

Beamforming

1 Questions

1. Look at the difference equation on slide 5. Explain the meaning/function of both summation signs. What entities do $y_m(n-i)$ and $g_{m,i}(n)$ represent? Which index can be dropped in the case of a fixed beamformer?
2. Look at the delay equation on the bottom of slide 7. Which units do the variables have? Show that the units in the equation are consistent!
3. Look on slide 10. In which parameter is the dependency on the angle hidden?
4. Which conditions have to be fulfilled in order to be able to separate the influence of the microphones and of the signal processing?
5. Which are the extreme cases (highest and lowest values possible) of the array gain?
6. Explain the delay-and-sum beamformer! Why isn't the time-domain solution simply a delay of τ_m samples?
7. What does superdirectivity mean?
8. What is the optimization criterion of the filter-and-sum beamformer? Why do we introduce a constraint in the derivation?
9. Look on slide 25. What is the origin of the sidelobes?

2 Answers

1. Sum 1 is sum over all microphones. Sum 2 is the convolution sum. $y_m(n-i)$ is signal of microphone m at sample index $n-i$. $g_{m,i}(n)$ is filter coefficient i of the filter of microphone m at time index n . For a fixed beamformer $g_{m,i}(n) = g_{m,i}$.
2. $f_s[1/s]$, $c[m/s]$, $\mathbf{r}_m[m]$. \mathbf{r} is dimensionless due to the normalization to 1.
3. The angle of incidence is hidden in $\tau_m = \tau_m(\mathbf{r})$.
4. The microphones must have the same characteristic (including direction).
5. Lowest for omnidirectional characteristic with $Q = 1$ ($Q_{\log} = 0$). Highest for extremely thin lobe with gain approaching infinity.
6. See slides for overview. Since τ_m is generally not integer, the solution is a fractional delay filter instead of an integer delay.
7. A characteristic that is better than a delay-and-sum beamformer.
8. See slides for overview. Minimizing $\tilde{u}(n)$ without constraints would lead to all filter coefficients converging to 0.
9. The sidelobes can be explained by the microphone distances which are getting larger than half the wave length.