Assignment 8

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1 Introduction

The submitted .ipynb notebook performs image reconstruction using Delay and Sum method. One change that I have made is that in the generation algorithm , I have made output as 0 for all points on the wave before the peak. This can be disabled by changing the the value of the variable 'symmetric' to True
The following outputs were generated for Nsamp = 200 , C = 2 , Nmics = 64

1.1 Waves received by microphones

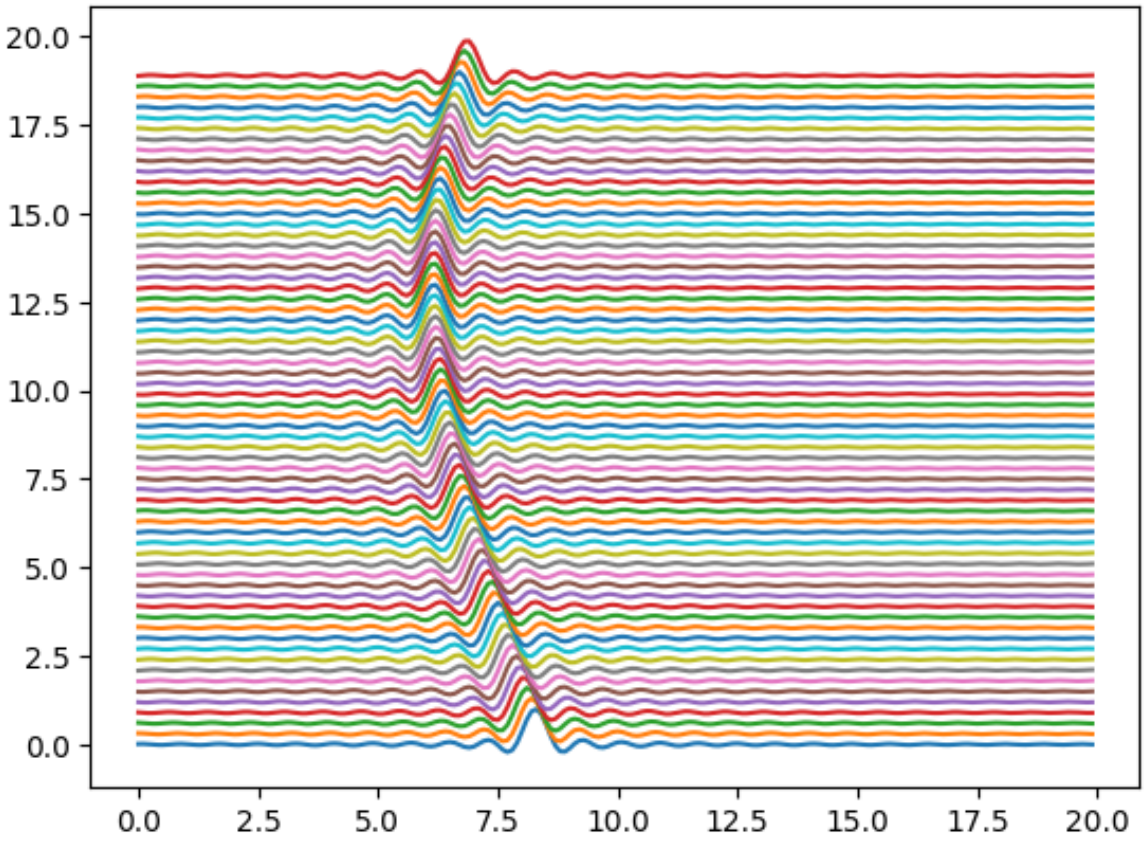

Figure 1: Waves received by microphones for obstacle at (3,-1)

