Room of Requirement

“It is a room that a person can only enter when they have real need of it. Sometimes it is there, and sometimes it is not, but when it appears, it is always equipped for the seeker's needs.” - Dobby

EE 522 Spring 2020
Final Project
By: Veena Vijai

Objectives

Design rooms

Design rooms

Calculate RIR

Design rooms

Calculate RIR

Similarity

Design rooms

Calculate RIR

Similarity

Acoustic Parameters

Design rooms

Calculate RIR

Similarity

Acoustic Parameters

Patterns

Dataset

Designing rooms which exist

Dataset

Designing rooms which exist

Dataset

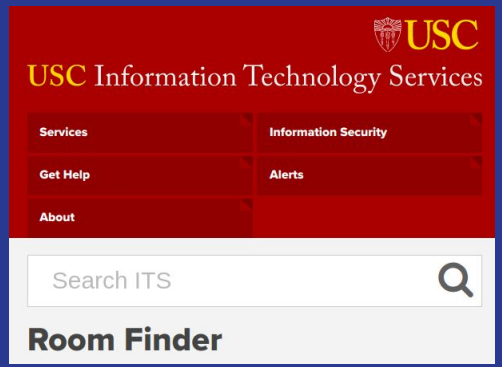
Designing rooms which exist

Dataset

Designing rooms which exist

Dataset

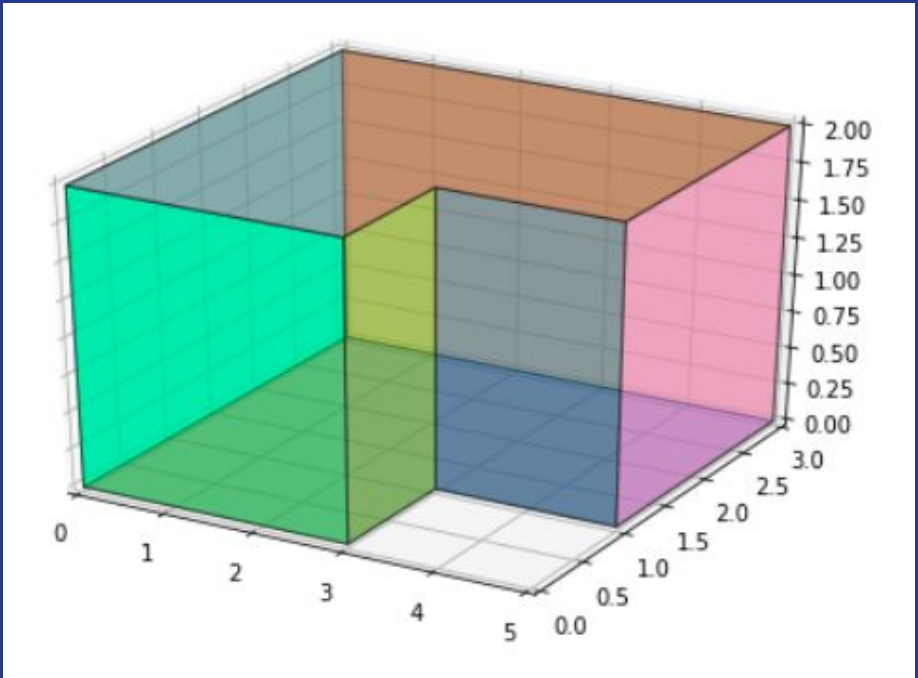
Designing rooms which exist



Pinterest floor plans

pyroomacoustics

Room design: pyroomacoustics



SPECIFICATIONS:

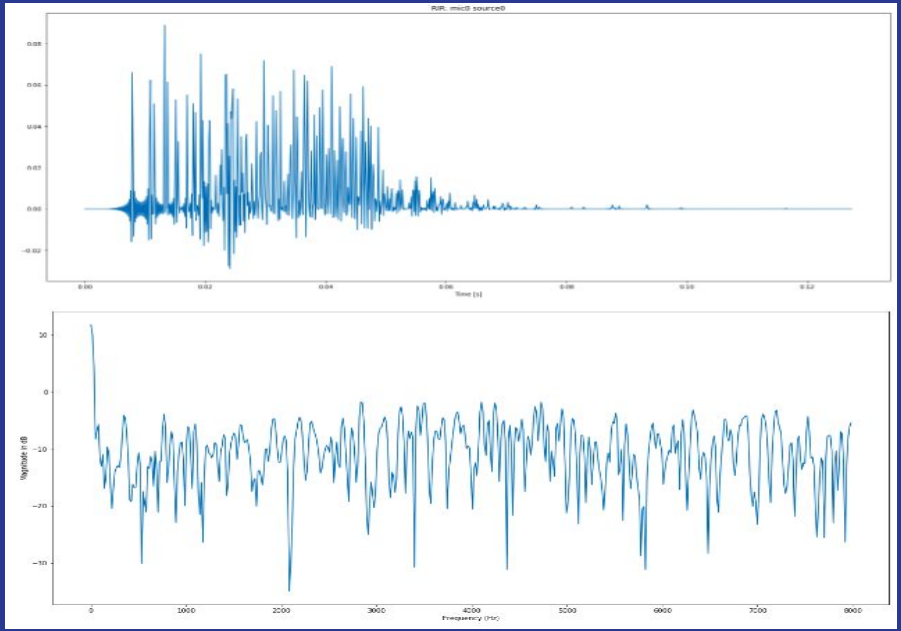
- Corners and height
- Position of source
- Position of mic(s)
- Absorption coefficient

FUNCTIONALITY:

- Viz of room
- Plot impulse response

R. Scheibler, E. Bezzam, I. Dokmanić, Pyroomacoustics: A Python package for audio room simulations and array processing algorithms, Proc. IEEE ICASSP, Calgary, CA, 2018.

Room design: pyroomacoustics



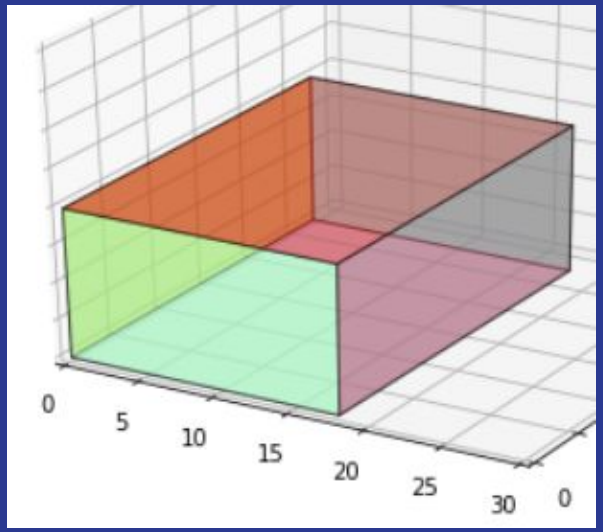
SPECIFICATIONS:

- 8 room designs
- 5 sizes - proportional
- 15 absorption coeffs (0.1 to 0.8)

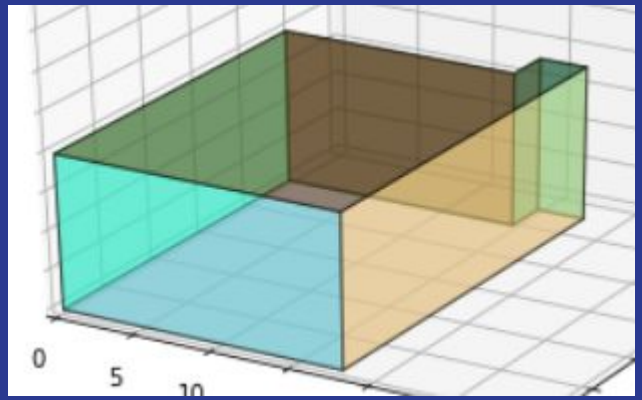
Total dataset = 6*5*15 + 3*15
= 450 + 45
= 495 rooms

R. Scheibler, E. Bezzam, I. Dokmanić, Pyroomacoustics: A Python package for audio room simulations and array processing algorithms, Proc. IEEE ICASSP, Calgary, CA, 2018.

