiver array configuration. This process produces *241* range profiles over the source region, $\hat{s}_n(x, y)$, for $n = 1, 2, \ldots 241$.

The goal is to perform multi-frequency range estimation of the $(60\lambda_0 \times 60\lambda_0)$ 2D source region with the *241* sets of wavefield samples corresponding to the *241* receiver positions. Each range estimate is formed from *64* wavefield samples corresponding to the *64* operating wavelengths.

(1) By repeating the range estimation procedure, produce the *241* range profiles over the source region.
(2) Superimpose the *241* sub-range profiles *sequentially* and observe the convergence to the overall image,

$$\hat{S}_n(x, y) = \sum_{k=1}^{n} \hat{s}_k(x, y) \qquad n = 1, 2, \ldots 241.$$

(3) Produce the spectra of the complex range profiles $\hat{S}_n(x, y)$, $n = 1, 2, \ldots 241$
(4) Compile a *241*-frame video of the range-profile sequence $\hat{S}_n(x, y)$.
(5) Compile a *241*-frame video of the spectra of the range-profile sequence.

Report format:

(A) Cover page.
(B) Video sequences.
(C) Summary: (comments based on your observations)
(D) Appendix: (computer code)