Assignment 7

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Introduction

This report describes the implementation to reconstruct an image using the Delay-and-Sum (DAS) algorithm. It also contains my answers to all the questions in the assignment pdf.

Outputs

Below are outputs for the following parameters: dist_per_samp = 0.1, pitch = 0.1, C = 2.0, SincP = 5.0, src = (0,0), obstacle = (3,-1)

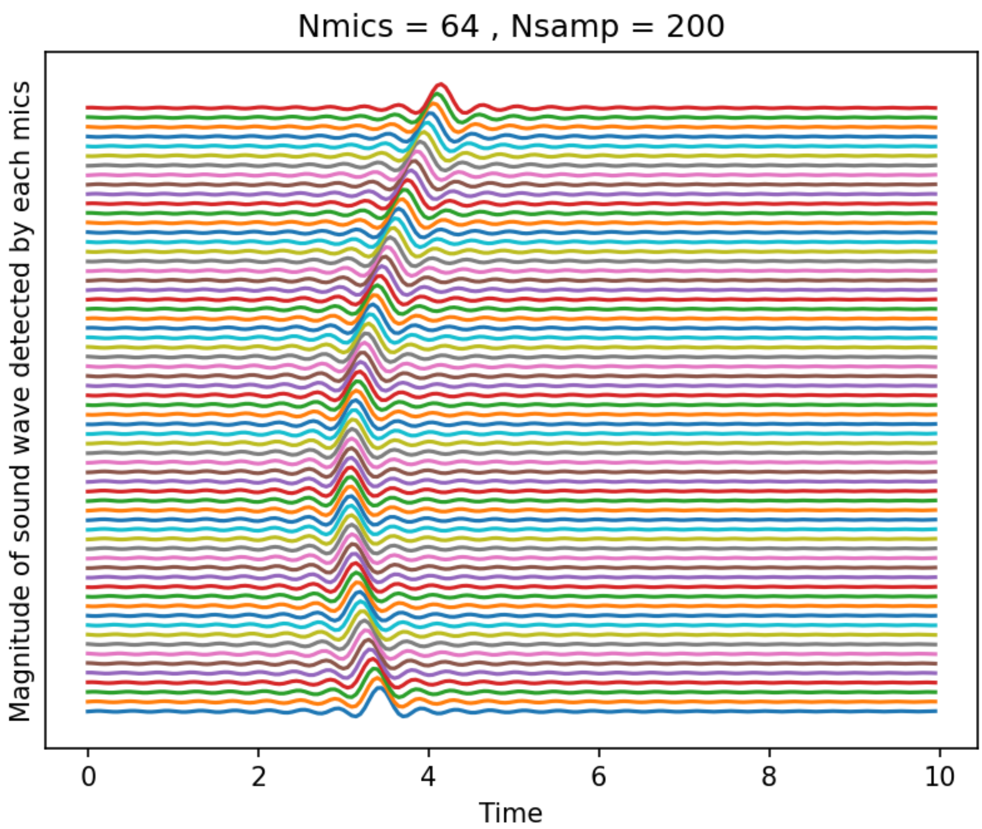


Figure 1: Reflected waves receiveed at the mic array

Below are reconstructed heatmaps showing obstacle positions for the following:

1. obstacle = (3,-1), parameters same as above
2. rx2.txt
3. rx3.tx2

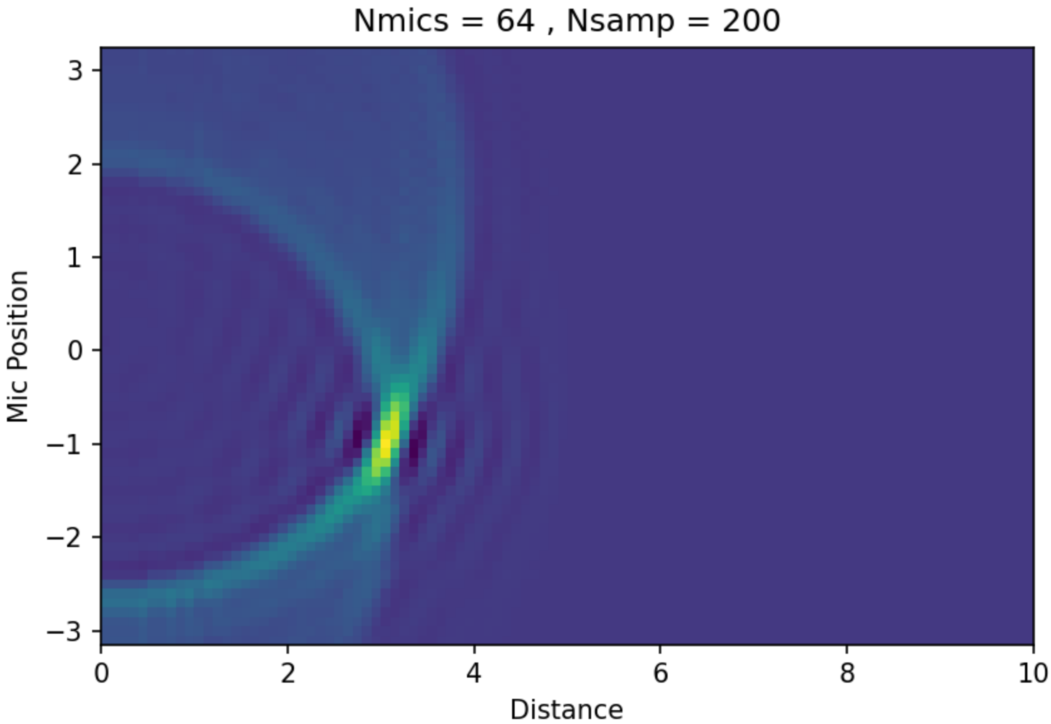


Figure 2: obstacle=(3,-1)

