ECE 738 Advanced Digital Signal Processing

Problem Set 7

Fall 2007

Issued: Friday, November 2, 2007 **Due:** Wednesday, November 7, 2007

Reading

10/31/07 — Paper by Krim and Viberg cited in the supplemental reading list

11/7/07 — Paper by Van Veen and Buckley cited in the supplemental reading list

---

ECE-738 Problem 7-1

Pick a paper for the final project. See the list posted on the "Announcements" page of the website for a set of possible papers. Please don't feel constrained to pick a paper on the list. I am simply providing the list as a starting point for your search. Let me know if you're interested in doing one of the papers. (Only one person per paper, so the first person who asks for it will get it.) Note that a brief description of the project requirements is now posted on the website.

ECE-738 Problem 7-2

In this problem you will use Matlab to generate minimum variance (Capon's method) and MUSIC spectral estimates using an ideal correlation matrix.

(a) First write a function to generate an ideal correlation matrix when the signal consists of multiple complex exponentials in white noise. Recall from this week's lecture that the correlation matrix of a vector $\mathbf{x}$ in such a case is

$$\mathbf{R}_x = \sum_{m=1}^{M} P_m \mathbf{v}_m \mathbf{v}_m^{\mathrm{H}} + \sigma^2 \mathbf{I},$$

where P_m is the power in the mth signal, $\mathbf{v}_m$ is the replica vector associated with the mth signal, and σ^2 is the white noise power. For this problem your function should take the following inputs:

- `L`: the length of the vector $\mathbf{x}$. $\mathbf{R}_\mathbf{x}$ is an $L \times L$ matrix
- `omega`: a length M vector containing the DT frequencies of the complex exponentials. (Remember, these should be numbers between 0 to 2π.
- `Pm`: a length M vector containing the powers P_m corresponding to the frequencies in the `omega` vector.
- `sigmasq`: the noise power.

(b) Write a Matlab function called `mvdr` to implement the Minimum Variance spectral estimator. The function should require the following input parameters:

`Rx`	ideal correlation matrix
`Nfft`	number of frequency samples to compute

The output of the `mvdr` function should be

`pmvdr`	MVDR power spectral density estimate
`omega`	a vector of discrete time frequencies for plotting

Provide a copy of your `mvdr` code and a brief summary of how it works in your homework. Note that you may choose to implement the MVDR estimator directly, or using the Fourier transform of the eigenvectors as discussed in last week's homework.

(c) Write a Matlab function called `music` to implement the MUSIC spectral estimator. The function should require the following input parameters:

`Rx`	ideal correlation matrix
`Nfft`	number of frequency samples to compute
`sigdim`	dimension of the signal subspace

The output of the `music` function should be

`pmusic`	MUSIC pseudospectrum estimate
`omega`	a vector of discrete time frequencies for plotting

Note that the MUSIC estimator requires knowledge of the number of signals (complex exponentials). For the purposes of this project, you will assume that you know the dimension of the signal subspace, and hence know the dimension of the noise subspace. In real applications, the signal subspace dimensions must be estimated from data, typically using either the AIC or MDL criteria, as discussed in class.

Provide a copy of your `music` code and a brief summary of how it works in your homework. Note that you may choose to implement the MUSIC estimator directly, or using the root method described briefly in class and in more detail in the Krim and Viberg paper.

(d) Assuming $L = 256$, construct several test cases and verify that your `mvdr` and `music` functions are working correctly. You should include a description of your test cases, including relevant plots, along with your homework. Your description needs to provide convincing evidence that the correct results are being obtained.

Please comment on how large `Nfft` should be. Do you encounter problems if the true source frequency does not correspond to one of the frequency samples you are calculating?

ECE-738 Problem 7-3

Begin work on Project II (will be posted on Friday 11/1). The last 20 minutes or so of class on Wednesday 11/7 will be devoted to questions about the project, so please familiarize yourself with it before class.