Fall 2013, Aaron Lanterman

ECE 6279: Spatial Array Processing Homework 3

Due date: Tuesday, October 1, at the start of class.

Late due date (30% penalty): Thursday, October 3. (Again, if you need to use this late option, your homeworks are due at the *start* of class.)

You are welcome to discuss approaches to the problems and solutions to difficulties you encounter with one another and with others outside the class. You can and should learn from each other as much as, and even more than, you learn from me. However, **your solutions should be your own work and should be written up by yourself**; feel free to discuss things, but **don't be looking at someone else's paper when you are writing your solution**. It's too easy to freeload that way and not learn anything. See the class website for more guidelines.

Looking at solutions to homeworks and quizzes from previous offerings of ECE6279 is expressly forbidden. Look, here I am expressing how forbidden it is. Forbidden! Forbidden!!!

A 30% penalty will be assessed on late homeworks (even homeworks turned in later the day it is due, at my discretion); I will distribute solutions to students in the different sections (on-campus or distance learning) shortly after class on the associated "late option" due date, so I will not accept solutions after that. If you cannot make a class, try to make arrangements to get your homework to me ahead of time.

1 Required Problems

1. Verify the formula in the box on p. 119 of J & D. To make your task easier, look up the "law of cosines."

2. Suppose we have an array consisting of M (M is odd) elements evenly spaced along the x-axis, centered at the origin, with spacing d. The twist here is that each element, instead of being a point, is actually a small linear segment of length L along the x-axis (where $L < d$, so the segments don't overlap), centered at the element locations. Using ideas from p. 131, find the wavenumber-frequency response of the resulting filter-and-sum beamformer if the sensor delays are adjusted to steer the beam to look for plane waves propagating with a slowness vector $\vec{\alpha}$. (On this problem, and actually on all the homeworks, feel free to quote results from the lectures whenever you find them useful; you do not need to rederive things we've already established in the slides.)

3. In Lecture 7 on 9/10/13, I showed a movie containing 2-D images of the absolute value of the W (with the strange curve over it, which I'm not sure how to do it in LaTex and don't feel like bothering to look up) function on Slide 13. The images showed variation with respect to what position the system focused on, and the true source position of the wave changed over time.

   In this problem, we will play with that idea a bit more.

   Please provide a code listing for one of the subparts of one of the problems (I don't care which.) You do not need to provide code for every problem, since only minor changes will be needed.

   (a) Change the code given for Lecture 7 to employ a circular array of between 20 and 30 elements, equally spaced around the origin, instead of the rectangular array used in the original code. Space your elements so that there is approximately one-half wavelength between them (this need not be exact). You may come up with situations with image values that involve division-by-zero—you will want to "hack" those in some way to get a decent plot.

       Print images showing the absolute value of the W-with-strange-curve-above-it function for: (i) the true source at the origin, (ii) the true source somewhere *on* the circle itself, spaced evenly between two of the elements, (iii) the source half way between the origin and the circle, on the *inside* of the circle, and (iv) the source at a distance from the origin of twice the radius of the array, as four separate images. It would be nice if all four images are on the same page, but this is not essential. (For this assignment, you will be modifying the code to make static images instead of a movie, although you may find it fun to make some movies on your own.)

       To avoid using up a lot of toner, you might want to consider using an inverted color map, i.e. using black to represent high values and white to represent low values. However, I am not picky about this; use whatever color map you think is most illuminating.

       Note that (iv) corresponds to the typical "surveillance" application we have often discussed in class, whereas (iii) corresponds more to a medical imaging or nondestructive testing (well, I guess medical imaging is, hopefully, a kind of nondestructive testing!) type of scenario.

   (b) Repeat the above experiment using an array that is approximately twice the diameter of what you used in part (a); increase the number of sensors used as needed to maintain an approximate one-half wavelength spacing.

   (c) Briefly comment on what interesting features you observe in comparing your results from parts (a) and (b).