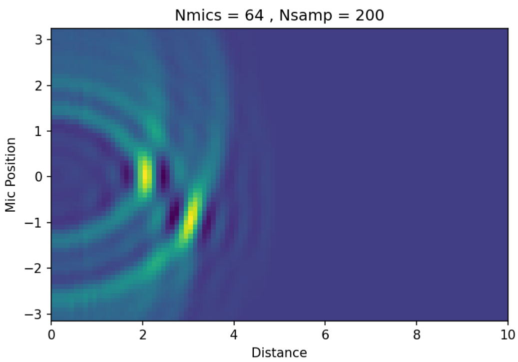


Figure 3: rx2.txt

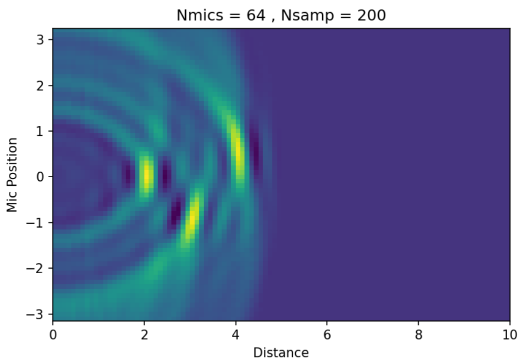


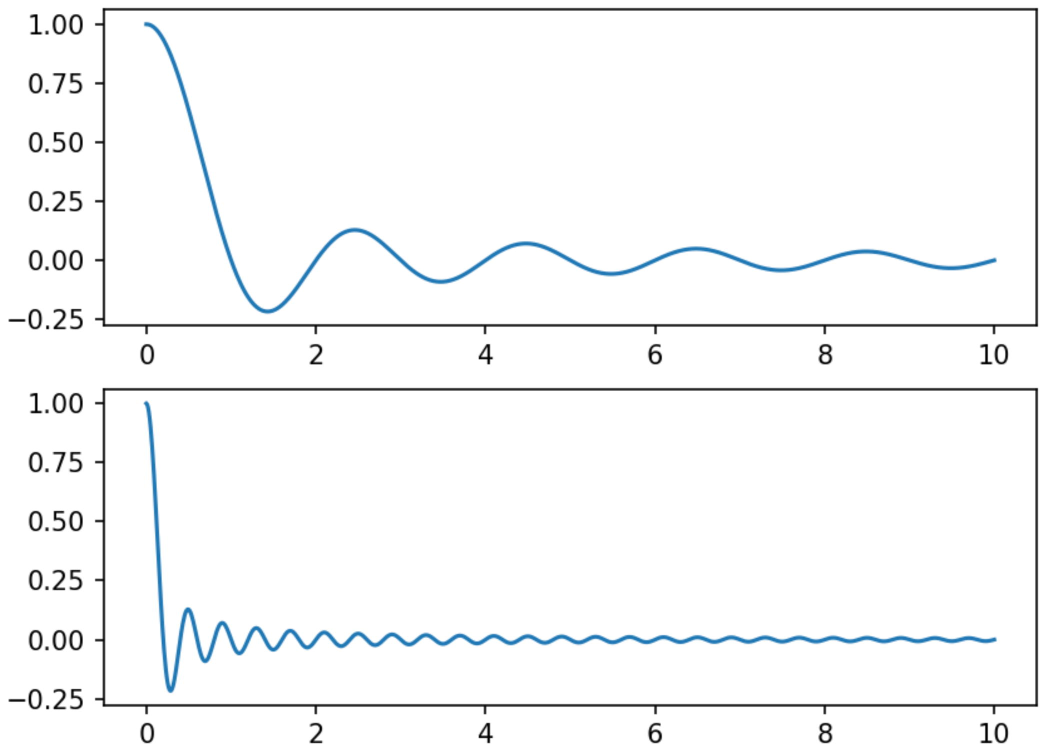
Figure 4: rx3.txt

Questions

Below are the answers to the questions in the assignment pdf.

1) Sinc pulse generation

To make sinc pulses narrower or broader, we need to change the factor multiplied with the input: 'SincP'



2) Upper limit for X-axis

Assuming our samples always contain the peak of the signals, the maximum delay in distance with which a microphone could detect a pulse is given by:

$$\text{Max Delay} = \text{Nsamp} \times \text{dist\_per\_samp}$$

If this entire delay was along the x-axis, the maximum x-coordinate needed would be:

$$\frac{\text{Nsamp} \times \text{dist\_per\_samp}}{2}$$

Since we are plotting with each unit on the x-axis corresponding to one dist_per_samp, we can go up to:

$$\frac{\text{Nsamp}}{2}$$

3) Obstacle Coordinates

In the assignment's reference image, the coordinates corresponding to the maximum amplitude are approximately (30, 22). This observation is based on the following:

- The x-axis represents samples up to $\frac{\text{Nsamp}}{2}$.
- The y-axis represents microphone indices, with values ranging from 0 to 64 (from top to bottom).

To convert the x-coordinate to actual distance:

$$30 \times \text{dist\_per\_samp} = 3$$

Similarly, for the y-coordinate:

$$22 \times \text{pitch} - \left(\frac{\text{Nmics}}{2} - 0.5\right) \times \text{pitch} = -1 \text{ approximately}$$

Therefore, (30, 22) corresponds to an obstacle located at (3, -1).

4) Farthest Obstacles Detectable in X and Y

The maximum delay distance for any microphone is:

$$\text{Nsamp} \times \text{dist\_per\_samp}$$

Maximum Distance in X

By symmetry, the farthest x-coordinate will be achieved when the obstacle is at some $(x, 0)$. The maximum delay distance from the bottom-most microphone (located at $(0, \left(-\frac{\text{Nmics}}{2} + 0.5\right) \times \text{pitch})$) is given by:

$$\text{Delay} = x + \sqrt{x^2 + \left(\frac{\text{Nmics} \times \text{pitch}}{2} - \frac{\text{pitch}}{2}\right)^2} = \text{Nsamp} \times \text{dist\_per\_samp}$$

We can further solve for x.

