INTERCON 2021

Paper 124

Regularized Spherical Fourier Transform for Room Impulse Response Interpolation

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Presenter: Julio Alarcón Ganoza

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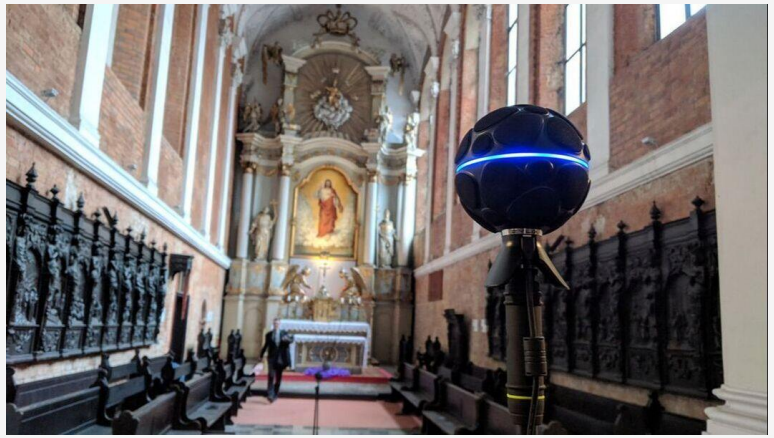
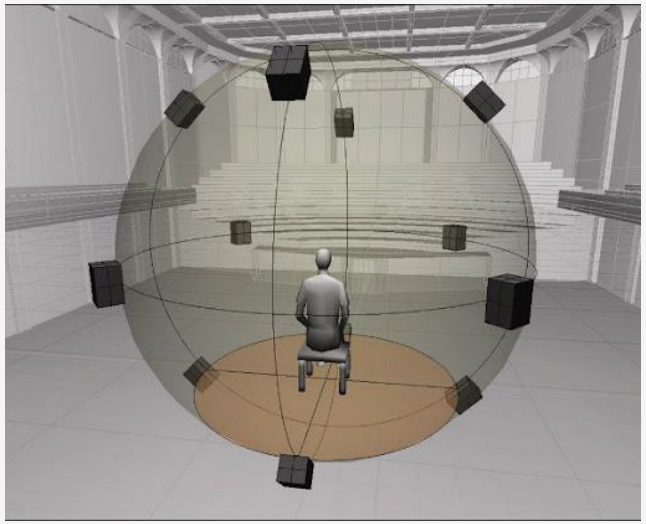
I. Introduction

Room impulse response (RIR)

- Room response to sound propagation between a source and a receiver
- Key tool in **architectural acoustics** and spatial sound for **virtual reality**





