Assignment 7 - Sound Localisation

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1 How to run code

- I have submitted a juypter notebook, open it and run the cells sequentially, one by one.
- Ensure the cells are run sequentially, and ensure the function definition cells are run before running the other cells. In case of some error or unexpected behavior, start running the cells from the beginning again.
- In case of any errors, please refer to the comments on what to do.
- Please read the instructions given in the top of the notebook before running the program.
- For any information on how code works, please refer to the documentation in the code for reference.

2 Question 1

- The number of sample points will determine how clear the signal is. More the number of sample points, more defined is the image.
- Varying the value of SincP allows us to generate the given graphs. The greater the value of SinP, the narrower the oscillations (which occur at a higher frequency) and the faster is the decay.
- The narrower sinc pulse (Figure 2 in the problem statement and the orange graph generated here) will provide more precision in locating an object because the sharp peak allowed us to distinguish between closely spaces objects, whereas the graph with the broader peak might not be able to pinpoint the location as well.
- However, if we consider noise in the system, the broader pulse will be a better alternative, as it will be less affected by noise spikes, due to its more gradual decay rate.

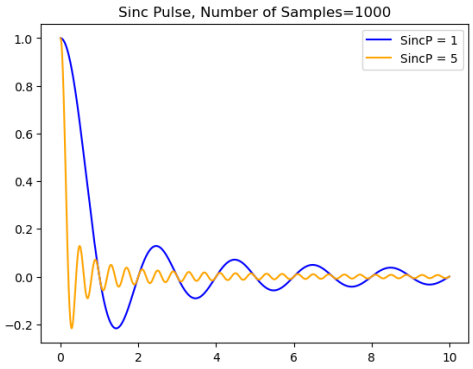

Figure 1: The two different sinc pulses

3 Part 2 - Generating the Waveform received by the Microphones

- This is constructed for the first sample given in the problem statement. It is constructed by plotting the output received by each microphone and plotting it in the same graph.

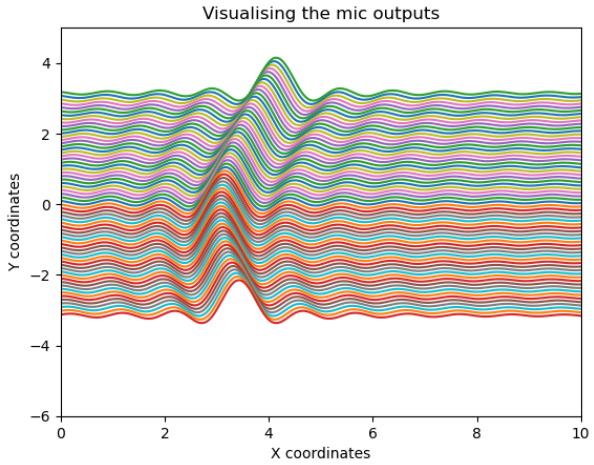

Figure 2: Microphone output

4 Question 2

- No, we need not plot till N_{samp}. We can plot till $\frac{N_{\text{samp}}}{2}$ (or in terms of the x coordinate, $N_{\text{samp}} \times \frac{\text{dis\_per\_amp}}{2}$).
- This is because if we consider a point past $N_{\text{samp}} \times \frac{\text{dis\_per\_amp}}{2}$, the distance from the source to the point and to a mic is greater than N_{samp}, and we have sample points only up to $N_{\text{samp}} \times \text{dis\_per\_amp}$. So we don't have data points for points past $\frac{N_{\text{samp}}}{2}$, so X coordinates should range from 0 to $\frac{N_{\text{samp}}}{2}$ ($N_{\text{samp}} \times \frac{\text{dis\_per\_amp}}{2}$ in terms of distance).

5 Question 3

- The obstacle is a perfect reflector, so any wave that strikes it will reflect and come back to the source.
- We are sending one pulse of a signal to the reflector and this will get reflected and come to the mic. This intensity will be captured by the microphones, in the data entry corresponding to the time interval it takes for the wave to reach the mic.
- Now, the intensity captured at this time stamp will be high, because it is reflecting the signal. So the regions with high intensity can be said to approximately be the location of the obstacle.