Maximum Distance in Y

For an obstacle at $(0, y)$, the maximum delay distance from the bottom-most microphone (located at $(0, (-\frac{\text{Nmics}}{2} + 0.5) \times \text{pitch})$) is given by:

$$\text{Delay} = 2y + \frac{\text{Nmics} \times \text{pitch}}{2} - \frac{\text{pitch}}{2} = \text{Nsamp} \times \text{dist\_per\_samp}$$

Solving for y gives:

$$y = \frac{\text{Nsamp} \times \text{dist\_per\_samp}}{2} - \frac{\text{Nmics} \times \text{pitch}}{4} + \frac{\text{pitch}}{4}$$

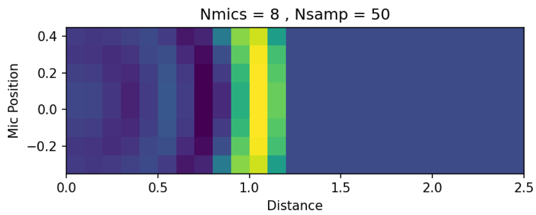
Note: When I say an obstacle can be "detected" I mean the pulse due to reflection from it is visible in ALL mics. That's why this x limit is lower than Nsamp/2

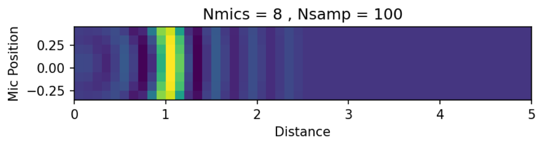
5) Effect of Changing C

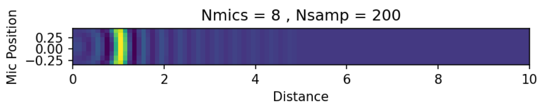
Reducing C while keeping dist_per_samp constant results in a reduced time interval between samples. This increase in sampling rate will make the graph sharper.

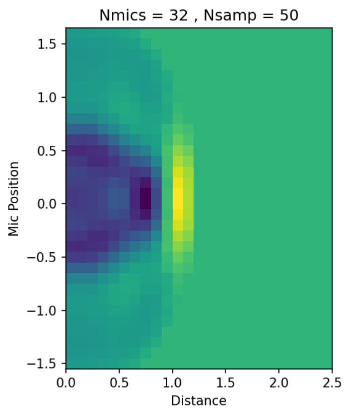
6) Experiments for Different Parameters

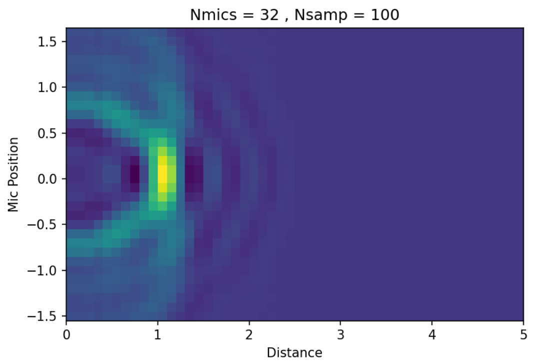
The heatmaps for different values of Nmics and Nsamps are given below. Obstacle is taken at (1,0). Rest of the parameters are same as everywhere else.

