Binaural room impulse responses interpolation using physics-informed neural networks in three dimensions

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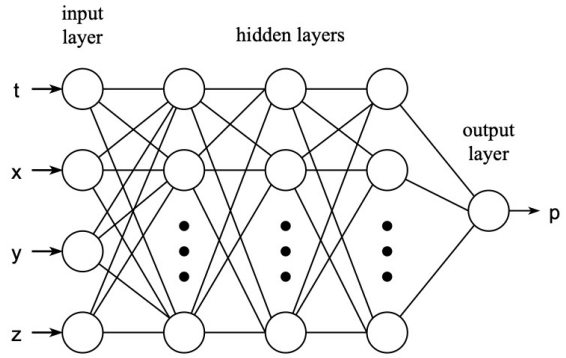
Motivation

- **Motivation:**
  XR applications and physical experiments both require accurate BRIRs at different spatial positions, which are difficult to measure.
  → BRIRs interpolation from a small set of measurements.

- **Challenge:**
  - Head existence changes the sound field.
  - Memory consumption for 3D datasets.

Network Architecture

Sinusoidal Representation Networks (SIREN) [1]



Physics-informed neural network (PINN) [2]
add physics constraints to the loss function

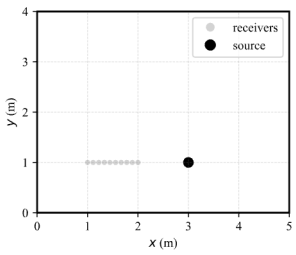
$$L = L_{data} + \alpha L_{PDE}$$

distance between estimation and measurements

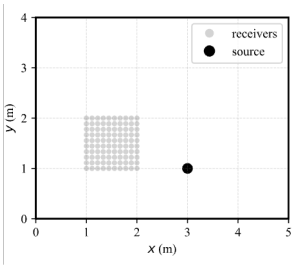
distance between estimation and the wave equation

Dataset

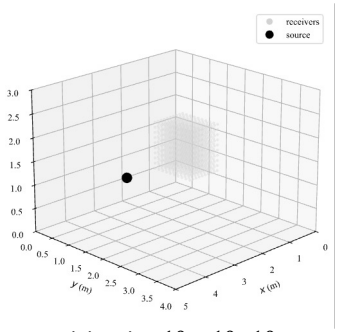
- **BRIR simulation**: razr simulator [3]
- **3 datasets:** 1D, 2D, 3D



training size: 10
evaluation size: 20



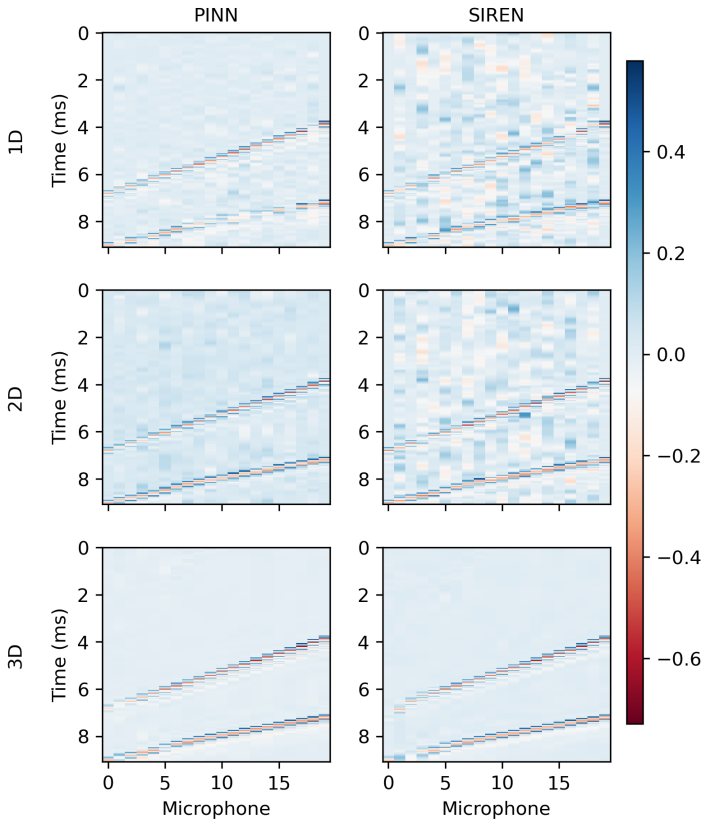
training size: 10 × 10
evaluation size: 20 × 20



training size: 10 × 10×10
evaluation size: 20 × 20×20

Results

NMSE (dB)	1D	2D	3D
Bilinear	1.89	1.89	1.89
SIREN	3.93	-0.18	-2.86
PINN	**0.04**	**-3.42**	**-4.09**



Conclusion

- PINN can learn physics information from data without complete physics equations.
  - PINN works for BRIRs.
  - PINN works for 1D and 2D datasets.
- PINN needs less training data.

Reference

[1] V. Sitzmann et al. "Implicit neural representations with periodic activation functions." In Neurips, 2020.
[2] X. Karakonstantis et al. "Room impulse response reconstruction with physics-informed deep learning." JASA, 155(2):1048–1059, 2024.
[3] T. Wendt et al. "A computationally-efficient and perceptually-plausible algorithm for binaural room impulse response simulation." JAES, 62(11):748–766, 2014.

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