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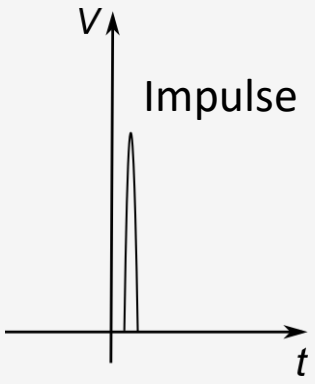
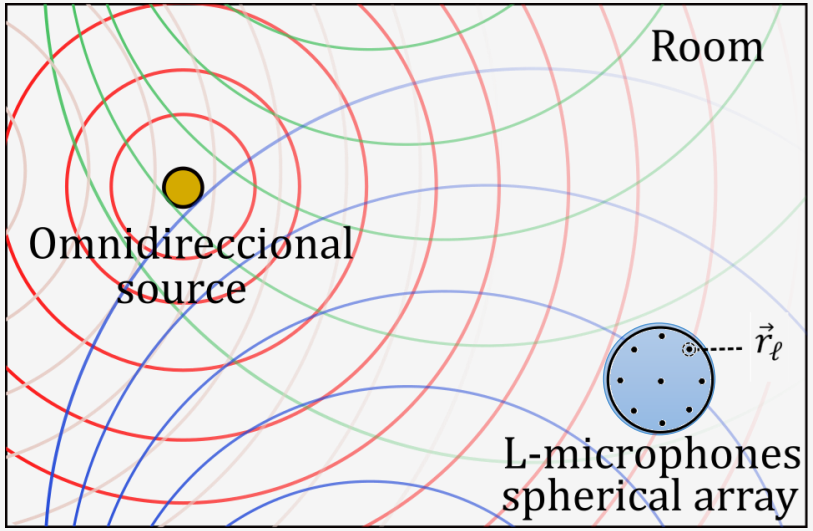
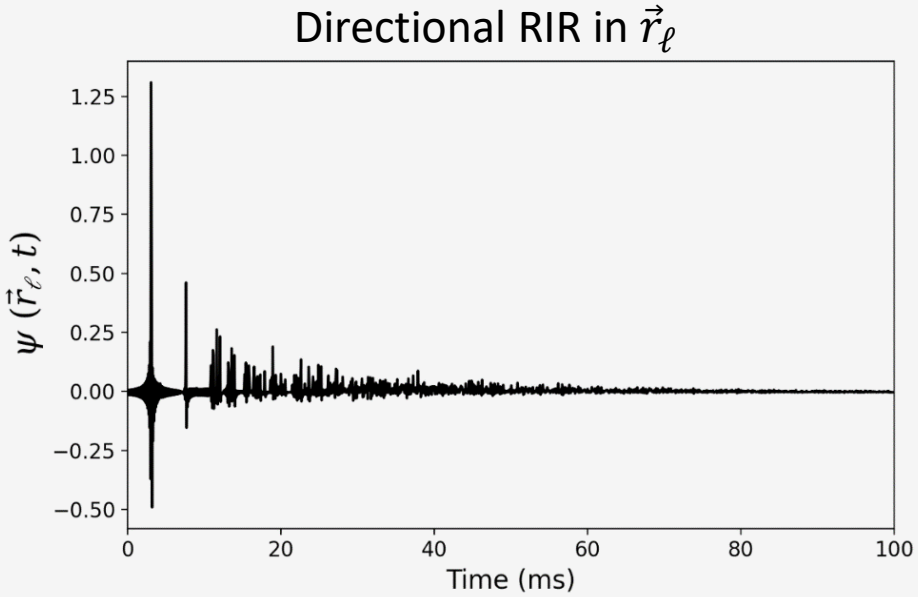
I. Introduction

Room impulse response (RIR)

- RIR is sound pressure measured in a reverberant room with an impulse
- Directional RIR can be measured with a spherical microphone array



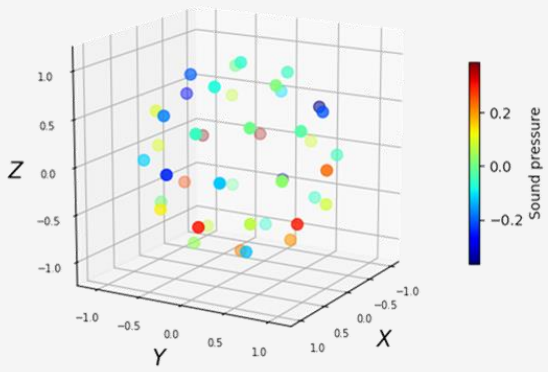




I. Introduction

RIR interpolation

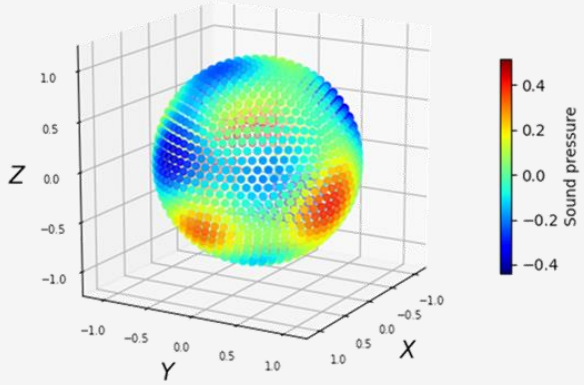
- Either because of the low number of microphones or limited computational capacity, there is a need to interpolate RIRs