6 Question 4

- The max X coordinate has to be Nsamp/2, as discussed earlier.
- The Y coordinates should range from the first to the last microphone of the microphone array. This is because if any obstacle is present at a Y coordinate outside this range, it may not reflect the pulse given by the source to the microphone array, which would lead to inaccurate readings, while if its present in a Y coordinate in the range of the Y coordinates of the microphone array, most of the reflected waves will reach one of the microphones, leading to more accurate readings.

7 Question 5

- If we decrease the value of C, the time delays will increase, and the distance per sample will decrease. This means that the sampling of the grid intensities is finer, and makes the image resolution higher, as it now captures the smaller variations in time of the signals. Hence, the image appears sharper.

8 Question 6

- These are the images formed for all the combinations required by the problem statement for the input "rx2.txt".

8.1 Explanation

  - We see that for all three cases, the accuracy of the output increases as the number of samples increase.
  - For the 50 samples case, there seems to be a beam on the right side, which is indicative of the obstacle being out of the range of the x coordinates.
  - Increasing the number of microphones increases the sharpness at the maxima, and locating exactly where the maxima becomes easier at the number of mics increase.
  - The maximas become more concentrated at the number of mics increase.

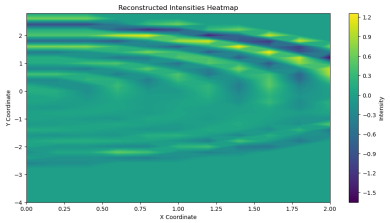

Figure 3: Number of Mics = 8, Number of Samples = 50

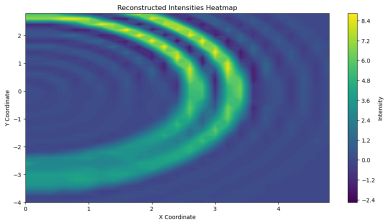

Figure 4: Number of Mics = 8, Number of Samples = 100

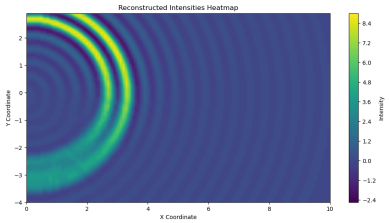

Figure 5: Number of Mics = 8, Number of Samples = 200

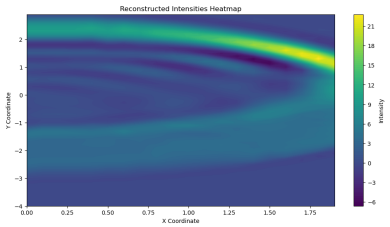

Figure 6: Number of Mics = 32, Number of Samples = 50

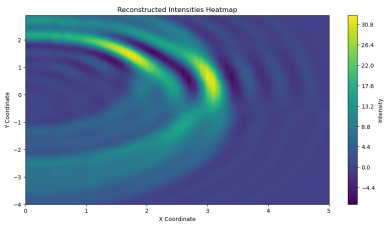

Figure 7: Number of Mics = 32, Number of Samples = 100

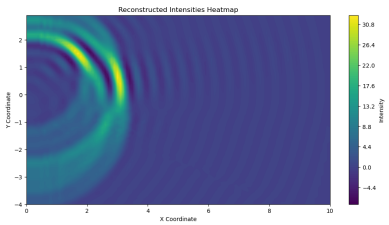

Figure 8: Number of Mics = 32, Number of Samples = 200

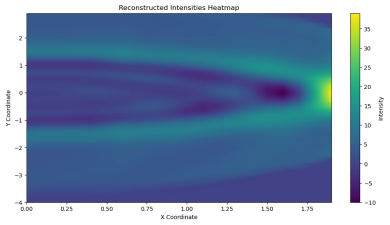

Figure 9: Number of Mics = 64, Number of Samples =50

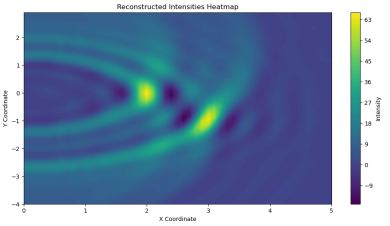

Figure 10: Number of Mics = 64, Number of Samples = 100

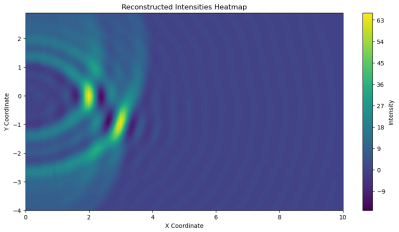

Figure 11: Number of Mics = 64 ,Number of Samples = 200

9 Final Outputs of ”rx1.txt” and ”rx2.txt”

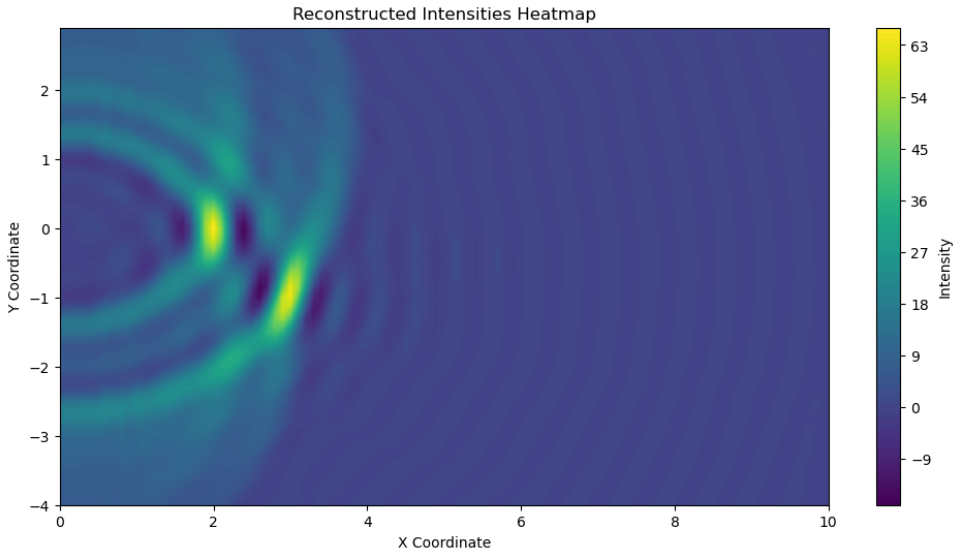

Figure 12: ”rx2.txt” output

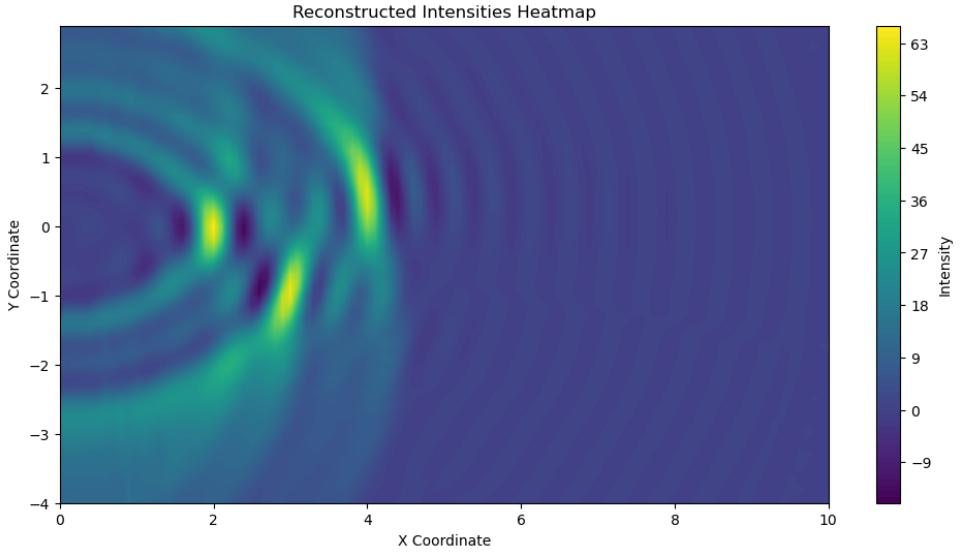

Figure 13: ”rx3.txt” output