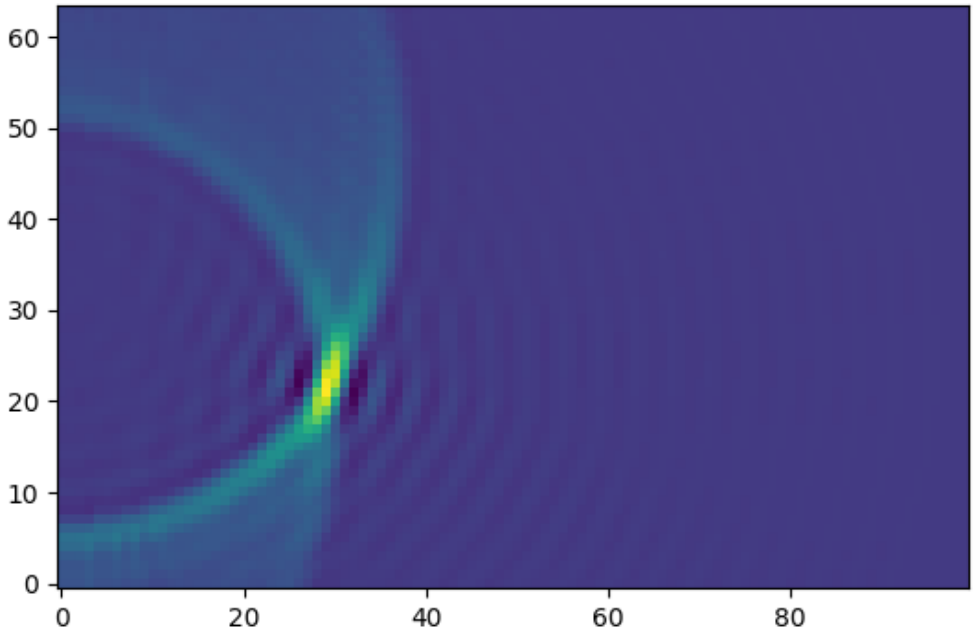

Figure 2: heatmap Generated for obstacle at (3,-1)

1.2 Final heatmap

2 Question 1

2.1 How to generate such a pulse

Use the wsrc function to generate the value of the source value at t = 0 . increase t by a small value and repeat. Then plot these values on the y axis with time as the x axis.

2.2 How to make the 2 different pulses

We change the parameter C , which is a constant for a given wave . It determines how closesly spaced the peaks and minimas are . Higher value of C means closer peaks, this is because the time input to wsrc is multiplied by a factor of 1/C . Therefore , to achieve the 2 different pulses , C must be changed to 10 and 2 respectively for the given 2 pulses.

2.3 Effect on final image

Sharper and closer peaks intuitively seem like they will give sharper images. Closer peaks implies a smaller wavelength which means the accuracy of the result is likely to be higher.

3 Question 2

Does it make sense to reconstruct up to Nsamp ?
Answer is No. The maximum distance that a sound wave can travel in the given amount of time is $Nsamp *$

dist_per_samp. For one of the microphones to pick the reflected sound wave up , the distance from source to object to microphone should be less than this. Int he above cases wherein src is at (0,0) , the maximum distance of an object that can be detected is at a distance of $\frac{Nsamp*dist\_per\_samp}{2*x}$. Where x is the distance between 2 consecutive points on the x-axis , witch in this case is 0.1 units (or the pitch).

4 Question 3

The (x,y) coordinates of the maximum amplitude is at (30,22) because the each point on the grid has been scaled and actually represents a unti square of pitch * pitch units square. Here pitch is 0.1 , therefore , (30,22) is actually (3,2.2) units in the real world coordinates. Also the x-axis is shifted by $\frac{Nmics}{2} * pitch$units , which in this case is 3.2 units. This shift of the x-axis means every y value from the grid is actually 3.2 units more than what it should be. Accounting for this , our result becomes (3,-1) which is the exact location of the obstacle.