Low-resolution RIR

Interpolation method

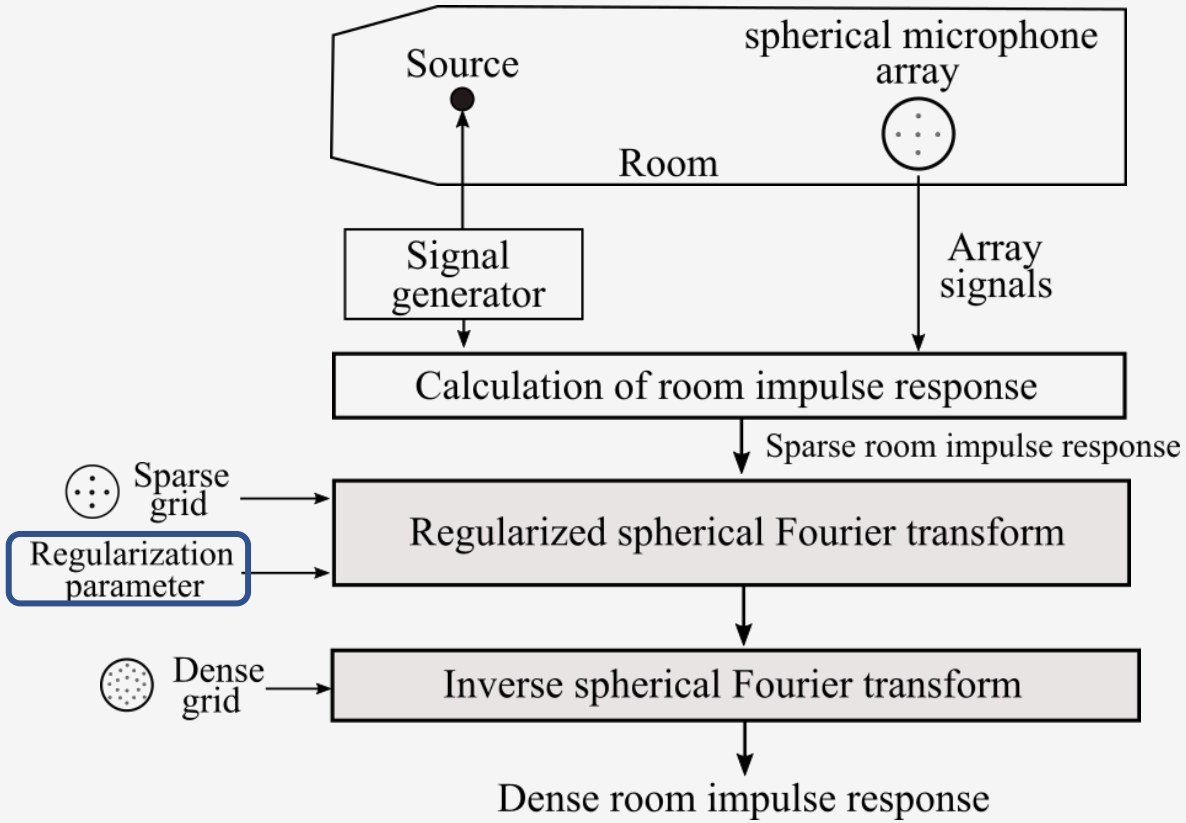
Based on the regularized spherical Fourier transform (SFT)



