

Auditory Localization using Trilateration in Two Dimensions

Final Project in DT Signals & Systems

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Problem Statement

" Use computer microphones from at least 3 laptops to record a 'gun shot' sound from a speaker."

- Develop an algorithm to determine the location of "gun shot"
- Vary the volume of gun shot, the distance of "gun shot" to study the robustness of your algorithm
- Add different background noise to the "gun shot" data, then analyze your performance of algorithm

Problem Approach

Use a microcontroller to sample three microphone sensors and use trilateration to find the source of the sound (in this case a buzzer triggered by an interrupt).

Two approaches:

Amplitude - find a predictable relationship between distance and amplitude, then run the trilateration.

Time Diff - detect the differences between arrival times and multiply by the speed of sound to find the distance.¹

Definition

Trilateration is a localization method which uses known points and their distances to an unknown point to find it.

¹343 m/1000 ms

Data Collection - Experiment Setup

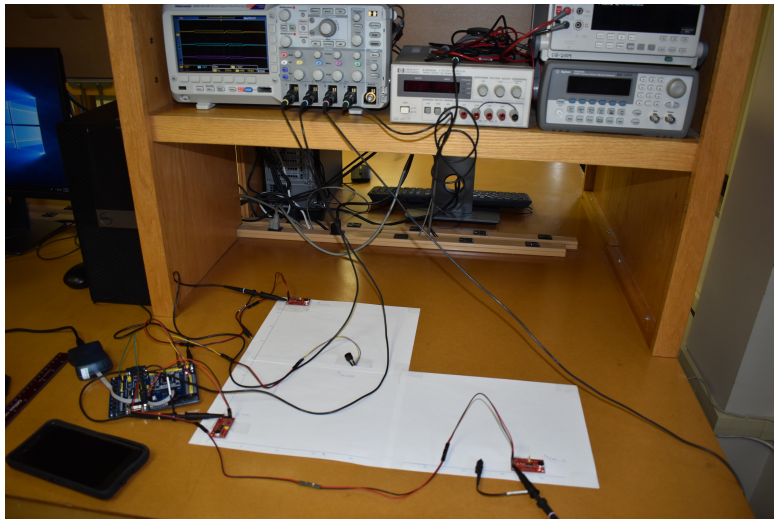


Figure: Sensor arrangement.

Data Collection - Experiment Setup

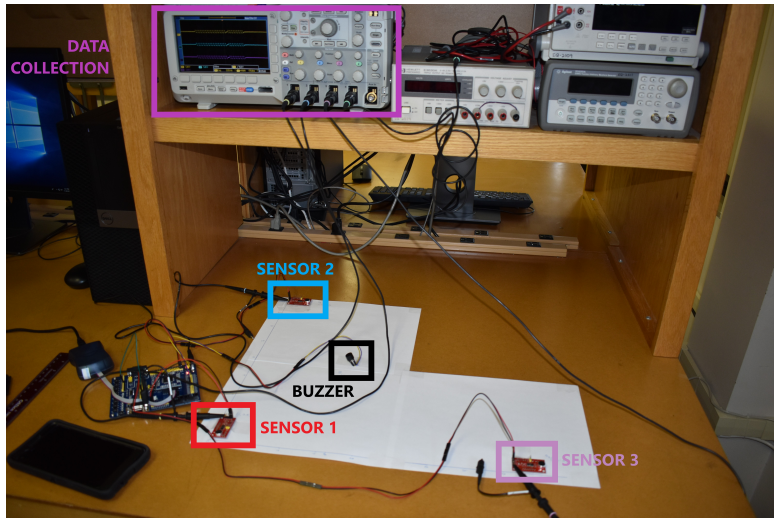


Figure: Sensor arrangement explained.

Data Collection - Experiment Setup

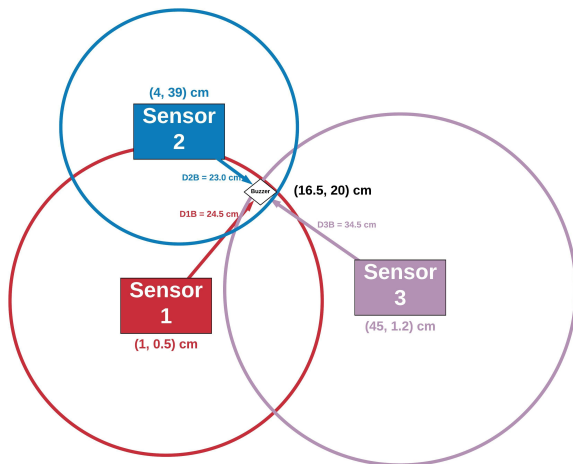


Figure: Experiment diagram.

