SIGNAL PROCESSING IN PRACTICE - ASSIGNMENT 12 - ARRAY PROCESSING

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ABSTRACT

This report is on estimating Direction of Arrival(DOA) of multiple signals(in our case 2 sources) using classical beamforming, MVDRbeamforming, MUSIC approaches and estimating original signal back by using matched filter and zero forcing receiver beamformers.In the report we analyzes spatial response foe fixed w case by varying Delta(Spacing between antenna array elements) and M (number of array elements) and we also analyze behaviour of singular values of covariance matrix of data(noisy case) by varying M,Delta,Separation,N,SNR as parameters.

RESULTS

PROBLEM-1

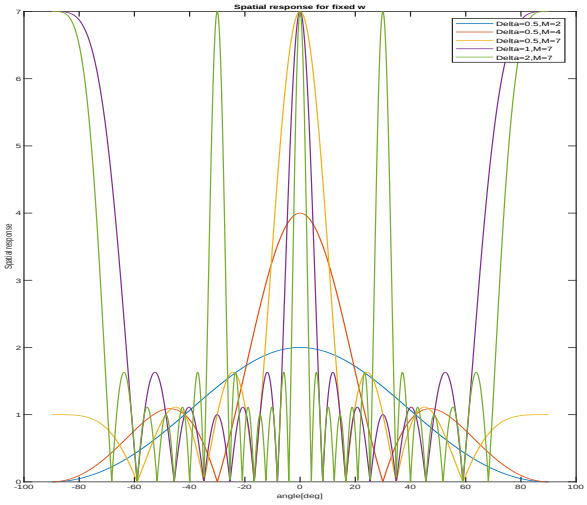

Fig. 1. Prob1 output

Prob 1) Observations:

- With a larger number of antennas, resolution improves i.e. more height of main lobe with narrower width but sidelobes occur.
- By keeping M= constant and increasing Delta will increase number of sidelobes in spatial response and after certain Delta ,if we increase Delta ,we get multiple mainlobes,which is called spatial aliasing.

PROBLEM-2

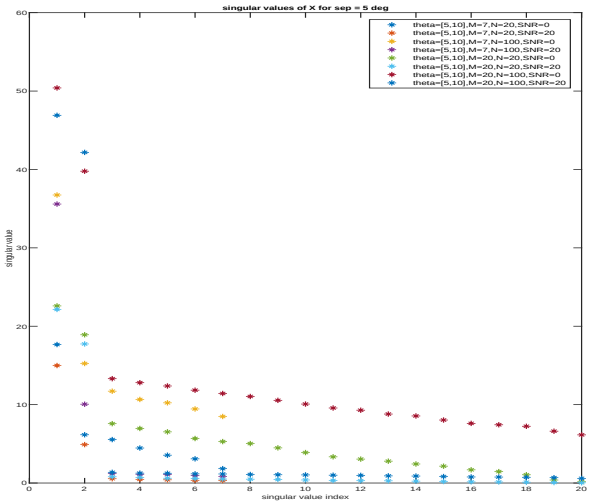

Fig. 2. "Singular values of X using svd(X) and sep=5deg "

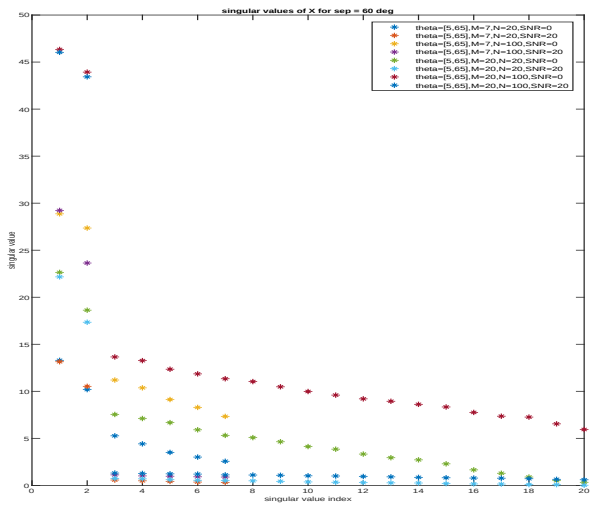

Fig. 3. "Singular values of X using svd(X) and sep=60deg "