High-resolution RIR

I. Introduction

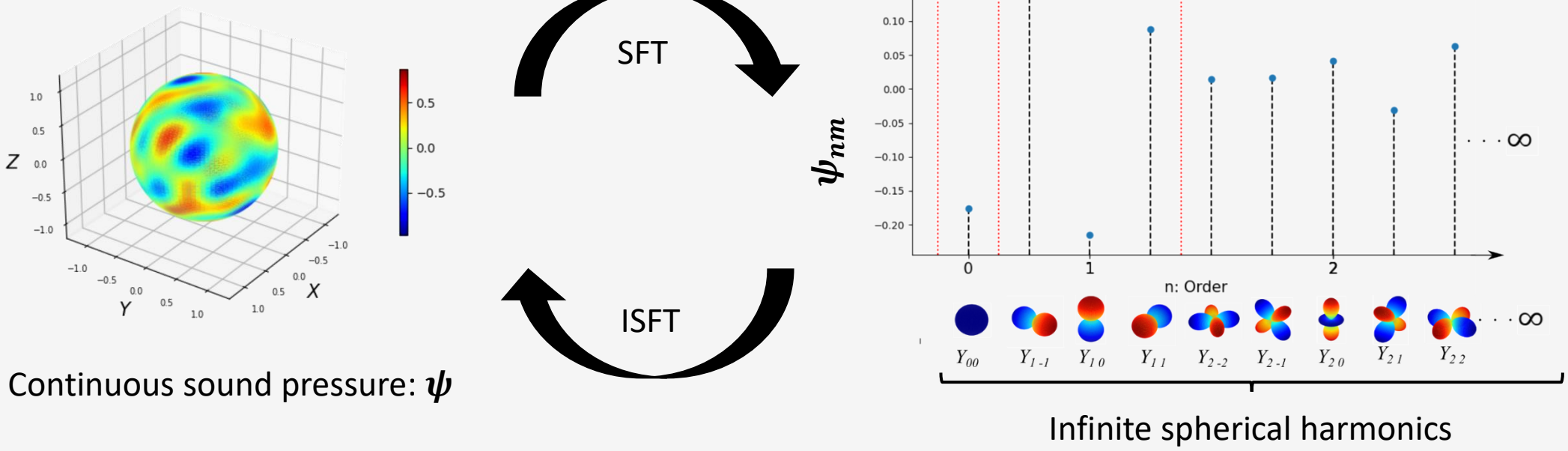
Proposal for RIR interpolation



II. Formulation of the regularized SFT

Continuous spherical Fourier transform (SFT) and inverse spherical Fourier transform (ISFT)

- The SFT and ISFT allows to express the **RIRs as a linear combination of orthonormal basis functions on the sphere (e.g., spherical harmonics)**



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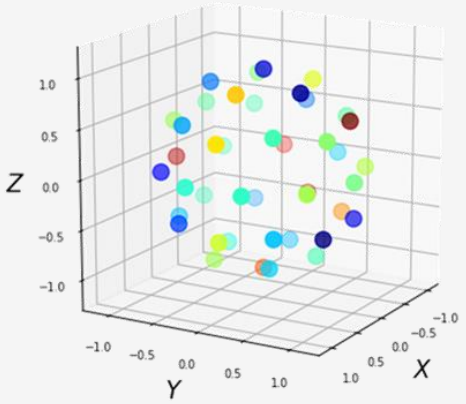
II. Formulation of the regularized SFT

Spherical discretization

Discrete SFT

Sample of sparse RIR



L microphones

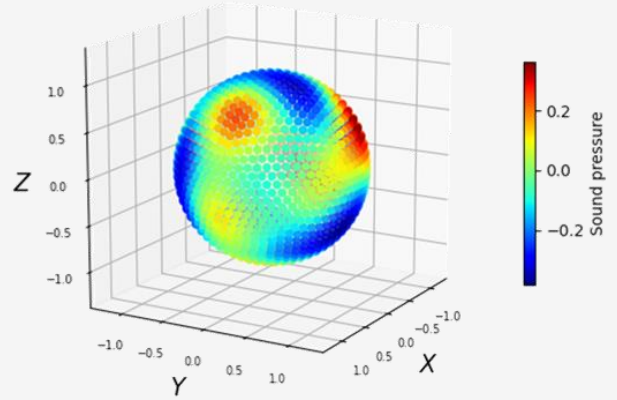
RIR interpolation

Discrete SFT

- Frequency limit
- Uniform distribution: Interpolation error ✔
- No-uniform distribution: Interpolation error ✖✖!

ISFT

Sample of dense RIR



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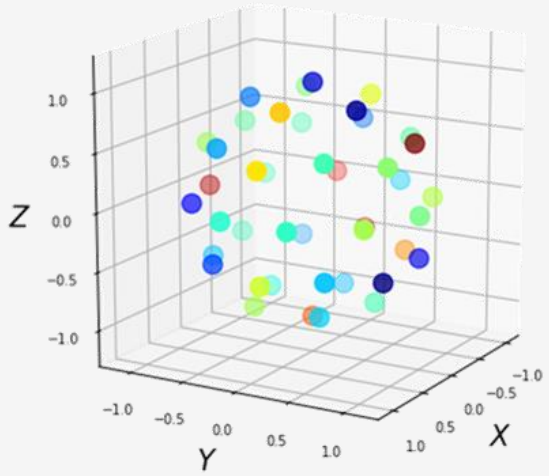
II. Formulation of the regularized SFT

