EE2703 - Applied Programming Lab
Assignment-7: Sound Localization

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November 2024

1 Introduction

In this assignment, our goal was to implement Delay and Sum (DAS) algorithm, which is commonly used in ultrasound image reconstruction.

2 Problem Description

There are roughly two sub tasks part of this assignment.

- To create a heatmap and use DAS algorithm to locate the object.
- Given the samples as text files, create a heatmap from this and again locate the object.

3 Details of the Implementation

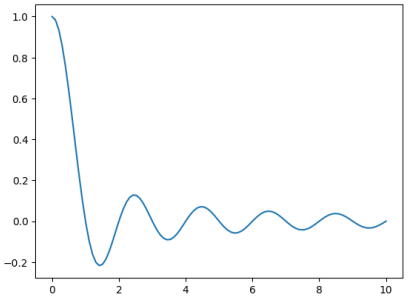
- The time samples array, I have assumed we are interested in time instants when the samples are received, so I have formulated t as:

```
t = np.linspace(0,(dist_per_samp)/C*Nsamp,Nsamp)
```

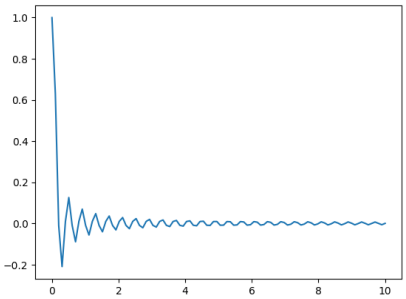
- The total vertical distance of the entire array of mics is $(Nmics-1)*pitch$

4 Answers to the questions

1. The plots below show two example sinc pulses. How will you generate pulses that look like this? Which parameter should be changed? What effect do you think this will have on the final image?
    - Inorder to generate the plots exactly as those given in the document, we need to use Nsamp = 100, dist_per_samp = 0.1, C = 0.5



(a) for SincP=1



(b) for SincP=5

- Following plots were generated 1(a) 1(b)

2. Does it make sense to reconstruct up to $Nsamp$? What value is more reasonable as an upper limit for the x-axis here?

   - It does not sense make to reconstruct the image upto Nsamp, since where ever the object is located, it must be detected within the time it takes for Nsamp, which is Nsamp*dist_per_samp/C. The maximum x that can be located is just, **Nsamp*dist_per_samp/2**, where y would be 0, so this would be a reasonable maxima on the x-axis.

3. The (x, y) coordinates corresponding to the maximum amplitude (yellow-colour) is approximately (30, 22). Explain why this is the correct expected position for the given obstacle.

   - We have taken the distance per sample as 0.1, and the pitch is also 0.1, given obstacle is at (3,-1). So, 30*0.1, gives the x-coordinate which is 3, and the microphone at the middle would correspond to the 32nd microphone, so (22-32)*0.1 would be -1, which is the location of the obstacle.

4. What is the maximum obstacle x- and y- coordinate that you can use and still have an image reconstructed?

- In order for the wave to reach, one of the mics, the condition is that, it must come before the time it takes for Nsamp samples, this is because we are assuming the mic is turned off after time for Nsamp samples is up. Now, a wave must travel from the source, to the obstacle, and reflects back to the mic, this will be 2*distance from source to obstacle, that implies, x_max is Nsamp*distance_per_samp/2, which in the above case is 5, but here y would be 0.

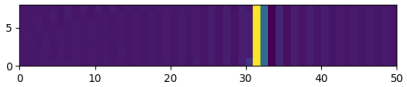
  Similarly, for the y coordinate, the y must be such that, distance from the furthest mic, to the obstacle, is covered in Nsamp, here again, x = 0, so, y_max is y_lastmic + Nsamp*distance_per_samp/2.

5. What happens if C is different - if C is decreased it looks like the image becomes sharper. Can you explain why intuitively?

   - When C is decreased, most values part of the t list go farther away from the peak, so the number of values with higher **intensity_factor**, decreases. As a result, when we are adding points to the grid, most of them get a lower intensity, so image looks sharper, highlighting only those points that have maximum intersection from different mics. To counter this effect, one must change the **SincP factor**.