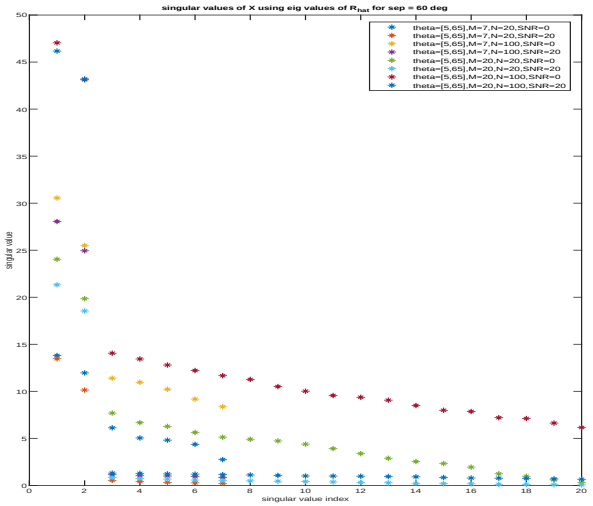

Fig. 5. "Singular values of X using eig values of Rx for sep=60deg "

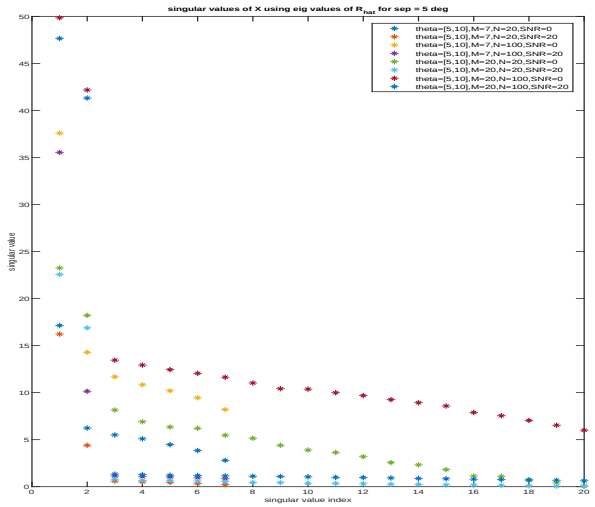

Fig. 4. "Singular values of X using eig values of Rx for sep=5deg "

Prob 2) Observations:

- Singular values of X for d = 2 sources i.e 2 signal singular values, M = 7 antennas i.e M-d = 7-2 = 5 Noise singular values, N = 100 samples.
  Observe any of the figures in Fig.2 to Fig.5,we can infer that
  (a) Well separated case(SNR =20dB, sep = 60 deg): large gap between signal and noise singular values,
  (b) closely separated case(SNR =20dB, sep = 5 deg):signals from close directions results in a small signal singular value,and noise singular values depends on SNR.on overall gap between signal and noise singular values decreases.
  (c)High noise case(SNR = 0dB, sep = 0 deg or 60 deg): increased noise level increases noise singular values,thus reduces gap between signal and noise singular values.
- The singular values using svd(X) and sqrt(eig(Rx)) are same,but we generated data again in calculating singular values from Rx,as data X =AS+N depends on Noise(N), therefore data changes and hence singular values changes in the above plots from using Rx case comapred to using svd(X) case.