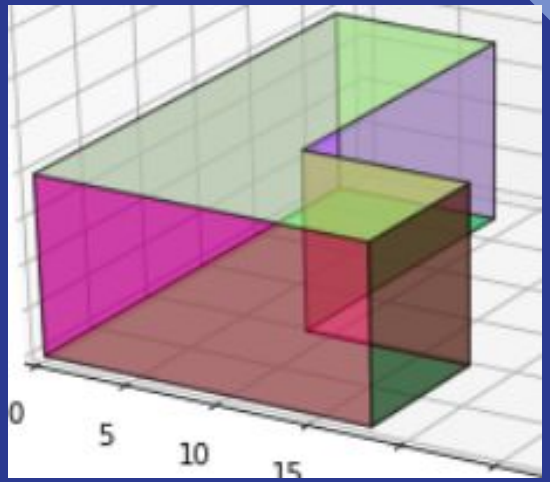
Room design: pyroomacoustics



ROOM 1

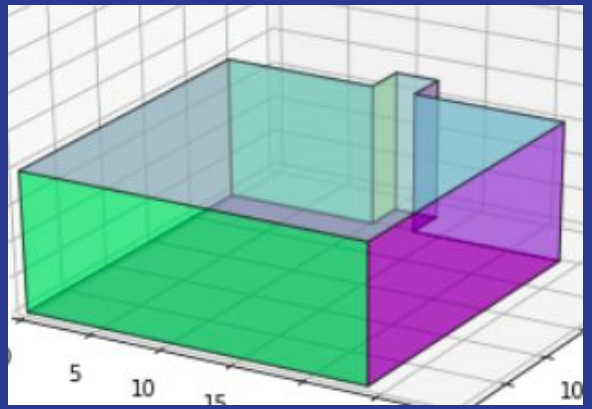


ROOM 2

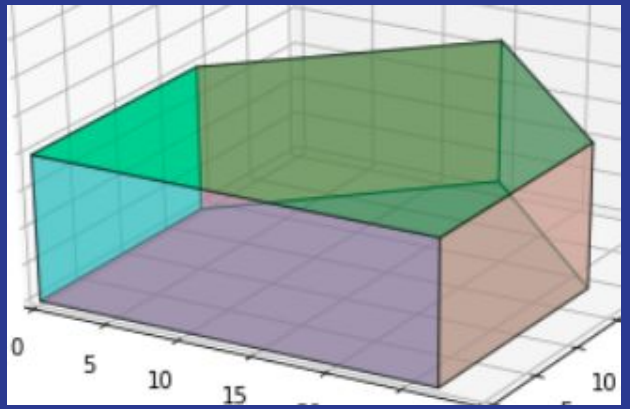


ROOM 3

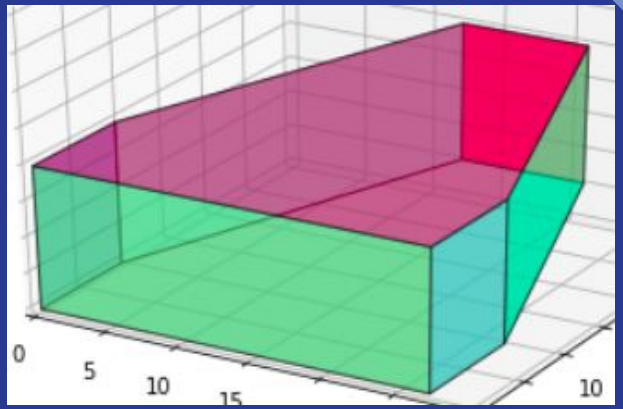
Room design: pyroomacoustics



ROOM 4

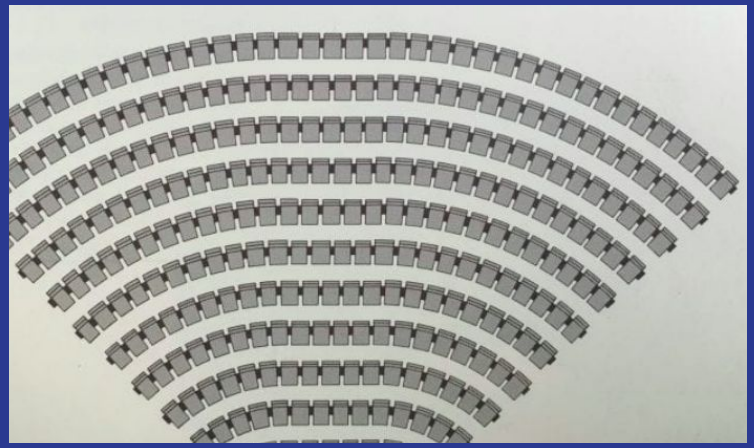


ROOM 5

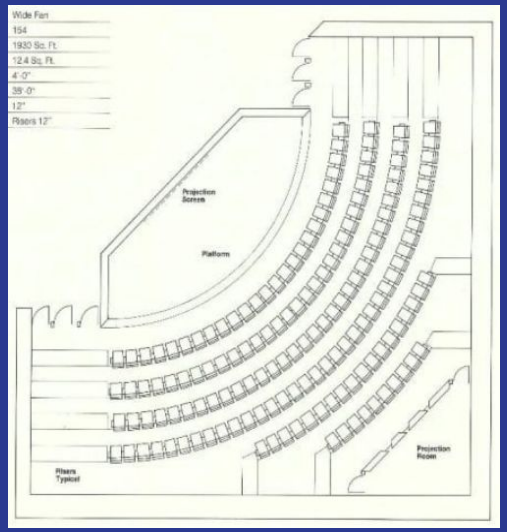


ROOM 6

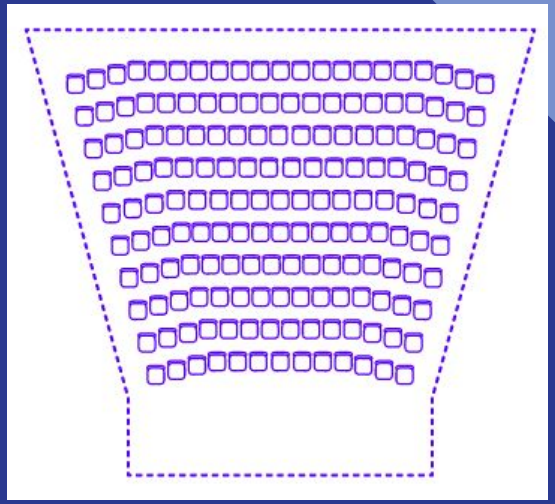
Room design: pyroomacoustics



CONTINENTAL SEATING



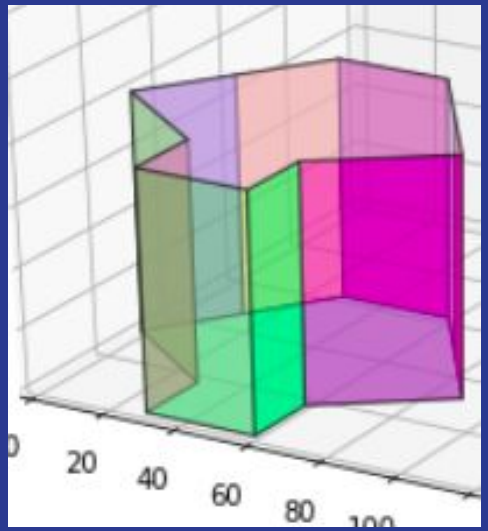
WIDE FAN



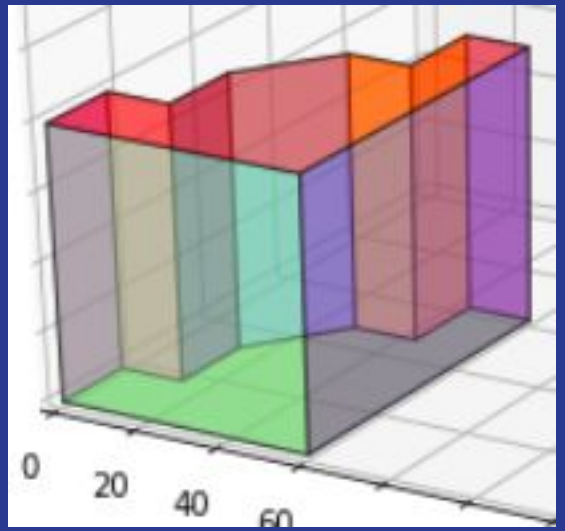
MULTIPLE AISLE

Source: https://blog.capterra.com/9-auditorium-plan-templates-to-inspire-your-next-project/
https://www.dimensions.guide/collection/theater-auditorium-layouts

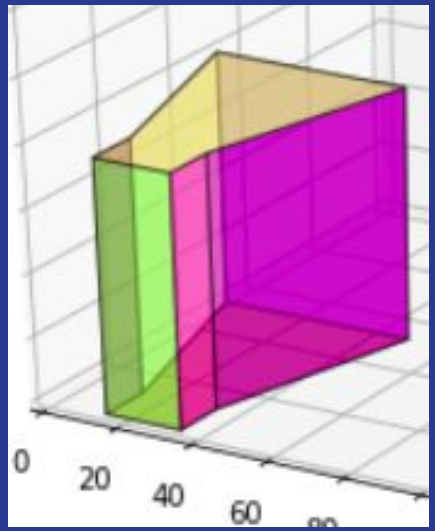
Room design: pyroomacoustics



ROOM 7



ROOM 8



ROOM 9

Similarity Calculation

- Correlation

Similarity Calculation

- Correlation
- Time or frequency domain?