Data Collection - Experiment Results

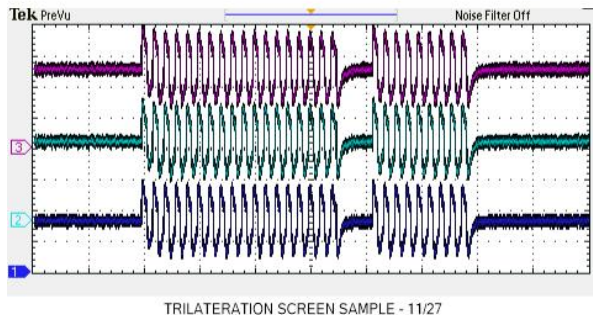


Figure: Data collection results².

²See this youtube video for a demonstration <https://youtu.be/WUPCAduKl10>

Data Collection - Experiment Results



Believe it or not, there is a delay in the arrival times of the audio samples, allowing us to apply the time difference approach.

Data Analysis - Data Preparation

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
1	Record Length	125000 Points		-5.00E-01	2.52		Record Length	125000 Points		-5.00E-01	2.6		Record Length	125000 Points		-5.00E-01	2.62		Record Len	125000 Points		-5.00E-01	2.5		Record Le
2	Sample Interval	8.00E-06 s		-5.00E-01	2.76		Sample Interval	8.00E-06 s		-5.00E-01	2.68		Sample Interval	8.00E-06 s		-5.00E-01	2.62		Sample Inte	8.00E-06 s		-5.00E-01	2.54		Sample In
3	Trigger Point	6.25E+04 Samples		-5.00E-01	2.52		Trigger Point	6.25E+04 Samples		-5.00E-01	2.68		Trigger Point	6.25E+04 Samples		-5.00E-01	2.66		Trigger Poi	6.25E+04 Samples		-5.00E-01	2.54		Trigger Pt
4				-5.00E-01	2.76					-5.00E-01	2.6					-5.00E-01	2.62					-5.00E-01	2.5		
5				-5.00E-01	2.52					-5.00E-01	2.6					-5.00E-01	2.46					-5.00E-01	2.54		
6				-5.00E-01	2.76					-5.00E-01	2.68					-5.00E-01	2.62					-5.00E-01	2.62		
7	Source	Glitch Capture CH1		-5.00E-01	2.52		Source	Sample CH1		-5.00E-01	2.6		Source	Glitch Capture CH2		-5.00E-01	2.46		Source	Sample CH2		-5.00E-01	2.5		Source
8	Vertical Units	V		-5.00E-01	2.68		Vertical Units	V		-5.00E-01	2.68		Vertical Units	V		-5.00E-01	2.66		Vertical Un V			-5.00E-01	2.58		Vertical U
9	Vertical Scale	2		-5.00E-01	2.52		Vertical Scale	2		-5.00E-01	2.6		Vertical Scale	1		-5.00E-01	2.46		Vertical Sc	1		-5.00E-01	2.54		Vertical S
10	Vertical Offset	0		-5.00E-01	2.76		Vertical Offset	0		-5.00E-01	2.68		Vertical Offset	0		-5.00E-01	2.62		Vertical Off	0		-5.00E-01	2.54		Vertical C
11	Horizontal Units s			-5.00E-01	2.44		Horizontal Units s			-5.00E-01	2.68		Horizontal Units s			-5.00E-01	2.46		Horizontal s			-5.00E-01	2.54		Horizonta
12	Horizontal Scale	1.00E-01		-5.00E-01	2.76		Horizontal Scale	1.00E-01		-5.00E-01	2.6		Horizontal Scale	1.00E-01		-5.00E-01	2.66		Horizontal	1.00E-01		-5.00E-01	2.5		Horizonta
13	Pt Fmt	Y		-5.00E-01	2.52		Pt Fmt	Y		-5.00E-01	2.6		Pt Fmt	Y		-5.00E-01	2.42		Pt Fmt	Y		-5.00E-01	2.5		Pt Fmt
14	Yzero	-3.66		-5.00E-01	2.68		Yzero	-3.66		-5.00E-01	2.68		Yzero	-2.58		-5.00E-01	2.62		Yzero	-2.58		-5.00E-01	2.58		Yzero
15	Probe Atten	10		-5.00E-01	2.52		Probe Atten	10		-5.00E-01	2.6		Probe Atten	10		-5.00E-01	2.46		Probe Attie	10		-5.00E-01	2.54		Probe Att
16				-5.00E-01	2.76					-5.00E-01	2.6					-5.00E-01	2.62					-5.00E-01	2.5		
17				-5.00E-01	2.52					-5.00E-01	2.6					-5.00E-01	2.46					-5.00E-01	2.5		
18				-5.00E-01	2.76					-5.00E-01	2.6					-5.00E-01	2.66					-5.00E-01	2.5		
19				-5.00E-01	2.52					-5.00E-01	2.6					-5.00E-01	2.46					-5.00E-01	2.54		
20				-5.00E-01	2.76					-5.00E-01	2.68					-5.00E-01	2.62					-5.00E-01	2.58		
21				-5.00E-01	2.52					-5.00E-01	2.6					-5.00E-01	2.46					-5.00E-01	2.54		
22				-5.00E-01	2.76					-5.00E-01	2.6					-5.00E-01	2.7					-5.00E-01	2.5		
23				-5.00E-01	2.52					-5.00E-01	2.6					-5.00E-01	2.46					-5.00E-01	2.5		
24				-5.00E-01	2.76					-5.00E-01	2.68					-5.00E-01	2.66					-5.00E-01	2.58		
25				-5.00E-01	2.52					-5.00E-01	2.6					-5.00E-01	2.46					-5.00E-01	2.5		
26				-5.00E-01	2.76					-5.00E-01	2.68					-5.00E-01	2.66					-5.00E-01	2.58		
27				-5.00E-01	2.44					-5.00E-01	2.6					-5.00E-01	2.42					-5.00E-01	2.46		
28				-5.00E-01	2.68					-5.00E-01	2.68					-5.00E-01	2.66					-5.00E-01	2.54		