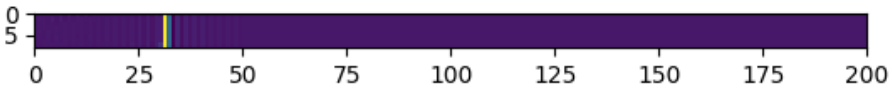
6. What happens if Nmics is increased or decreased? Do the experiments with Nmics = [8, 32, 64] and Nsamp = [50, 100, 200] (all combinations). Attach the resulting images.

   - As the number of mics decreased it gets harder to pin point the exact y location of the object. When number of mics was 8, then the point 1, was beyond, the furthest mic, so we see that straight line. You can refer to the plots here 6

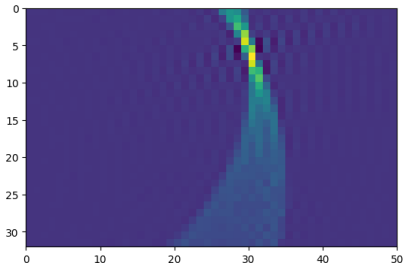


(c) 50 samp x 8 mics

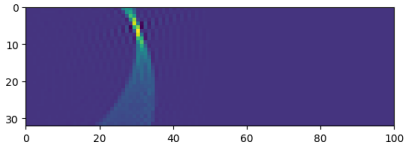
(d) 100 samp x 8 mics



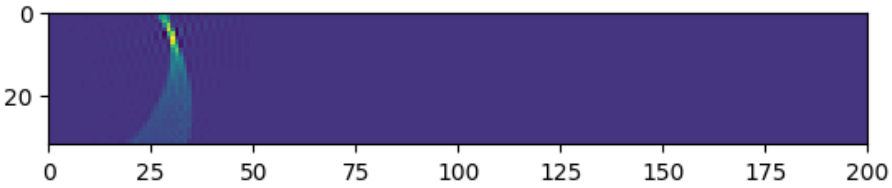
(e) 200 samp x 8 mics



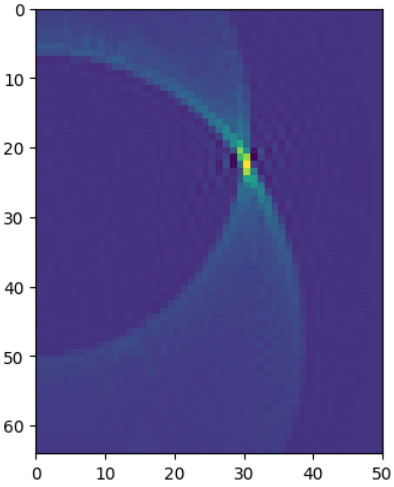
(f) 50 samp x 32 mics



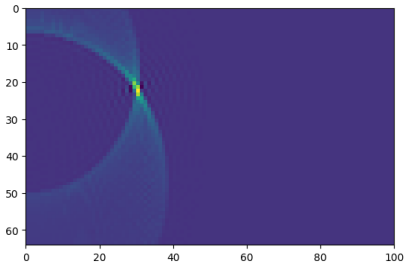
(g) 100 samp x 32 mics



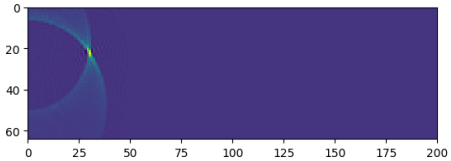
(h) 200 samp x 32 mics



(i) 50 samp x 64 mics

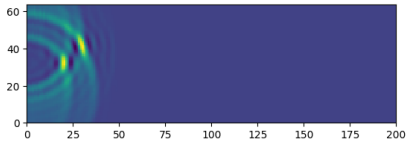


(j) 100 samp x 64 mics

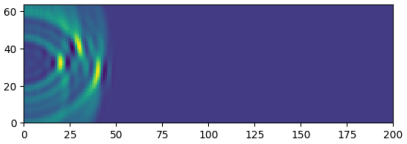


(k) 200 samp x 64 mics

5 Samples from Text Files



(l) rx2.txt file



(m) rx3.txt file

Here we see two and three objects from the samples in rx2 and rx3 text files respectively.

6 References

1. Creating Latex Document

2. The Python3 Documentation

3. Matplotlib Documentation

4. Stack Overflow