Similarity Calculation

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- Time or frequency domain?

  PROBLEM: different lengths of freq response too

Similarity Calculation

- Correlation
- Time or frequency domain?

  PROBLEM: different lengths of freq response too

  SOLUTION: bins!

Similarity Calculation

```
# helper function to compute energy in bins

def get_fr_bin_indices(FR, fs, num_bins, multiples=100):


    freq_bins = fs*np.arange(FR.shape[-1])/float(2*FR.shape[-1])
    for f in freq_bins:
        f = round(f)

    #find the frequency index numbers to group in bins of 10 kHz width
    # from 0-100 Hz, 100-200 Hz, up to 8 kHz
    stop_freq_arr = np.zeros((num_bins, ))
    start_freq_arr = np.zeros((num_bins, ))

    for i in range(num_bins):

        stop_freq = multiples*(i + 1)
        stop_freq_arr[i] = freq_bins.searchsorted(stop_freq, side='right') - 1

        if (i < num_bins - 1):
            start_freq_arr[i + 1] = stop_freq_arr[i] + 1

    return start_freq_arr.astype(int), stop_freq_arr.astype(int)
```

- Sampling frequency = 16 kHz
- Nyquist freq = 8 kHz
- 100 Hz evenly spaced bins
- = 8000/100, or, 80 bins
- Sum up energy carefully
- Calculate Pearson's coefficient

https://docs.scipy.org/doc/scipy-0.14.0/reference/generated/scipy.stats.pearsonr.html

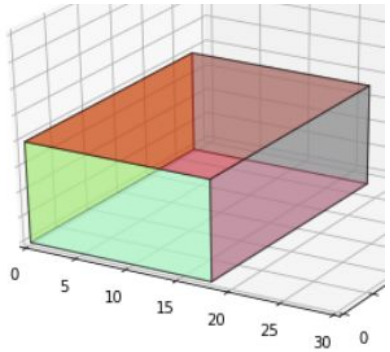
Test Set

RESULTS!

Results: Room 1

TEST DETAILS:

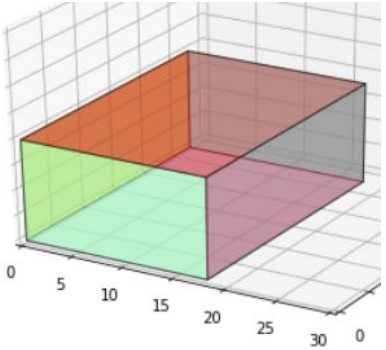
- Room of type 1
- Size scaling 2.5 (not in dataset)
- Absorption coefficient 0.25
- Height 9 (not in dataset)
- Source signal: noise (exercise bike) & voice

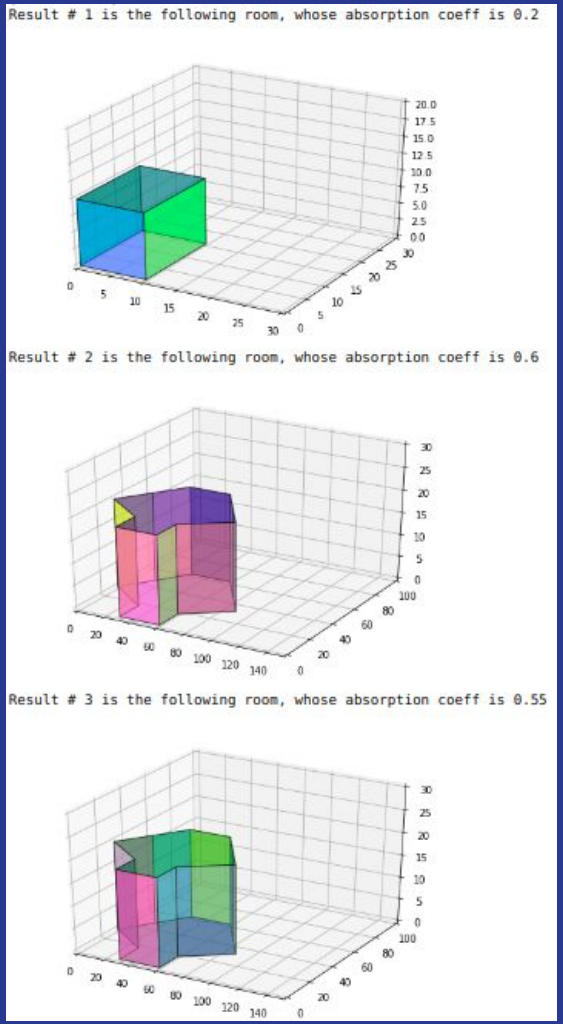


Results: Room 1

TEST DETAILS:

- Room of type 1
- Size scaling 2.5 (not in dataset)
- Absorption coefficient 0.25
- Height 9 (not in dataset)
- Source signal: noise (exercise bike) & voice
- Max correlation = 0.34

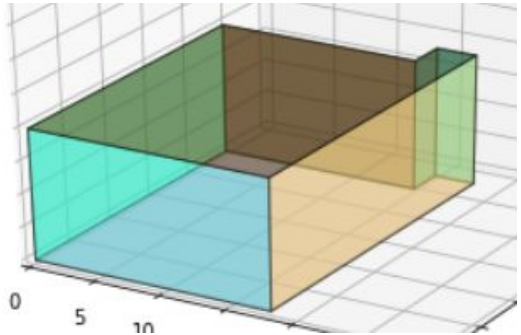




Results: Room 2

TEST DETAILS:

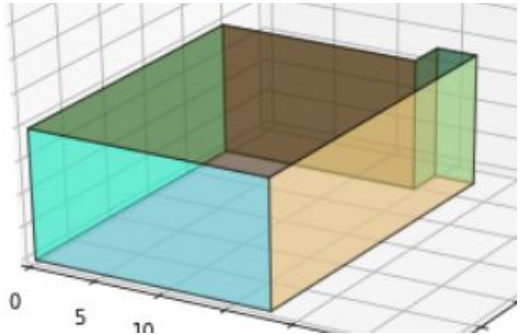
- Room of type 2
- Size scaling 3.5 (not in dataset)
- Absorption coefficient 0.4
- Height 9 (not in dataset)
- Source signal: noise (exercise bike) & voice

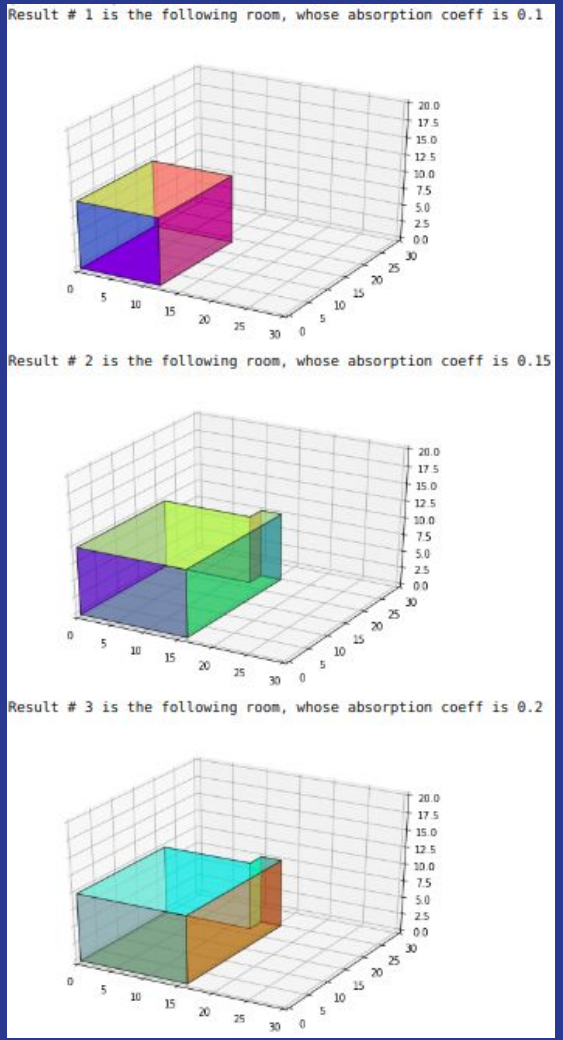


Results: Room 2

TEST DETAILS:

