Image Reconstruction

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1 Introduction

I am Deepak Charan S and this is my report for the seventh assignment of EE2703 course (Applied Programming Lab).

2 Approach:

- First I made some utility functions that would help me out. They are:
  - gen_mics: To generate the mics along y-axis (same x coordinate as src to be precise) and centering them about src (Taking pitch and number of mics as parameters)
  - wsrc: To generate the equation of the waveform. takes in a numpy array, t and SincP as parameters
  - euc_dist: To calculate the euclidean distance between two points (which are provided as parameters)
  - dist: To get the total path traveled from src to mic via reflection from an obstacle
- To generate the mic array output, I first created a list of time samples. Then for each mic, I computed the time delay to receive signal from src. Finally, I combined the reflected waves from all the mics and plotted it.
- For Delay And Sum algorithm, I first loaded the dataset using np.loadtext()
- I constructed a grid of Mic Locations v/s Time samples.
- For each (i,j) in the grid, I converted it to its corresponding space coordinates (x=i∗dist_per_samp and y=j) and assumed an obstacle to exist there
- With that assumption, I computed the time delay and figured out which sample of the mic to use and summed all these sampled values across all mics. Points which were likely to have the obstacle had large values of the sample sum and vice versa

3 How To Run:

1. First run the import libraries cell of *EE23B022_DelayAndSum.ipynb* and then all the utility functions
2. Then run the ultrasound() function cell to observe the plot of the reflected waves received at the mic array
3. Run the cells which are loading *"rx2.txt"* and *"rx3.txt"* (Ensure you have downloaded these 2 text files from the zip folder)
4. Then run the plot() function cell to generate the DAS heatmap. You can use this function and change the *'data'* parameter with your preferred dataset to get the heatmap and consequently estimate the position of the obstacle
5. Finally I have kept a section of the Notebook which answers the Questions asked in the assignment. Please have a look at them (Although I have answered it here as well)

4 References:

Writing it here cos I was facing some Latex issue
Handout from Moodle. I also got tips on how to approach this assignment from my roommate, N Deenabandhan (EE23B021) and Medha B Girish (EE23B112)

5 Questions:

5.1 Generating the two pulses

To get the following pulses, We just have to change the dilation factor and tweak the sampling. For the first graph, I took Sincp=0.5 and Nsamp=100 and took Sincp=0.5 and Nsamp=1000 for the second.

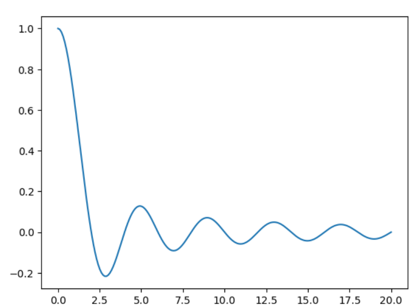


Figure 1: First Pulse

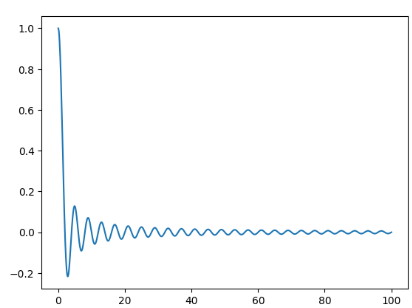


Figure 2: Second Pulse

5.2 X-limit for DAS algorithm:

No, we dont need to reconstruct the graph till Nsamp as the time delay/time per samp would easily exceed Nsamp. A good limit would be Nsamp/2 as time delay/time per sample (for a mic which is straight in front of the obstacle) would be exactly Nsamp

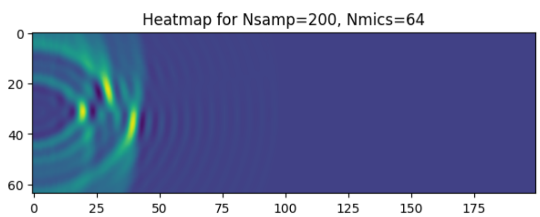


Figure 3: Unchanged Graph

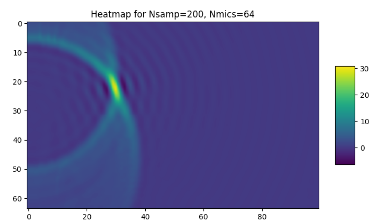


Figure 4: Updated graph

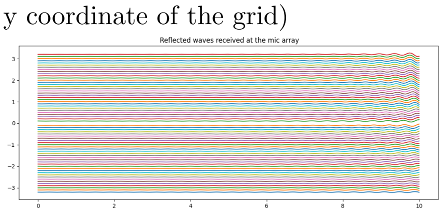
5.3 Expected Position of Obstacle

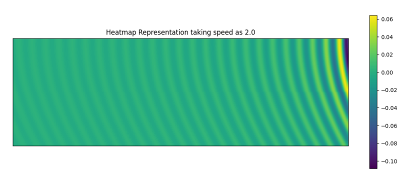
Yes, amplitude at (30,22) is good since if we convert it to the 2D space:

X coordinate = x $*$ dist_per_samp=30 * 0.1=3
Y coordinate = -3.2+y $*$ pitch = -3.2+2.2 = -1
(Interpolating from y=0 -> mic at (0,-3.2) and y=64 -> mic at (0,3.2))

5.4 Maximum possible coordinates

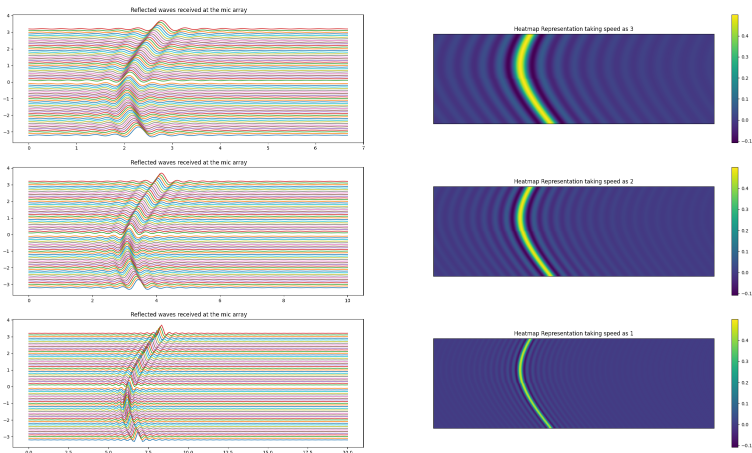
The maximum x and y values we can take are:
x=nsamp$*$dist_per_samp/2 = 200$*$0.1/2=10 (the division by 2 has been explained in the second part)
y=y coordinate of source+(nimcs$*$pitch)/2 = 0+64$*$0.1/2=3.2 (the maximum y coordinate of the grid)



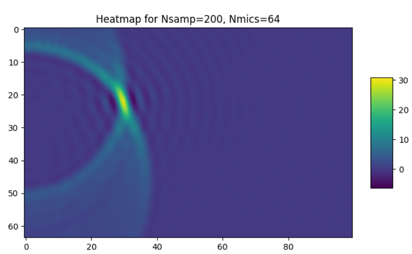


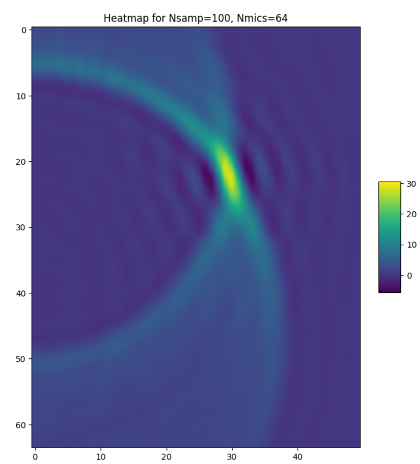
5.5 Sharpening graph by changing speed

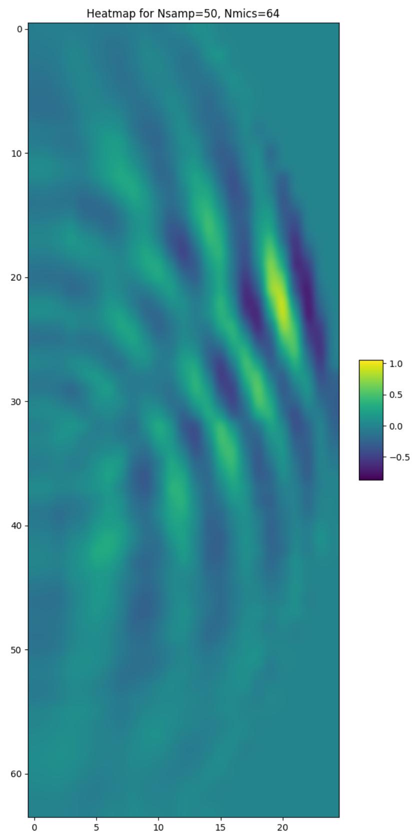
Lower speed means would mean the time between the samples become larger. This also means that the time duration at which you observe the peak intensity is small compared to the overall time of observation. Hence, the graph would be sharper