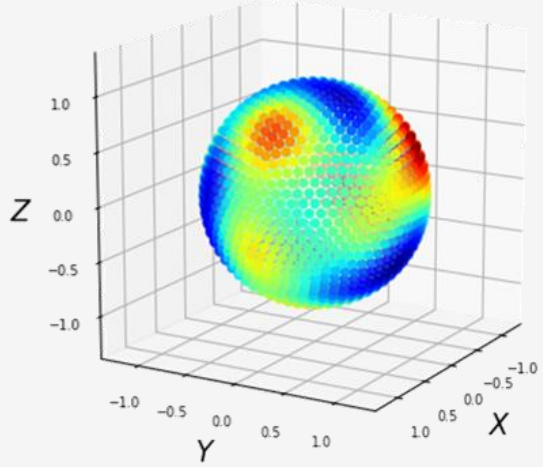
Regularized SFT

Sparse RIR



Interpolation based on the regularized SFT

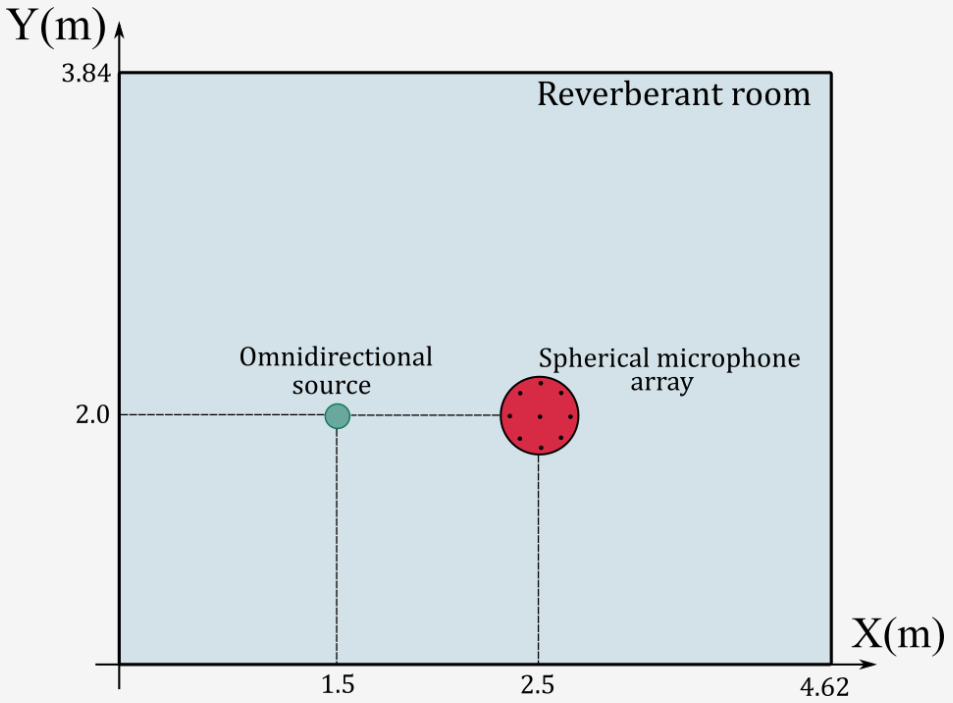
Dense RIR



- Frequency limit.
- Uniform distribution: Interpolation error ✔
- No-uniform distribution: Interpolation error ✔
- **Random distribution**: Interpolation error ✔

III. Evaluation of RIR interpolation

Initial Conditions



Room dimensions
4.62m wide, 3.84m long, 3m high.
Reverberation time: 0.2 s.
Sampling frequency: 16 kHz.
Number of samples in time: 3200.

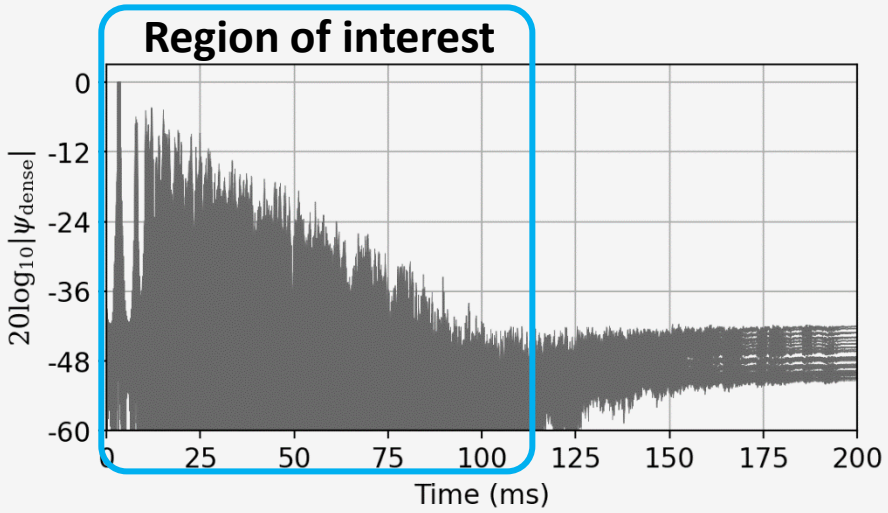
Sparse grid
Radius: $r = 8\text{cm}$
Random distribution, $L = 49, 16$.