5 Question 4

General solution for maximum obstacle x and y can be calculated using the following formula : $Nsamp * dist\_per\_samp > min(dist(src, (x, y), mics[i]))$ The RHS is the minimum total distance from source to object and back to a microphone. The general solution to this inequality is a conic section. For the given case , LHS of the equation is 20 units. This gives the limits to be (10,0) on the x-axis and (0,+-8.4) for the y-limit.

6 Question 5

Intuitive explanation for why smaller C gives sharper image is that the peak of the curve with smaller C is much more sharply defined . This means that during reconstruction of image , the neighbouring points , will have a very small amplitude because the sharpness of the curve ensures that the higher contributions go only to the target location.

7 Question 6

The following are the results for the various values of Nmics and Nsamp with obstacle at (3,0)

7.1 Observation and Inferences

- As we increase the Number of Samples , the localisation of the x- coordinate of the obstacle improves greatly.
- As we increase the Number of mics, the localisation of the y-coordinate of the obstacle improves greatly

From this information , depending on our use case requirements , we can choose to increase Number of Samples or Number of Mics , depending on which accuracy is more important to us , x or y axis accuracy.

8 rx2 and r3x

To solve these problems , the generate (sound waves) function is not used , instead , I just read and format the data from the file and then apply the DAS algorithm directly on it.

8.1 Observation and Inferences

- For rx2.txt , we see 2 bright spots indicating 2 objects at the following locations :
  1. (1.9,0)
  2. (2.9, 1)
- Similarly for rx3.txt we see 3 bright spots indicating 3 objects at the following locations :
  1. (1.9,0)