- Room of type 2
- Size scaling 3.5 (not in dataset)
- Absorption coefficient 0.4
- Height 9 (not in dataset)
- Source signal: noise (exercise bike) & voice
- Max correlation = 0.41

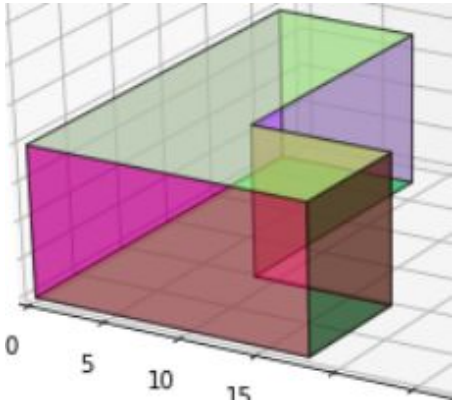


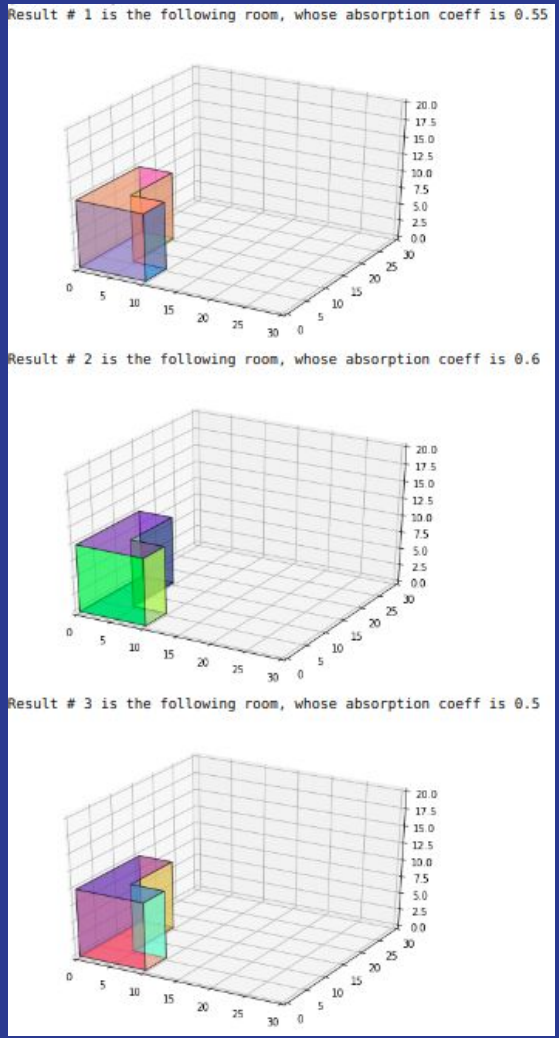


Results: Room 3

TEST DETAILS:

- Room of type 3
- Size scaling 1.5 (not in dataset)
- Absorption coefficient 0.5
- Height 9 (not in dataset)
- Source signal: noise
- Max correlation = 0.497

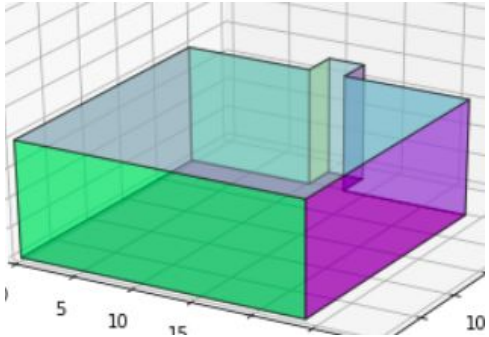




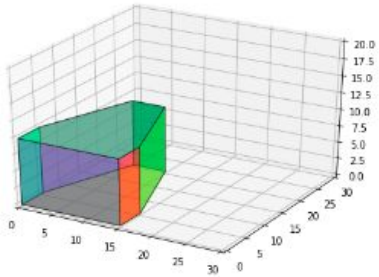
Results: Room 4

TEST DETAILS:

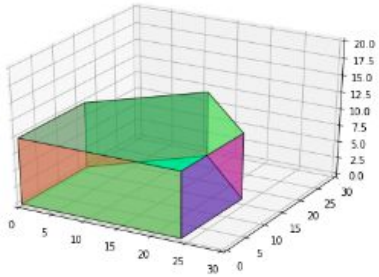
- Room of type 4
- Size scaling 1.75 (not in dataset)
- Absorption coefficient 0.6
- Height 9 (not in dataset)
- Source signal: noise
- Max correlation = 0.36



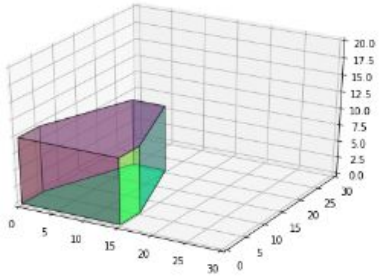
Result # 1 is the following room, whose absorption coeff is 0.1



Result # 2 is the following room, whose absorption coeff is 0.3



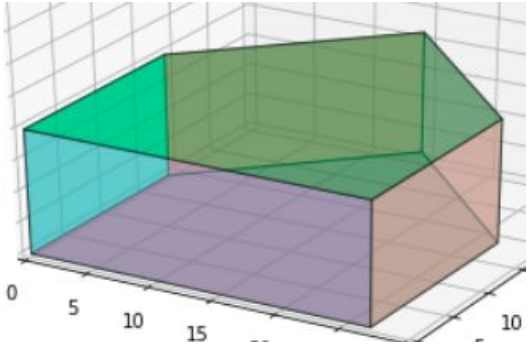
Result # 3 is the following room, whose absorption coeff is 0.15



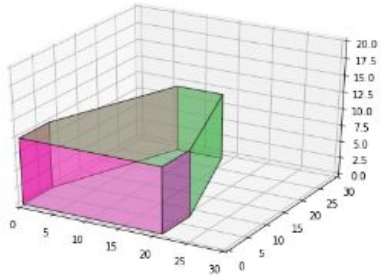
Results: Room 5

TEST DETAILS:

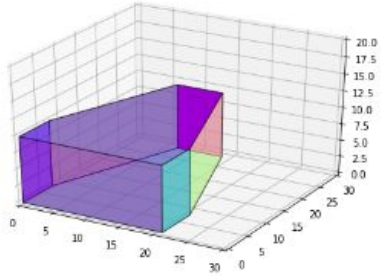
- Room of type 5
- Size scaling 3.25 (not in dataset)
- Absorption coefficient 0.65
- Height 9 (not in dataset)
- Source signal: noise
- Max correlation = 0.33



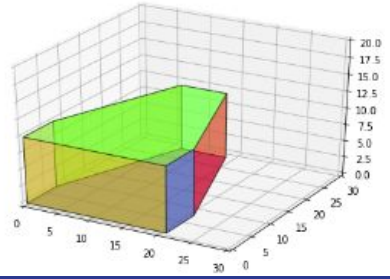
Result # 1 is the following room, whose absorption coeff is 0.1



Result # 2 is the following room, whose absorption coeff is 0.15



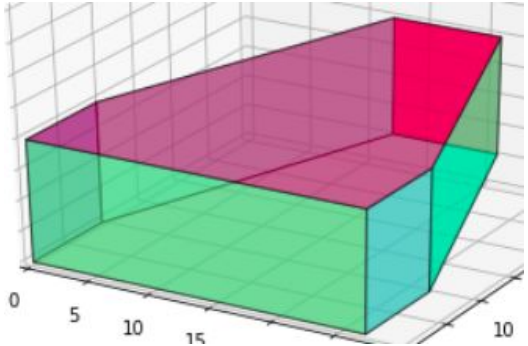
Result # 3 is the following room, whose absorption coeff is 0.25