Dense grid
Icosphere distribution, 162 microphones

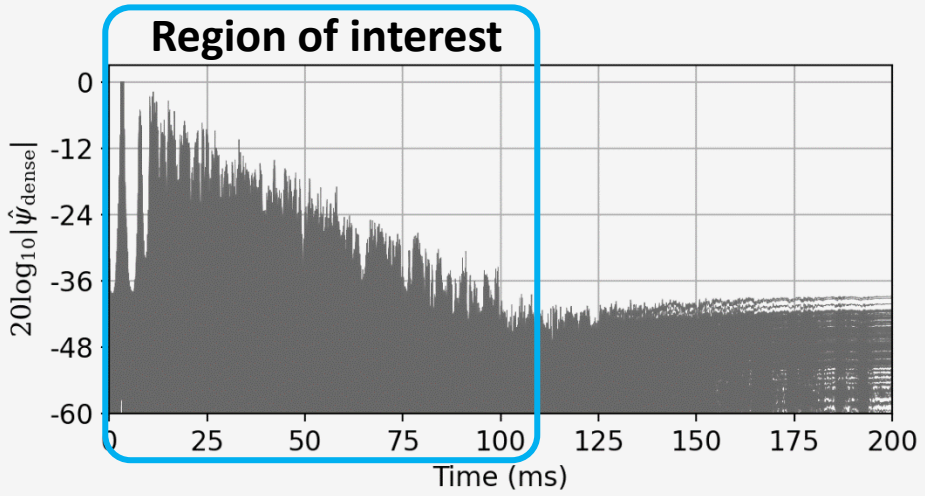
III. Evaluation of RIR interpolation

RIR energy comparison

- In both cases, the energy remains concentrated within the first 100 ms
- Envelopes are very similar in the region of interest