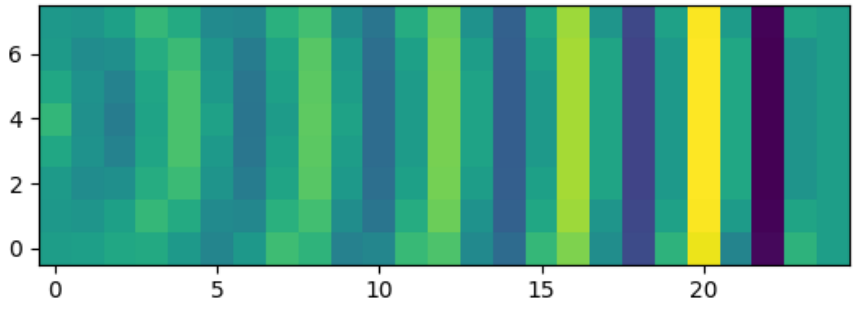

Figure 3: Heatmap for Nmics = 8 and Nsamp = 50

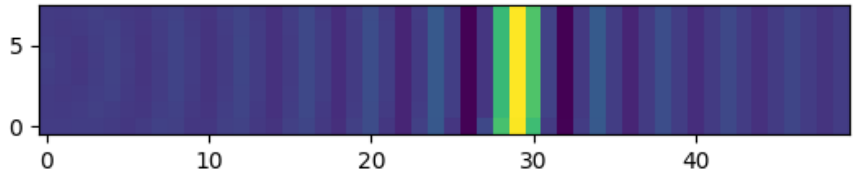

Figure 4: Heatmap for Nmics = 8 and Nsamp = 100

Figure 5: Heatmap for Nmics = 8 and Nsamp = 200

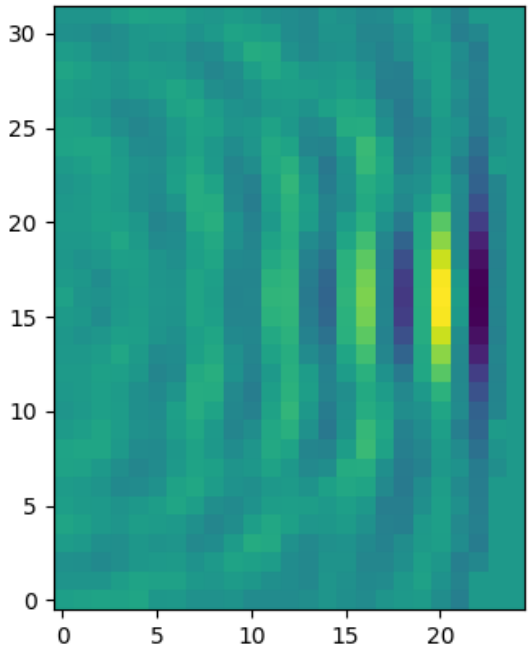

Figure 6: Heatmap for Nmics = 32 and Nsamp = 50

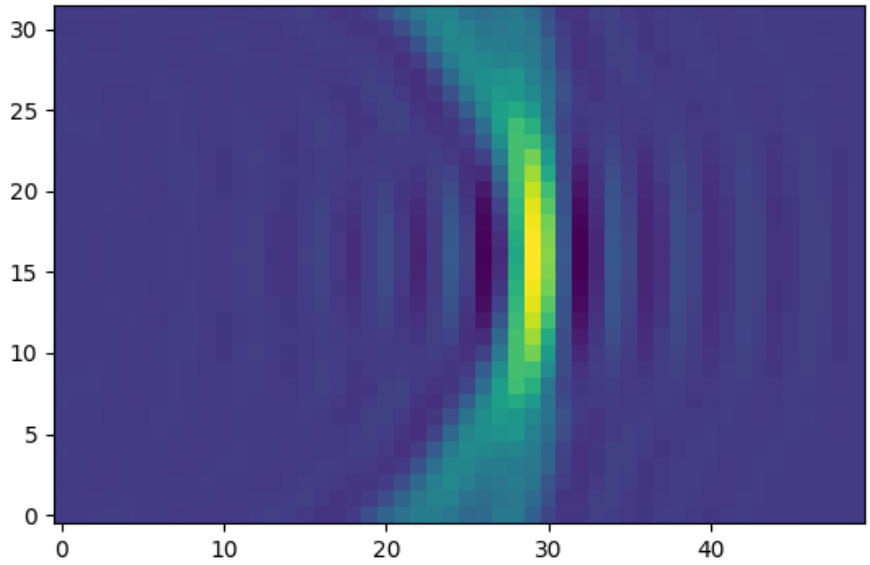