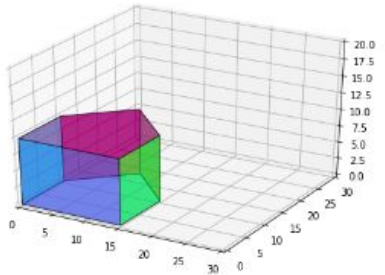
Results: Room 6

TEST DETAILS:

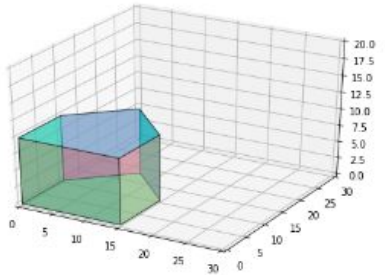
- Room of type 6
- Size scaling 3.25 (not in dataset)
- Absorption coefficient 0.7
- Height 9 (not in dataset)
- Source signal: noise
- Max correlation = 0.33



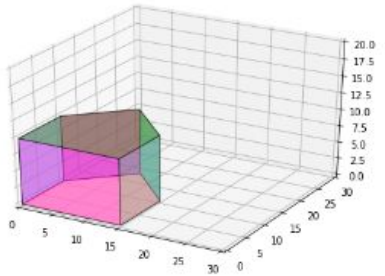
Result # 1 is the following room, whose absorption coeff is 0.2



Result # 2 is the following room, whose absorption coeff is 0.15



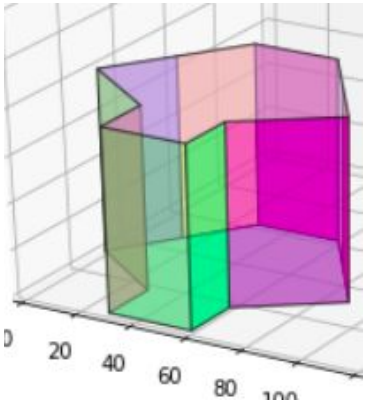
Result # 3 is the following room, whose absorption coeff is 0.25

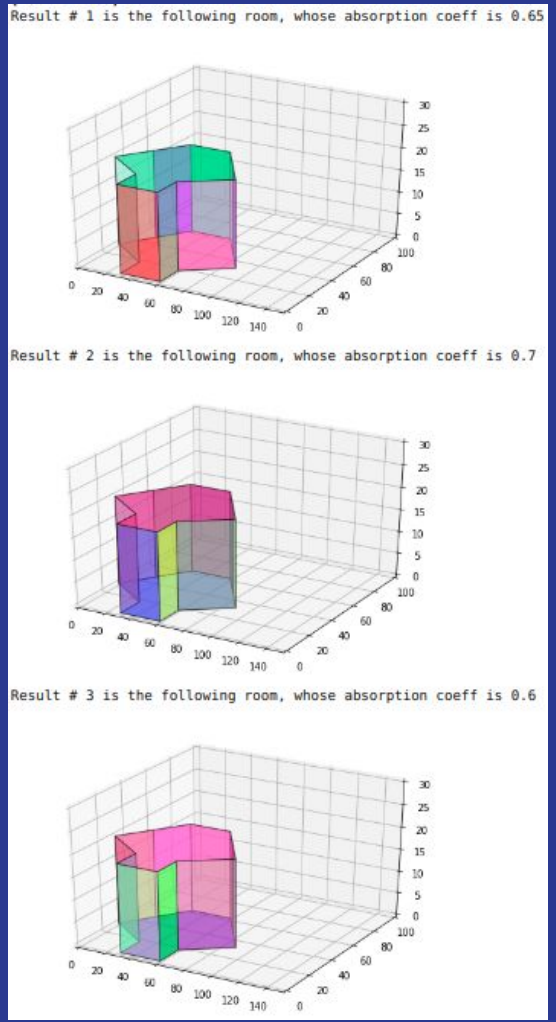


Results: Room 7

TEST DETAILS:

- Room of type 7
- Size scaling 5.25 (not in dataset)
- Absorption coefficient 0.75
- Height 17 (not in dataset)
- Source signal: noise
- Max correlation = 0.48

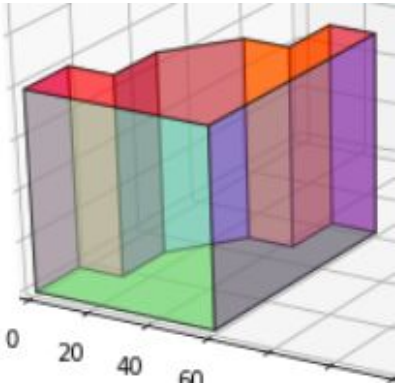


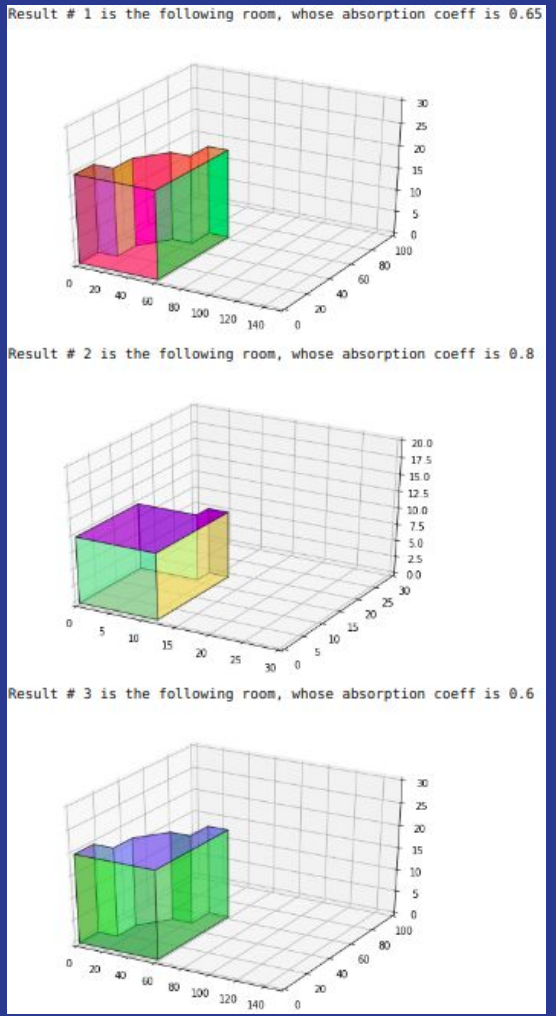


Results: Room 8

TEST DETAILS:

- Room of type 8
- Size scaling 4.75 (not in dataset)
- Absorption coefficient 0.35
- Height 18 (not in dataset)
- Source signal: noise
- Max correlation = 0.34

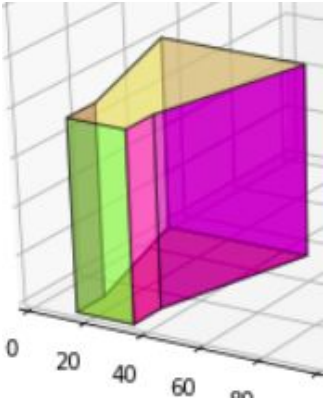


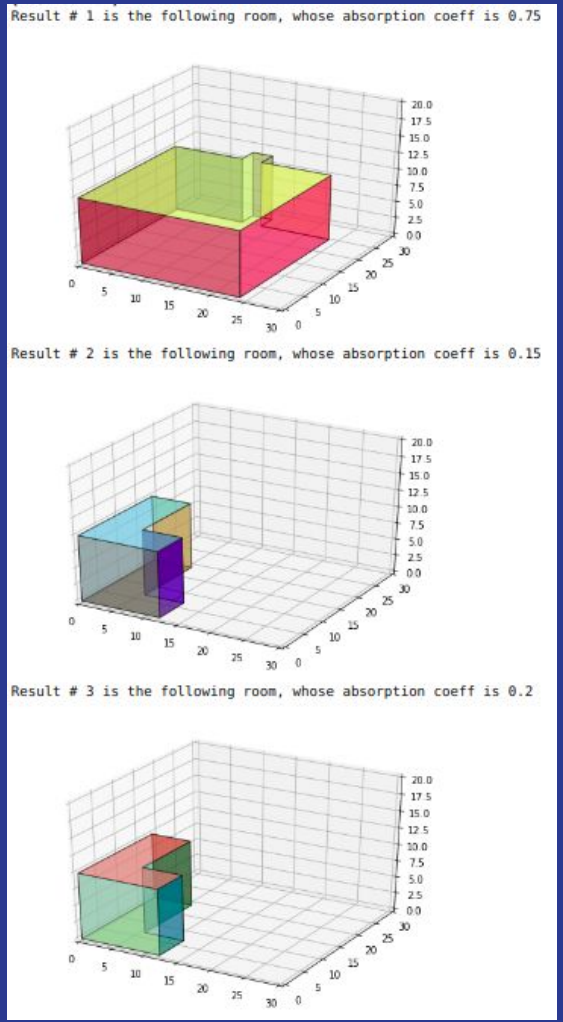


Results: Room 9

TEST DETAILS:

- Room of type 9
- Size scaling 4.8 (not in dataset)
- Absorption coefficient 0.45
- Height 15 (not in dataset)
- Source signal: noise
- Max correlation = 0.37





Acoustic Parameters

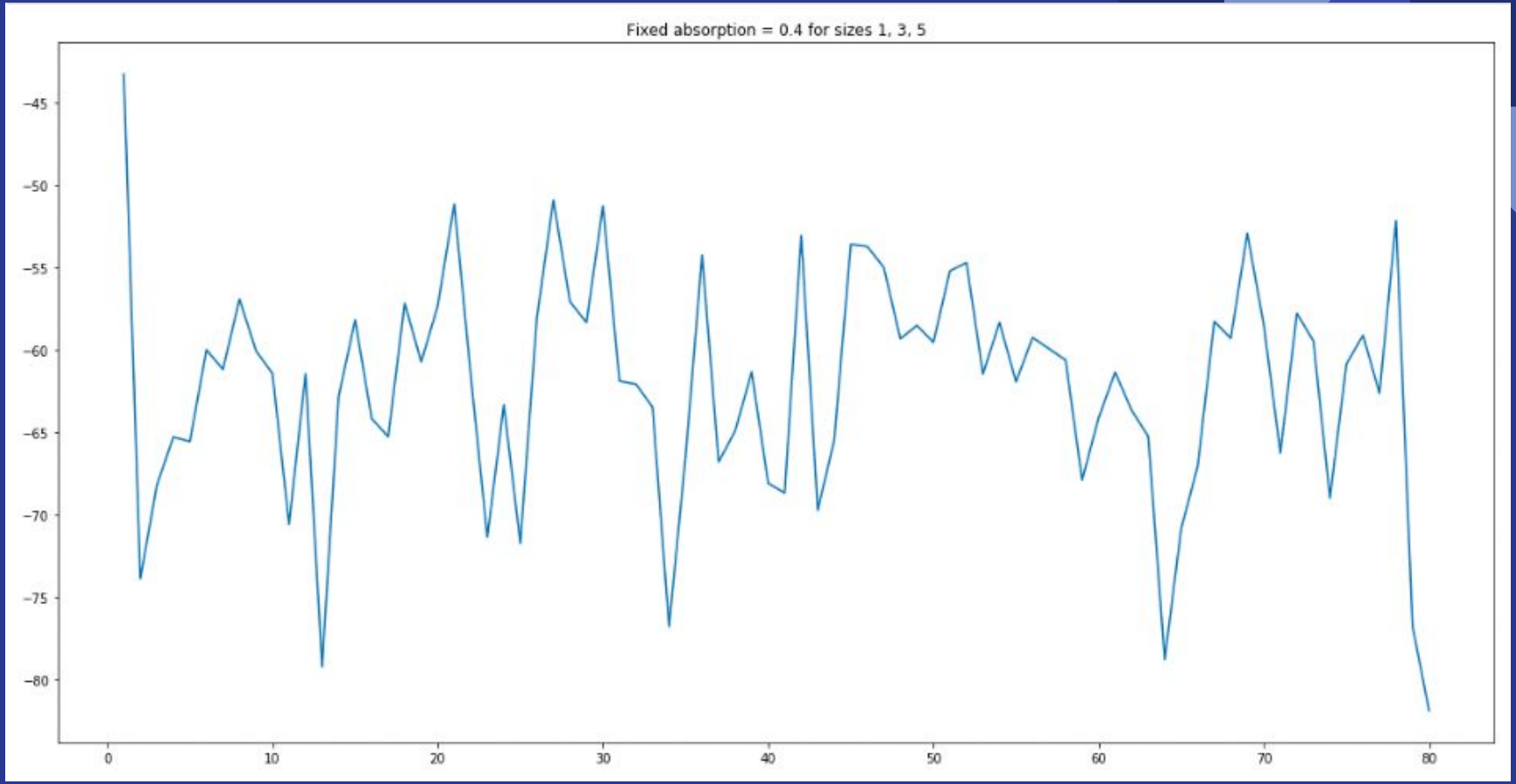
Recording Need	Reverb Time (seconds)
Broadcast	Low (below 0.8)
Speech / Vocals	Low (0.7-1.1)
Live instruments	Medium (1-1.4)
Symphony / Drama	High (1.4-2)

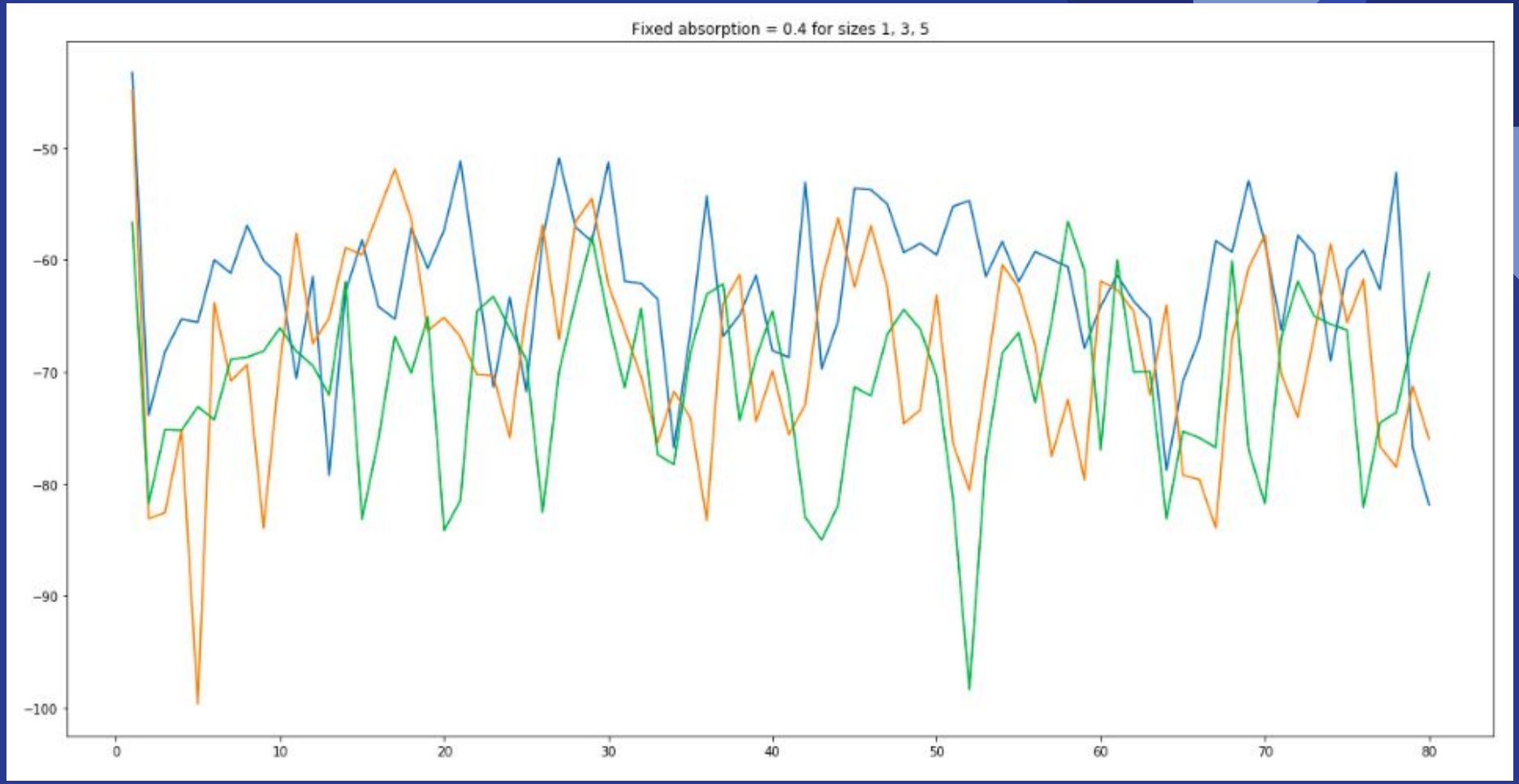
T_{60}, C_{80} (clarity of music), C_{50} (clarity of speech)