PROBLEM-3

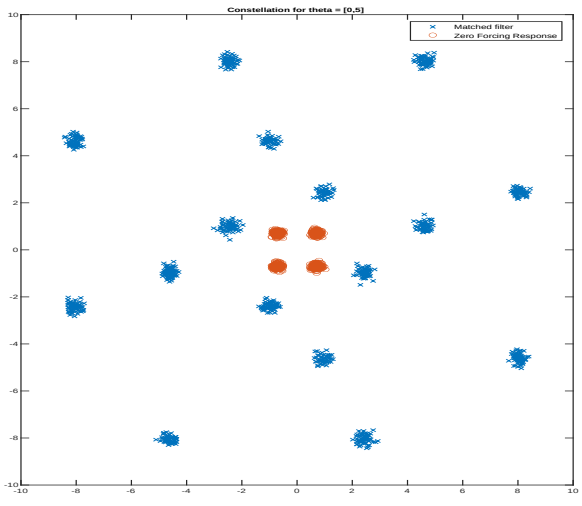

Fig. 6. θ = [0,5] i.e separation=5 deg

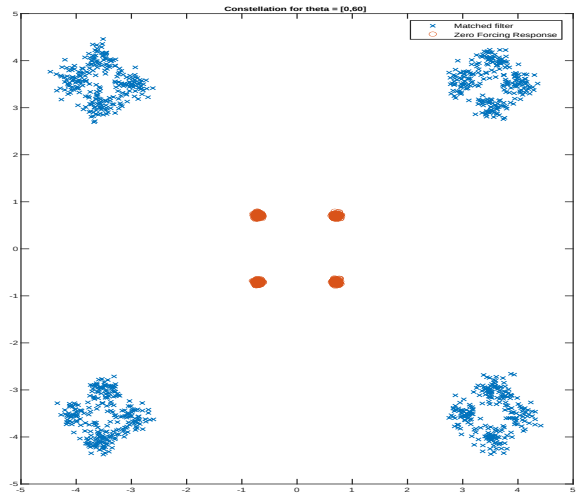

Fig. 7. θ = [0,60] i.e separation=60 deg

Prob 3) Observations:

- From Fig.6 and Fig.7 ,we can observe that zero-forcing receiver performs better than matched filter for separation =5 deg and for separation = 60 deg ,both are performing well,so that we can clearly observe 4 clusters and all source symbols are correctly estimated by using some detector like minimum distance detector.

PROBLEM-4

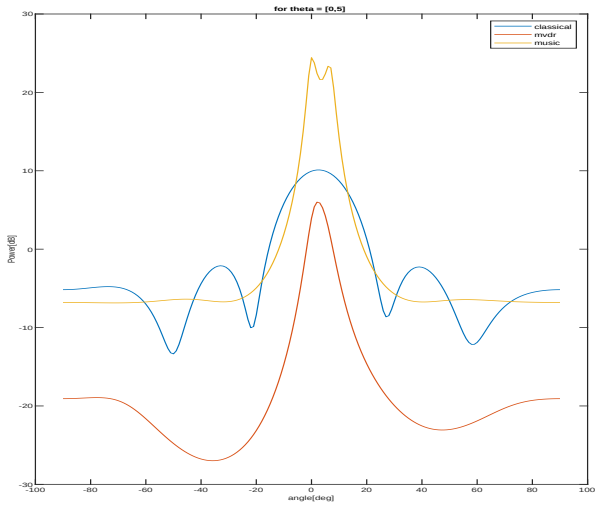

Fig. 8. θ = [0,5] i.e separation=5 deg

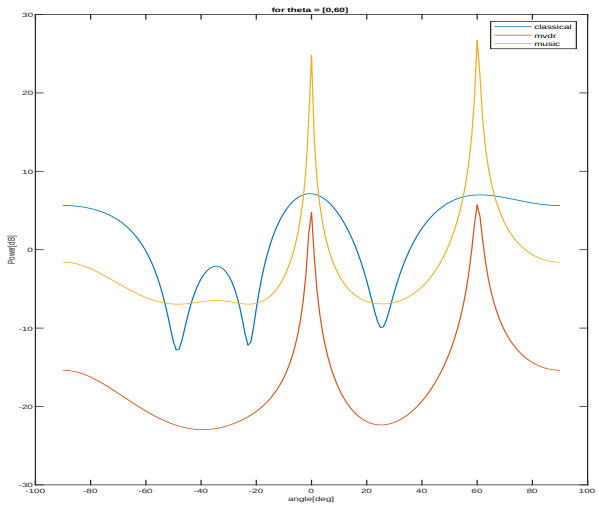

Fig. 9. θ = [0,60] i.e separation=60 deg

Prob 4) Observations:

- From Fig.8 and Fig.9 ,we can observe that direction of arrival(DOA) of the two sources is clearly observed as peaks of MVDR,MUSIC curves or maximas of Classical beamformer curve at θ = 0 deg and θ = 60 deg ,for well sepated case(θ = [0,60] i.e separation=60 deg).

- But for smaller separation case i.e θ = [0,5] i.e separation=5 deg,we can still find clear peaks in MUSIC curve at θ = 0 deg and θ = 5 deg but MVDR and Classical beamformers fail to detect the direction of arrival(DOA) of the two sources.