Figure 7: Heatmap for Nmics = 32 and Nsamp = 100

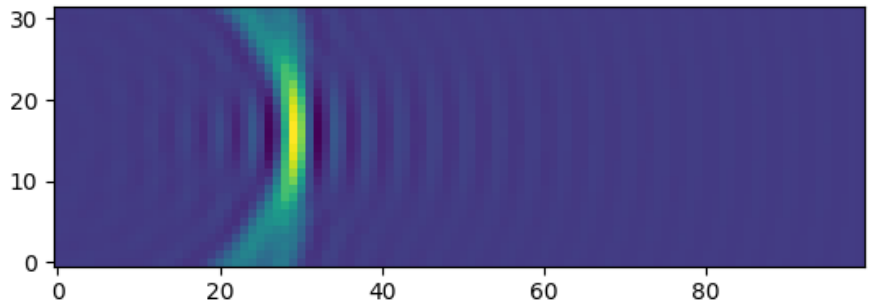

Figure 8: Heatmap for Nmics = 32 and Nsamp = 200

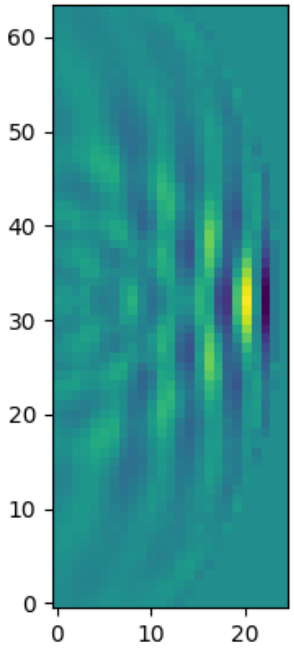

Figure 9: Heatmap for Nmics = 64 and Nsamp = 50

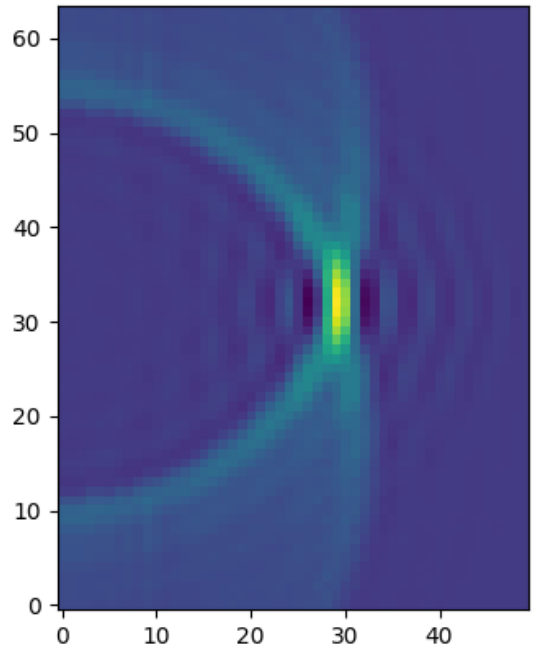

Figure 10: Heatmap for Nmics = 64 and Nsamp = 100

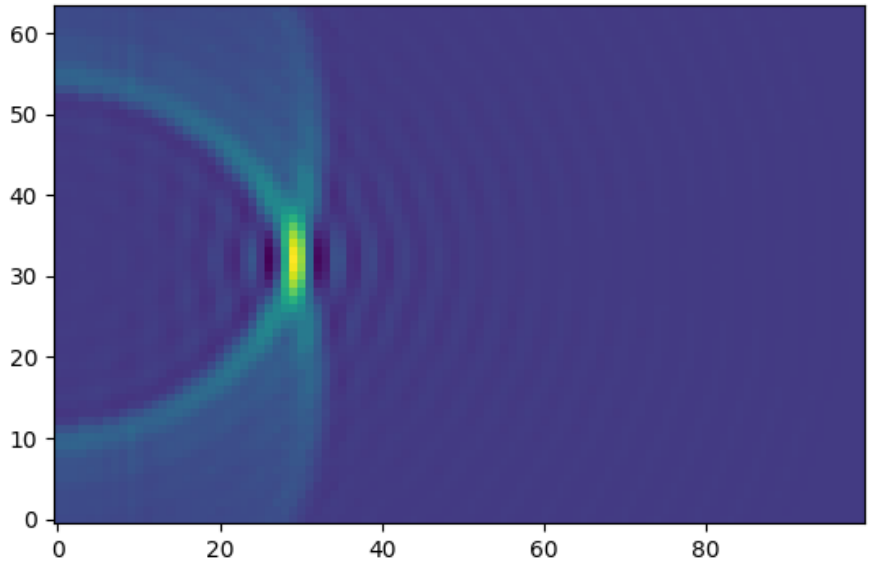

