

Exercise 1

In this exercise we will explore Huygens' principle and closed form spatial in pulse response method for acoustic field calculations, along with some general properties of field calculations. To make the calculations less complex we will not involve ourselves with the correct amplitude and timing of the calculated quantities.

1. Huygens' principle

- a) We start-out with the parameter space set-up in the m-script *exercise_1.m*. Complete the quadruple for-loop by filling in the correct expression to calculate the spatial impulse response in the frequency domain using Huygens' principle (see sub-subsection 2.1.1, first paragraph, page 100).
- b) Plot the normalized magnitude of the calculated impulse responses for the observation points. Remember we are dealing with a complex amplitude function and we are only interested in its magnitude here.
- c) Compare the directivity of the aperture, from part b, with the one of formula 3.33 on page 160.
- d) What is the most prominent reason for the observed differences? Compare a double spatial resolution with a double axial coordinate of the observation points.

2. Acoustic field

- a) Change the x-coordinate of the observation points to a single value (e.g. 0 or $5e-3m$) and set the frequency range to: $0:df:\text{floor}(N_FFT/2)*df$. Now calculate the pressure signal in the observation point using the spatial impulse response, which is calculated in the quadruple for-loop, and the excitation signal s . To accomplish this you could use the MatLab function:
`<time signal>=ifftmmv(<complex amplitude function>, N_FFT);`
- b) What is the alternative procedure to calculate the pressure signal, using the same variables?

3. Spatial impulse response

- a) Compare the algorithm described in the first paragraph of sub-subsection 3.3.1 (page 151) with the MatLab function: `sirmmv(a, x_0, y_0, z_0, f_Sample, c_0)`.
- b) Calculate the pressure signal in the observation point closed form expression of `sirmmv`.
- c) Using the result from part b as a reference what can you say about the accuracy of Huygens' principle (e.g. decrease the spatial resolution by a factor 2)? At this spatial resolution what happens if you move the observation point to $x_0=10e-3$ and $z_0=25e-3$? How can you explain this effect?
- d) Using the `tic` `toc` functions, as is used with the quadruple for-loop, what can you say about the calculation speed of Huygens' principle and the closed form spatial impulse response method?