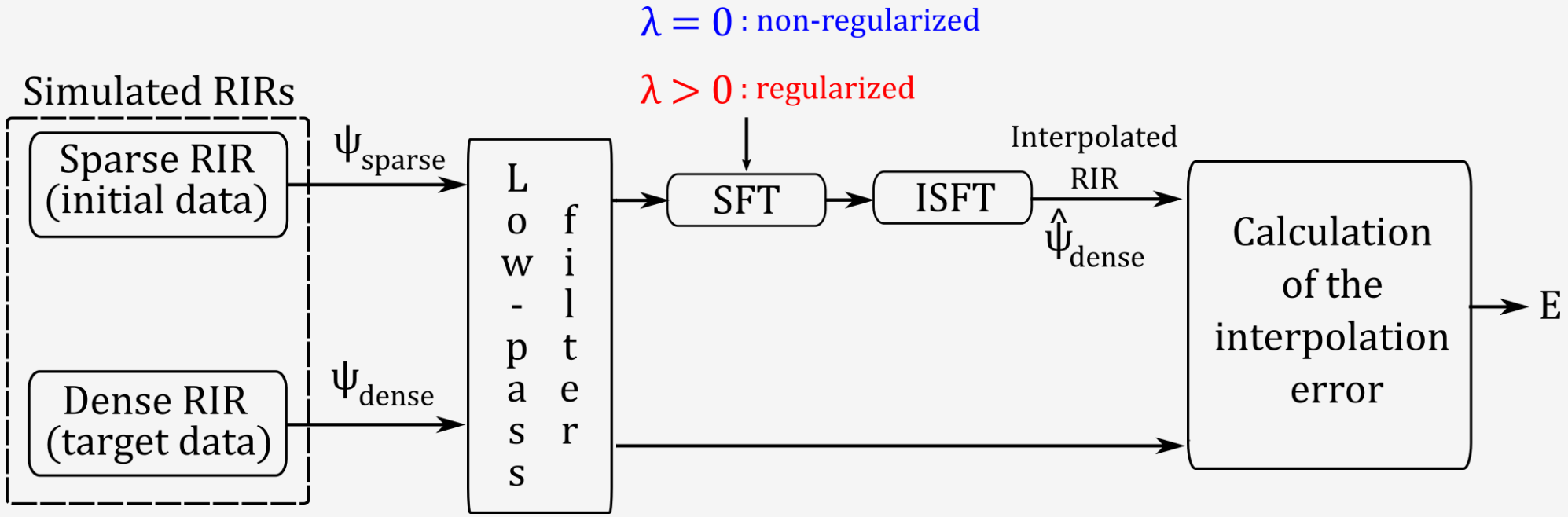
Energy of the target RIRs



Energy of the interpolated RIRs

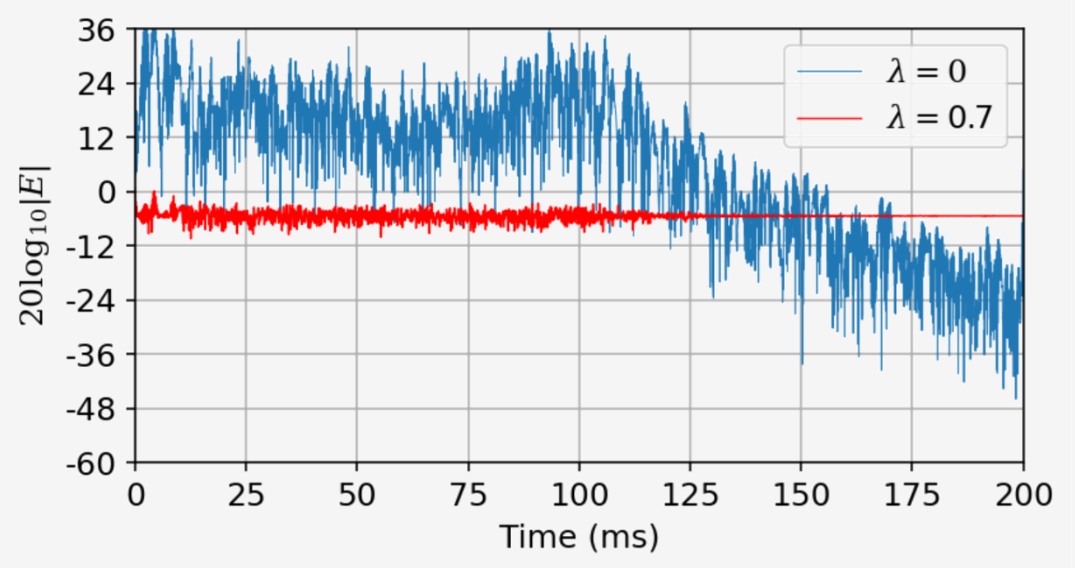
III. Evaluation of RIR

Interpolation error

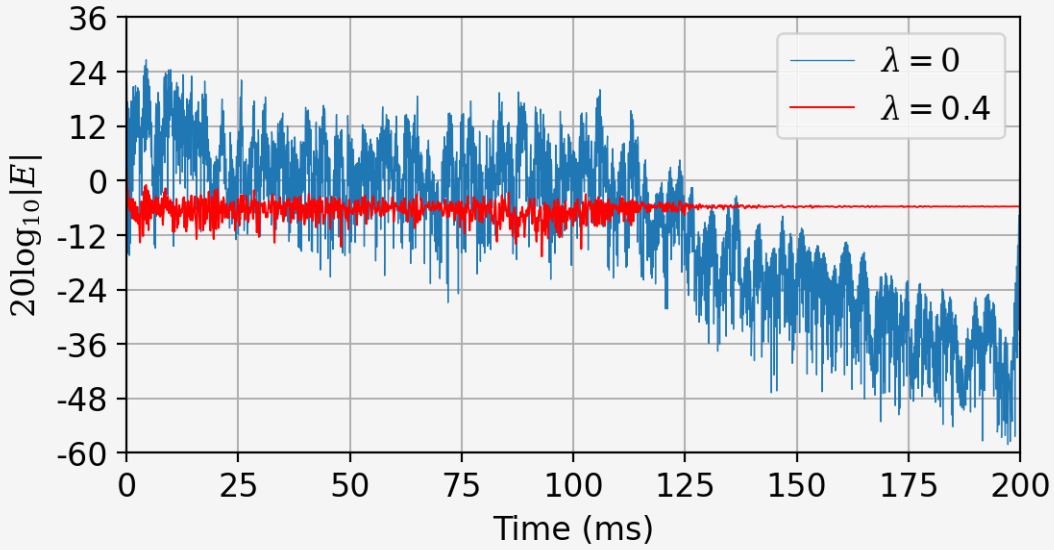


III. Evaluation of RIR interpolation

Interpolation error



Number of microphones: $L = 49$
Max order: $N_{\max} = 6$



Number of microphones: $L = 16$
Max order: $N_{\max} = 3$