Figure 11: Heatmap for Nmics = 64 and Nsamp = 200

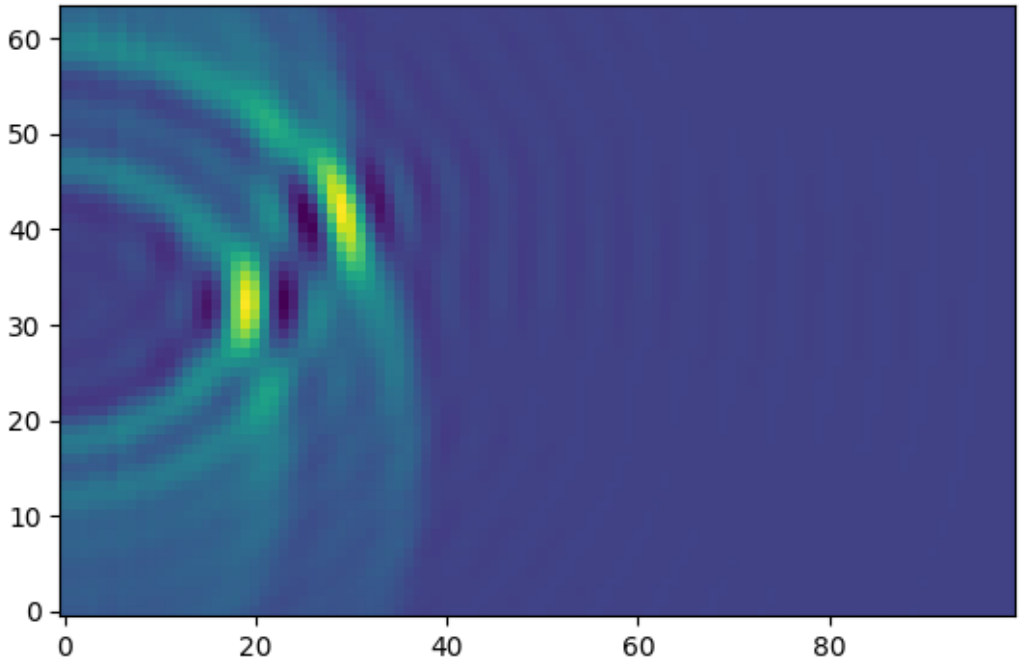

Figure 12: Heatmap for rx2

2. (2.9, 1)
3. (3.9,-0.5)

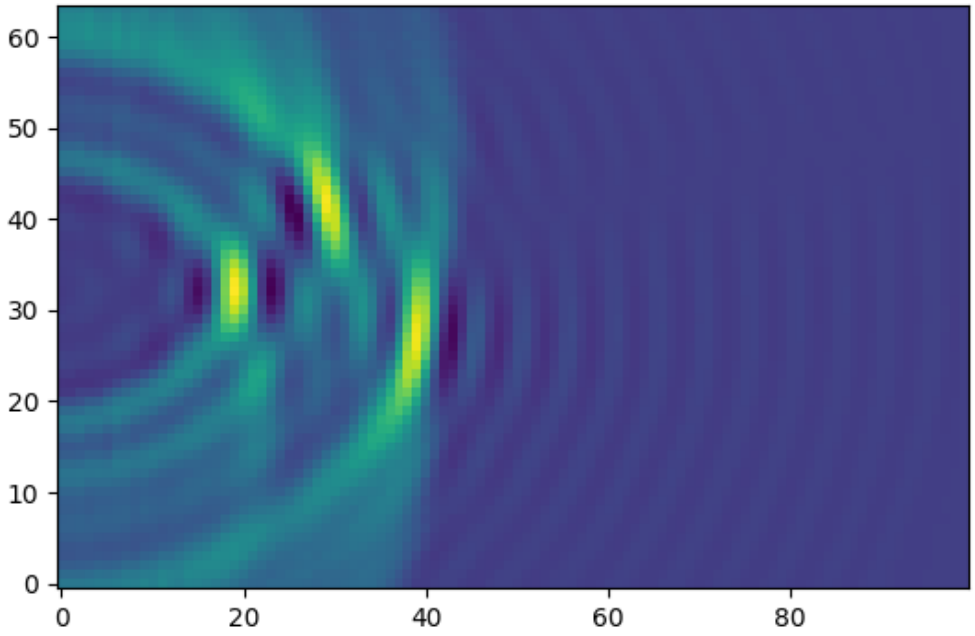

Figure 13: Heatmap for rx3

- Inference from this is that distinct objects , if placed sufficiently faer apart can be detected simultaneously by DAS algorithm.