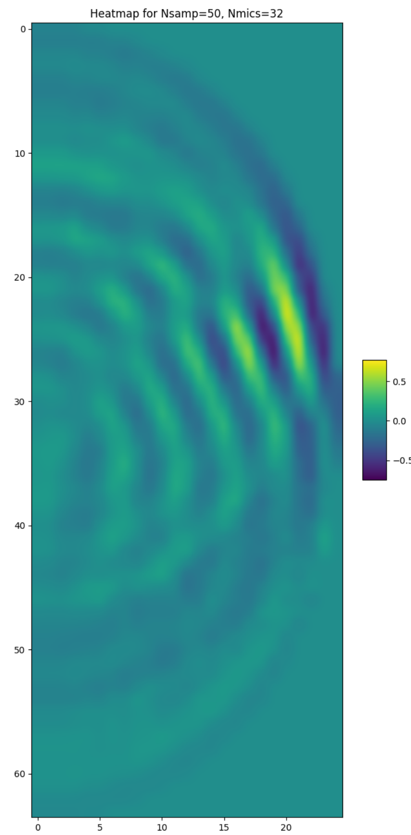


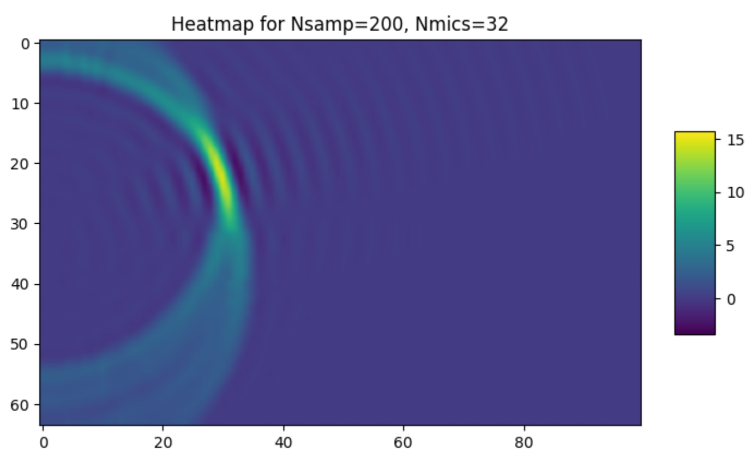
5.6 Tweaking Nsamp and Nmics values:

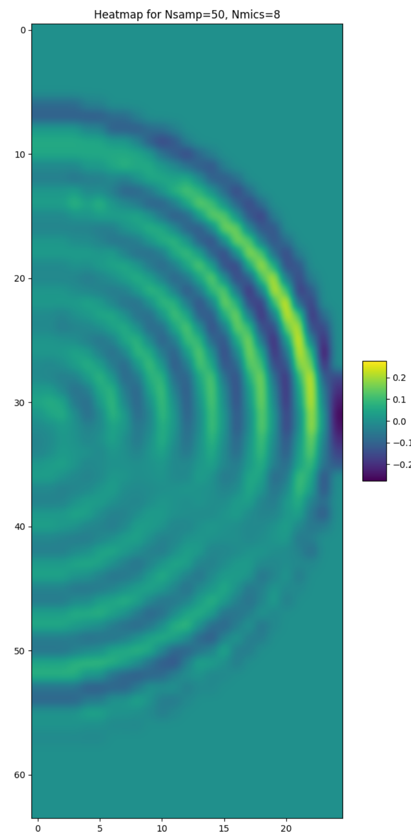


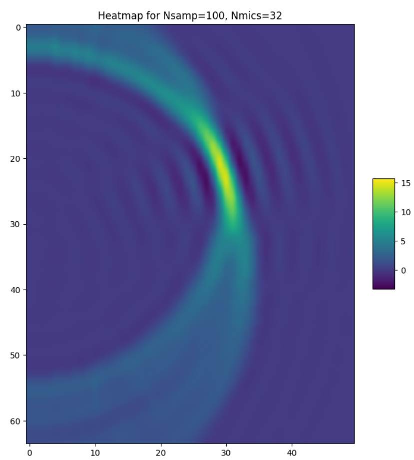


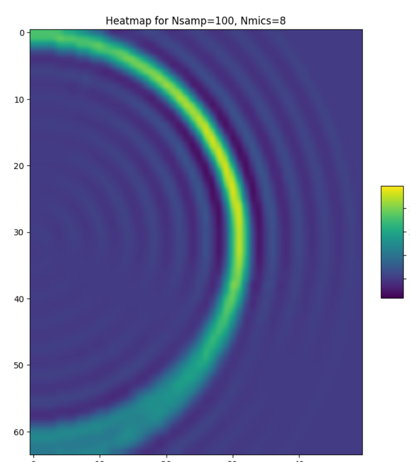

Heatmap for Nsamp=50, Nmics=64

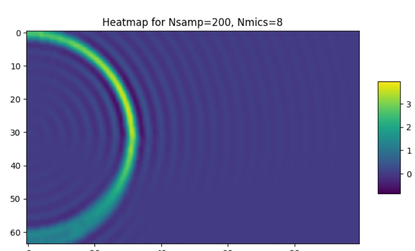

Heatmap for Nsamp=50, Nmics=32


Heatmap for Nsamp=200, Nmics=32


Heatmap for Nsamp=50, Nmics=8


Heatmap for Nsamp=100, Nmics=32


Heatmap for Nsamp=100, Nmics=8


Heatmap for Nsamp=200, Nmics=8