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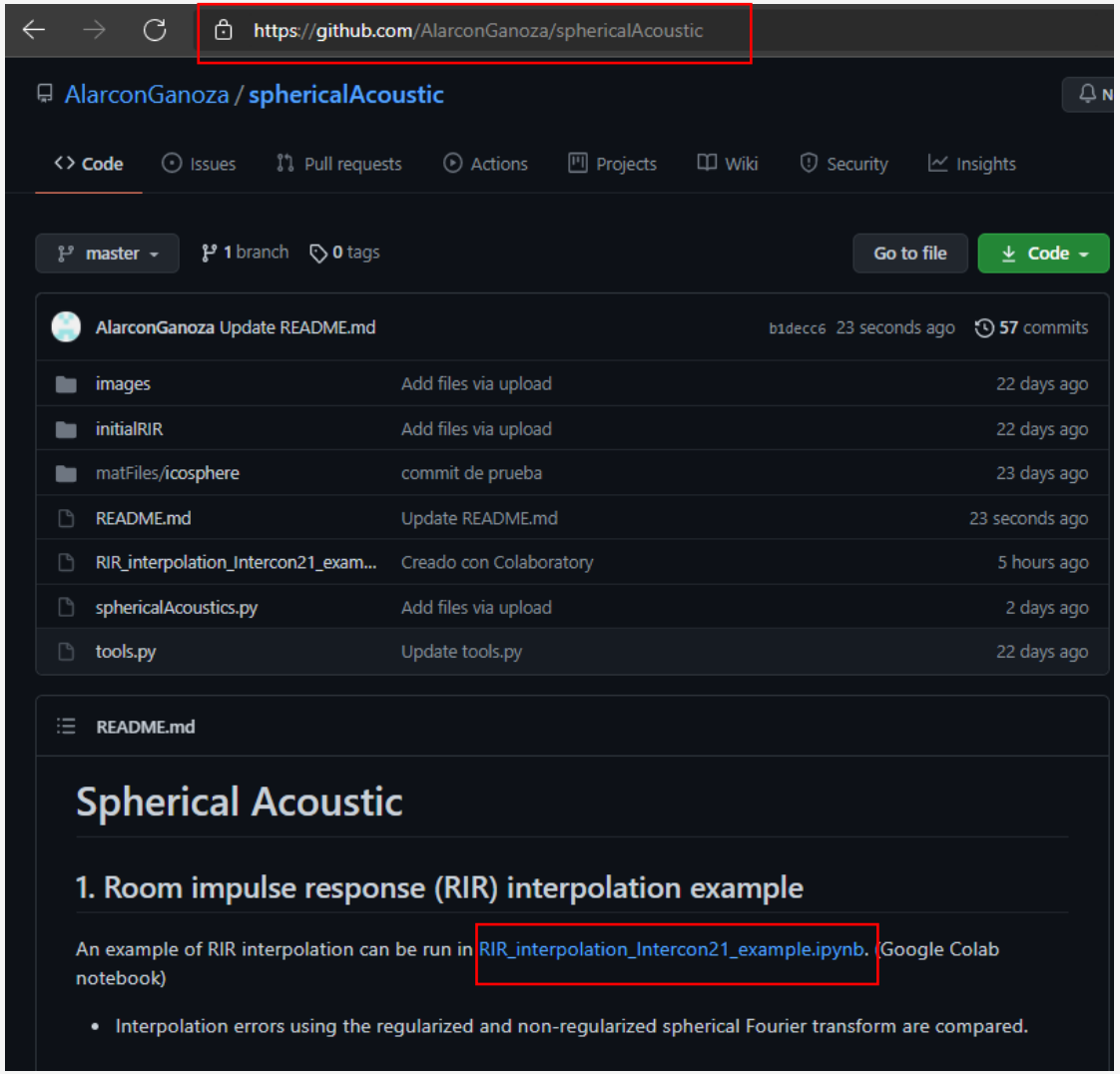
IV. Conclusions

- Regularized SFT based interpolation maintained the errors bounded at high-energy values in time

- Extensions to this work might include physics-based frameworks for the reconstruction of sound pressure fields

- Open-source library available at: https://github.com/AlarconGanoza/sphericalAcoustic



We invite you to use our library

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