Figure: Oscilloscope data export format.

Data Analysis - Data Preparation

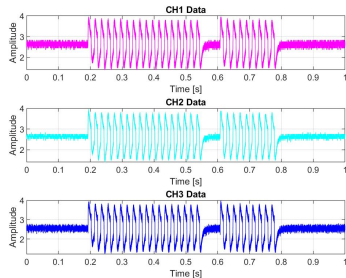
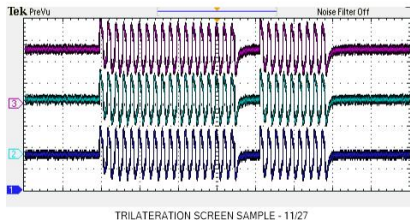
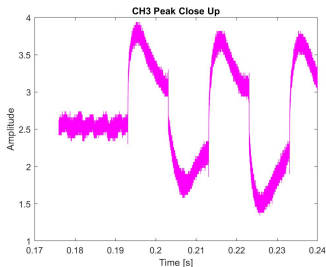


Figure: Comparison of data import.

Data Analysis - MATLAB Synthesis



We can use `findpeaks()` to locate extrema in the data.

Data Analysis - Results

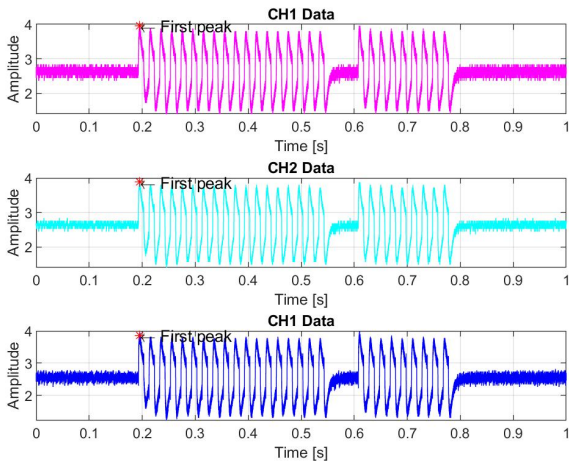


Figure: MATLAB peak search results.

Data Analysis - Results

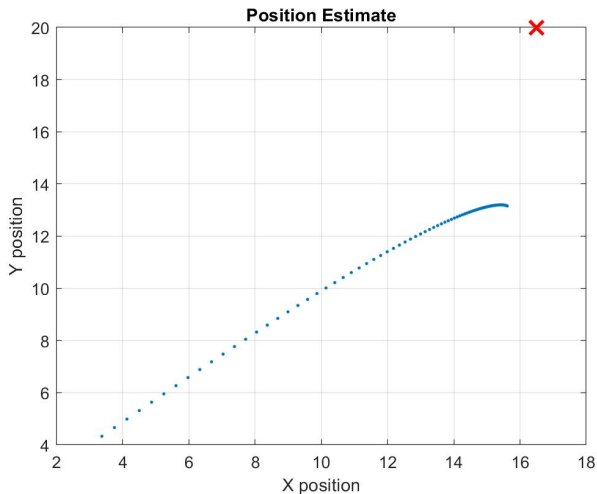


Figure: Trilateration results.

Going Further

There are several areas for further development:

- Use the envelope to utilize the amplitude approach.

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- ...

Questions?