Sources:
https://www.soundassured.com/blogs/blog/reverberation-and-its-application-in-recording-studios

https://www.encida.dk/2020/02/26/how-to-calculate-room-acoustic-parameters/

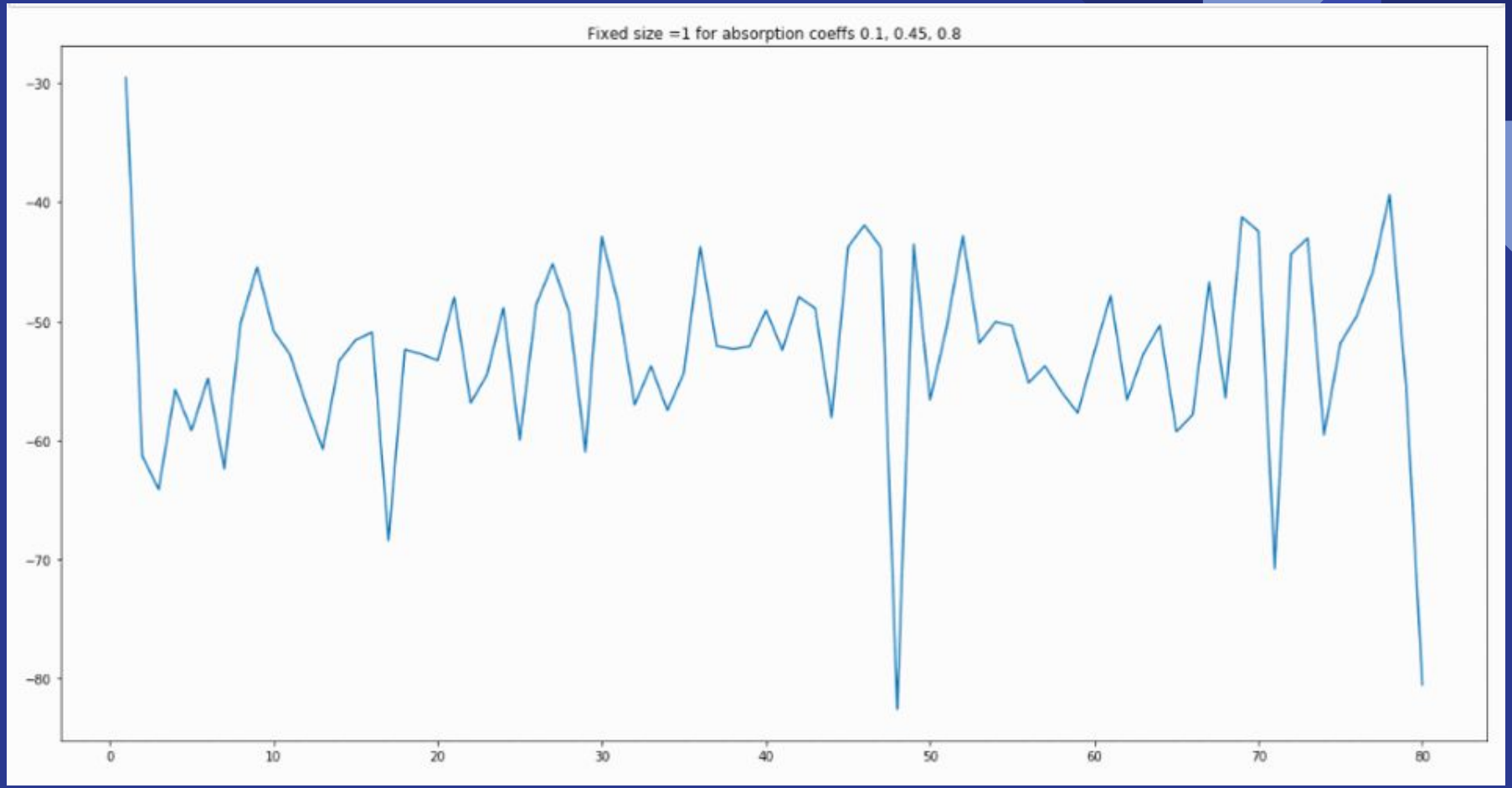
Patterns

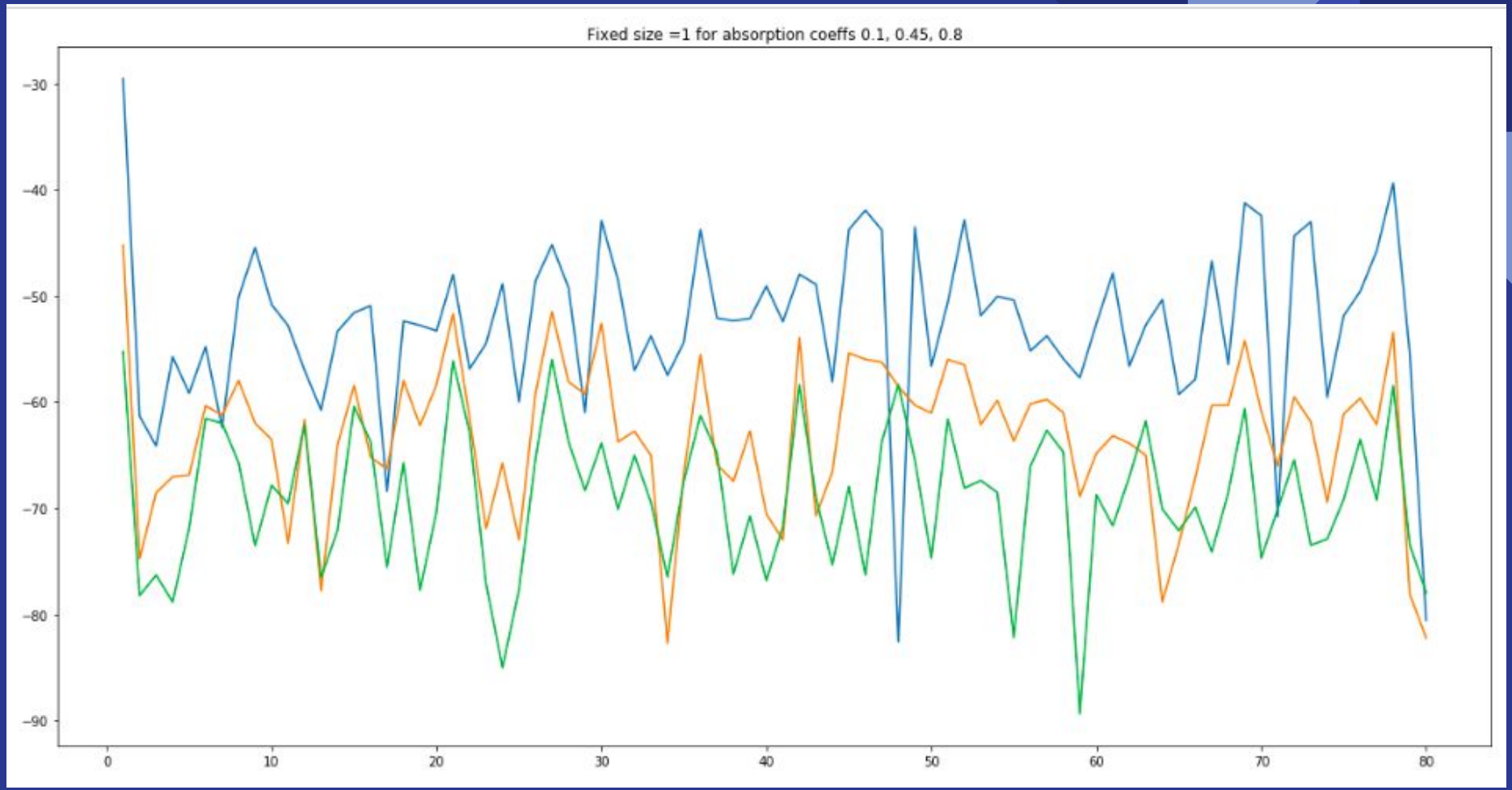

Fixed absorption = 0.4 for sizes 1, 3, 5
−45
−50
−55
−60
−65
−70
−75
−80
0
10
20
30
40
50
60
70
80


