Sensor Array Signal Processing – 2016W

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List of exercises – 3

1. Explain with your own words the concept of performing direction finding with a sensor array and why this is fundamental for beamforming.

2. Consider a uniform linear array (ULA) array with N elements that must process signals from D sources according to the model given by

$$\boldsymbol{x}[i] = \sum_{d=1}^{D} s_d[i]\boldsymbol{a}(\theta_d) + \boldsymbol{n}[i],$$

where $\boldsymbol{x}[i]$ is an N x 1 received vector, $s_d[i]$ is the dth signal and $\boldsymbol{a}(\theta_d)$ is its steering vector. The noise vector $\boldsymbol{n}[i]$ represents the measurement noise which is modeled as a complex Gaussian random variable with zero mean and variance σ^2.

a) Compare the spatial spectrum of the Capon and the MUSIC algorithms for a scenario with N = 10 sensors, i = 40 snaphots, signal-to noise ratio (SNR) = 10 dB and angles of arrival equal to 30 and 35 degrees.

b) What happens if the angles of arrival get closer in the above scenario? Explain and plot the spatial spectrum.

c) Compare the root mean-square error (RMSE) against the SNR performance of the Capon and the MUSIC algorithms using a scenario with N = 8 sensors, i = 40 and angles of arrival equal to 30 and 40 degrees.

d) Given the Root-Capon and the MUSIC algorithm, develop a Root-MUSIC algorithm. Choose an arbitrary scenario and compare their RMSE against snapshots performance.

e) Compare the RMSE against SNR performance of Root-Capon, MUSIC and the ESPRIT algorithms for a scenario with N = 10 sensors, i = 40 snaphots and angles of arrival equal to 40 and 45 degrees.

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