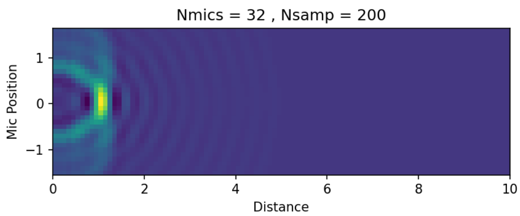


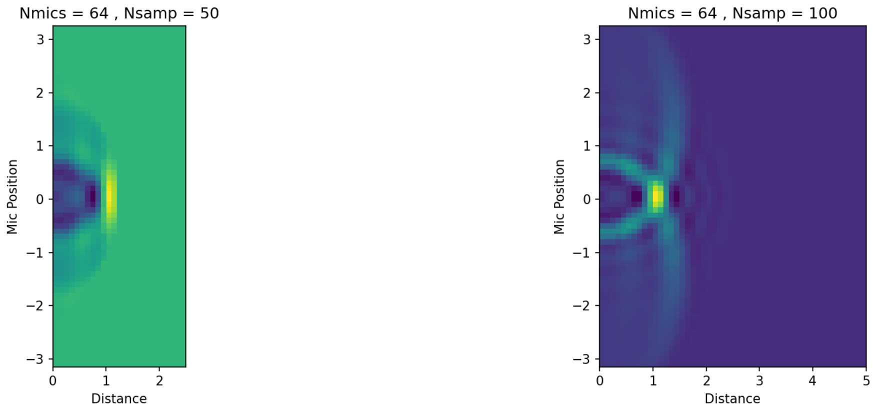




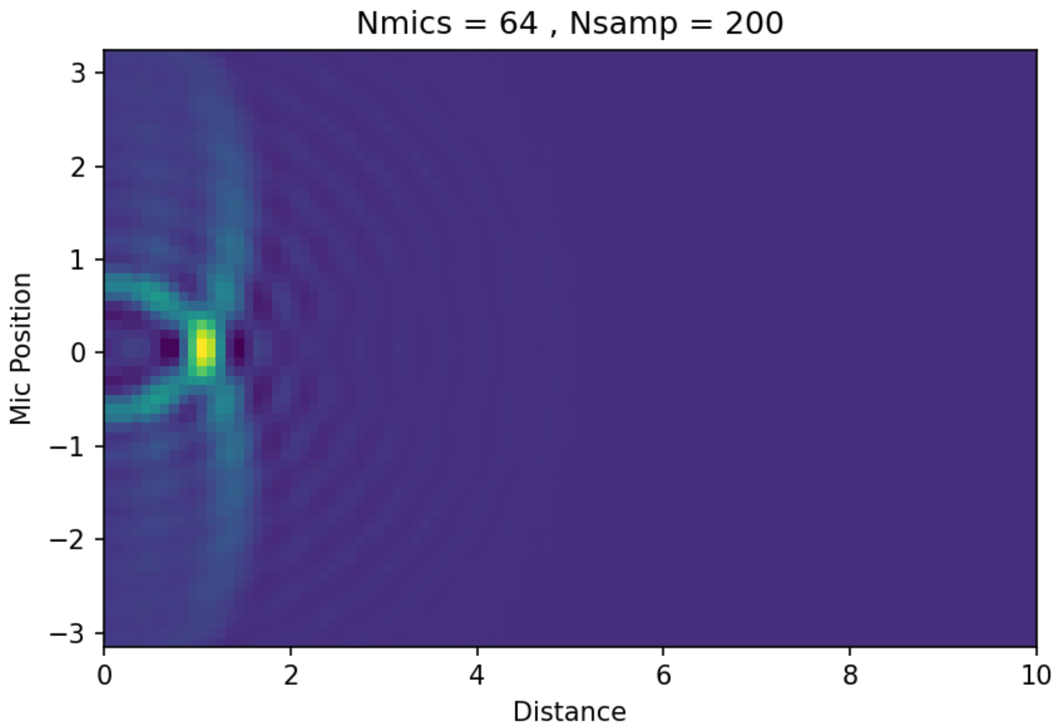








Nmics = 64 , Nsamp = 50
Mic Position
Distance
Nmics = 64 , Nsamp = 100
Mic Position
Distance



Nmics = 64 , Nsamp = 200
Mic Position
Distance