Fixed absorption = 0.4 for sizes 1, 3, 5
−50
−60
−70
−80
−90
−100
0
10
20
30
40
50
60
70
80

Observations

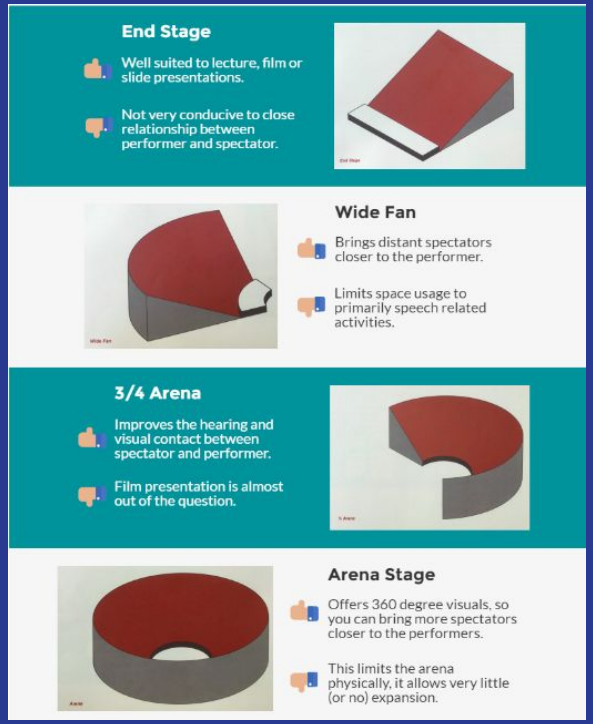
#1	#2	#3
LESS ENERGY IN FREQ RESPONSE	OVERALL SIMILAR PATTERNS	STAGGERING: PEAKS BECOME VALLEYS


Fixed size =1 for absorption coeffs 0.1, 0.45, 0.8
−30
−40
−50
−60
−70
−80
0
10
20
30
40
50
60
70
80


Fixed size =1 for absorption coeffs 0.1, 0.45, 0.8
−30
−40
−50
−60
−70
−80
−90
0
10
20
30
40
50
60
70
80

Further Extension

Further Extension



curved walls + varying height

Source: http://www.deglerwhiting.com/auditorium-seating-layout-dimensions-the-complete-guide/

Further Extension

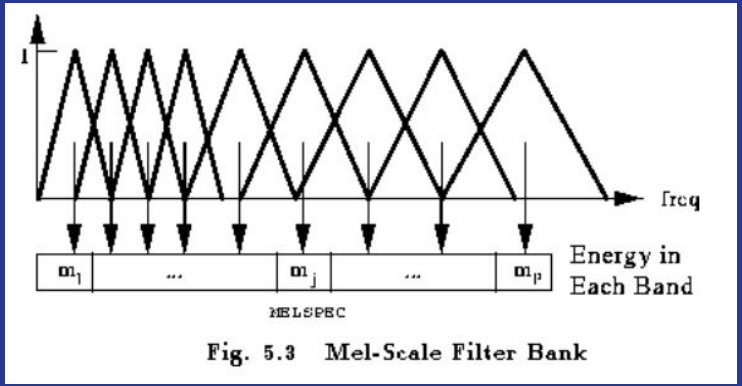


Fig. 5.3 Mel-Scale Filter Bank

Alternative filterbanks:

- mel
- Bark
- gammatone

Source:
https://labrosa.ee.columbia.edu/doc/HTKBook21/node54.html

Further Extension

Listening test!

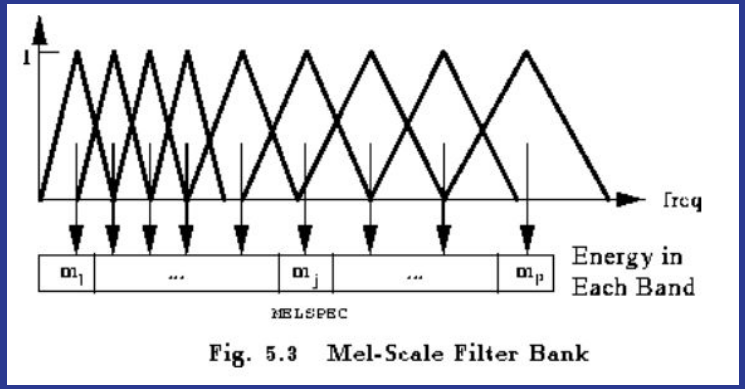


Fig. 5.3 Mel-Scale Filter Bank

Alternative filterbanks:

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Source:
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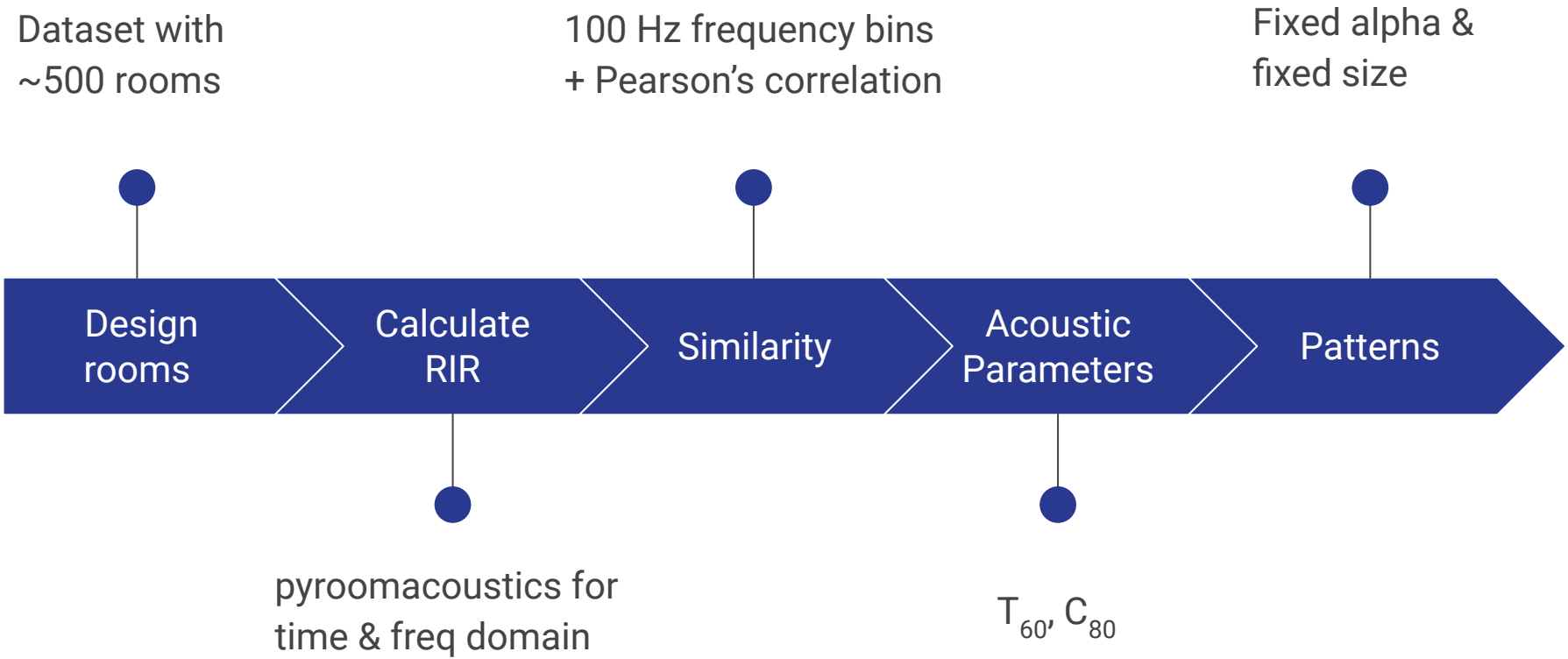
Conclusion


Dataset with
~500 rooms
100 Hz frequency bins
+ Pearson's correlation
Fixed alpha &
fixed size
Design rooms
Calculate RIR
Similarity
Acoustic Parameters
Patterns
pyroomacoustics for
time & freq domain
T_{60}, C_{80}

Questions?