Where to Go from Here?

ECE 6279: Spatial Array Processing
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Lecture ??
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Detection Problems

- **Class focused on estimation of directions-of-arrival of sources**
- **Related problem: given a particular direction-of-arrival, do we want to declare that there's a source at that angle?**
- **All roads lead to the Likelihood Ratio Test**
  - Compare to a threshold which trades off probability of detection and probability of false alarm
- **Take ECE7251 to learn about Detection Theory**
  - Also shows up in many telecom courses

Space-Time Adaptive Processing

- **Radar sends a series of pulses**
- **Matched filter against transmitted waveform to get range resolution**
  - Sort "fast time" (within pulse) into "range bins"
- **Target velocity gives Doppler shift**
  - Shows up as sinusoid in "slow time" (across pulses)
- **Extend our presentation (MVDR, etc.) to include the Doppler frequency in addition to angle**
- **Adaptive Detection: Can use data from other bins to estimate noise (clutter) covariances, etc.**

Arrays in Communications

- **Throughout the class, we've put little (if any!) structure on the signals**
- **In communications, you're typically looking for one of a particular set of signals**
- **Puts a lot of structure on the resulting estimation and detection algorithms that can improve performance**

Calibration

- **Often don't know exact sensor locations**
- **Sensor electronics may introduce unknown amplitude and phase shifts**
- **It's best if you have some known calibration sources…**
- **…but often don't, so you have to jointly estimate sources and calibration parameter**

Radio Astronomy (1)

- **Distributed sources**
  - Not specific directions of arrival
- **Can think of "pixels" in the sky as emitting complex Gaussian noise**
- **Looking at the power in the "conventional beamformer," and using small-angle trignometric approximations, results in an interpretation of the power of the conventional beamformer in terms of Fourier transforms**

Radio Astronomy (2)

- **Elements of the estimated correlation matrix correspond to points on the Fourier transform, with the positions given by the lags**
- **Results in image processing problem of recovering a function from sparse samples of its Fourier transform**
  - CLEAN Algorithm
  - Maximum Entropy
  - Aaron's EM Algorithm

Inverse Scattering Problems

- **In ECE6279, assumed medium was known, and sources unknown**
- **Inverse scattering problem: Sources known, must determine characteristics of an inhomogeneous medium**
  - Medical or NDE ultrasound
  - Buried mine detection with EM
  - Seismology (oil exploration)
- **Literature often focuses on complicated wave physics (diffraction, etc.)**

Tomography

- **Recovery of an image from projections (line integrals)**
  - X-ray CAT Scans
  - Emission Tomography (PET and SPECT)
- **Synthetic Aperture Radar can be interpreted in terms of tomography**

Recommended Books

- **M. Soumekh, *Fourier Array Imaging***
  - Underrated
  - Out-of-print
  - Strange notation and termonology
  - But does a good job of connecting different topics
- **R. Blahut, *Theory of Remote Image Formation***
  - Wide-ranging masterpiece