PDEEC/MAP-TELE DOCTORAL PROGRAMS
Advanced Topics on Signal Processing

Academic year 2024-2025
Home assignment
(solutions to be handed-in –on Moodle- by November 15th 2024)

A random process is defined as $x[n] = e^{j(n\omega_A + \theta_1)} + 2\sin(n\omega_B + \theta_2) + w[n]$, where ω_A and ω_B are fixed frequencies to be defined for each group of Student, and θ_1 and θ_2 are two independent random variables uniformly distributed in the range [-π, π[, and $w[n]$ represents white noise. The variance of the white noise is such that the Signal-to-Noise Ratio (SNR) may vary between -5 dB and 20 dB in steps of 5 dB. Each realization of the data vector has length N=64. The purpose of this home assignment is to estimate the frequencies of the first two terms of $x[n]$, using either periodogram-based frequency estimation (presuming the rectangular window), or the MUSIC method (with M=8).

Note: notice that one of the terms is a complex exponential and the other term is a real sinusoid, which means that, in total, three complex exponentials exist.

For each value of the SNR, and for each frequency, obtain the mean and variance of the normalized absolute error (average over 1000 trials) of the frequency estimation (if ω is the frequency and $\hat{\omega}$ is its estimate, the normalized absolute error is $|\omega - \hat{\omega}|/(2\pi/N)$), in the case of periodogram-based frequency estimation (using the rectangular window and the provided frequency-domain interpolation function), and in the case of MUSIC-based frequency estimation. Make a graphical representation (with means and 95% confidence intervals) for each case so as to better understand how results depend on the SNR. Comment on the results.

Note: in your report (make it short!) please include a printing of the Matlab code