DeepWave: an RNN for Real-Time Acoustic Imaging

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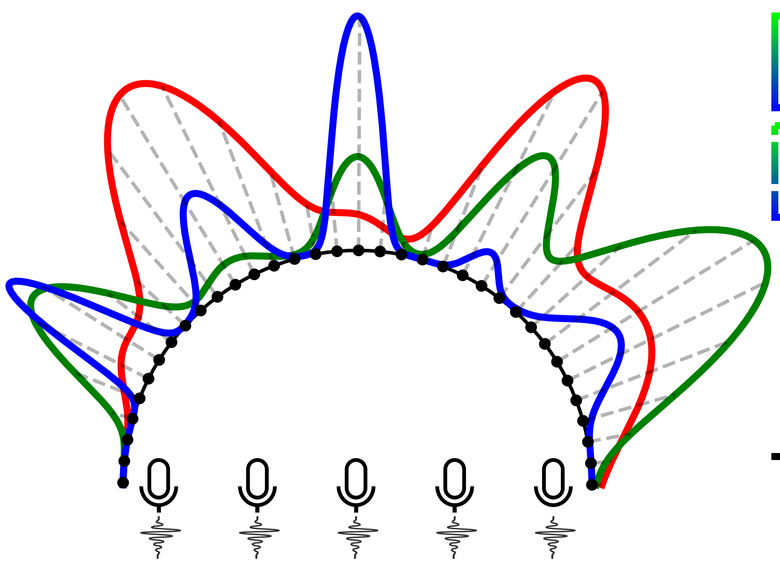
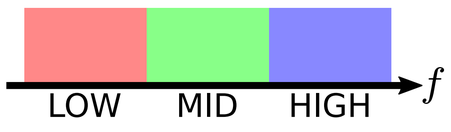
Abstract Real-time high-resolution sound field imaging is difficult with small microphone arrays. We propose DeepWave, a complex-valued RNN architecture inspired by iterative solvers from optimization theory. DeepWave-computed sound fields have higher resolution & contrast than real-time data-driven approaches.

1. Acoustic Imaging Problem



$$x_f : \mathbb{S}^2 \to \mathbb{R}_+$$

$$\mathbf{x}_f \in \mathbb{R}_+^N$$



$$\mathbf{\Sigma} = \mathbf{A}\,\mathrm{diag}(\mathbf{x}_f)\mathbf{A}^H \in \mathbb{C}^{M\times M}$$

Goal: estimate discretized sound intensity field $\mathbf{x}_f$ from measurements $\mathbf{\Sigma}$

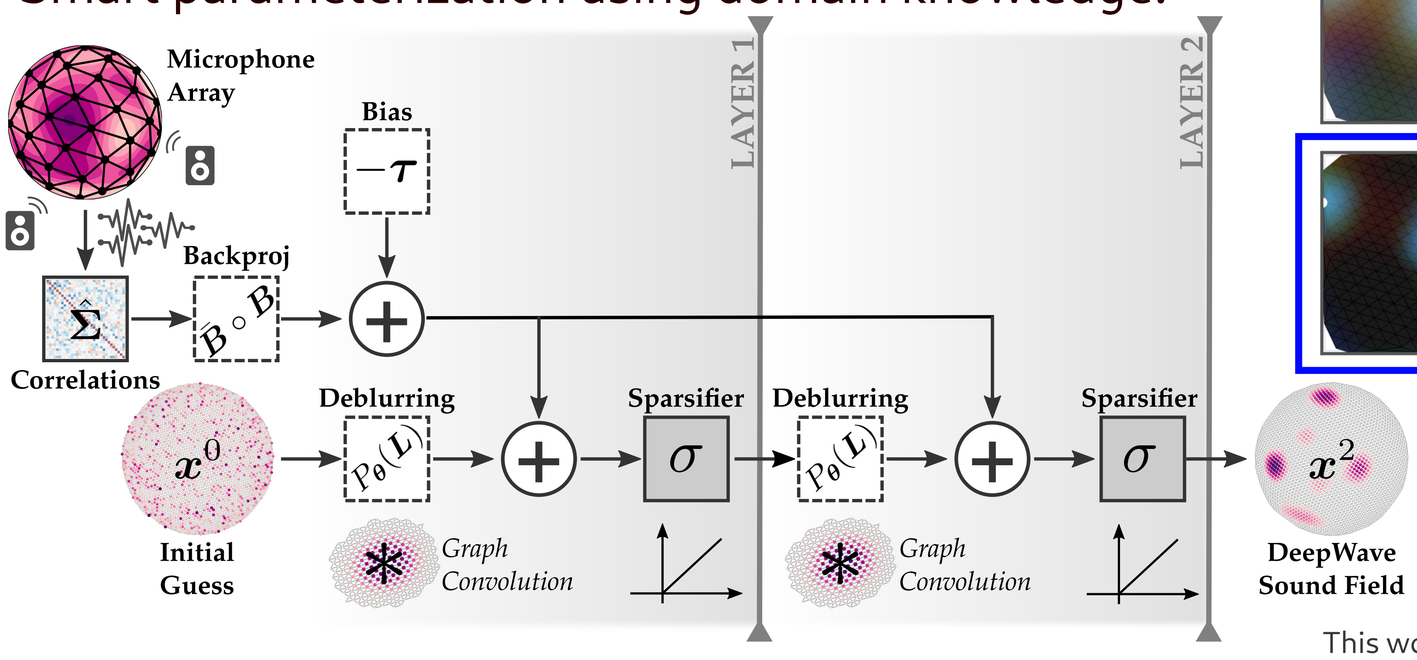
Possible Solutions

		Angular Res.	[ms]
DAS	$\mathbf{x}_f = \left(\overline{\mathbf{A}} \circ \mathbf{A}\right)^H \mathrm{vec}(\mathbf{\Sigma})$	✗	2
PGD	$\mathbf{x}_f^{(k)} = \mathrm{prox}_{\mathrm{EN}}\left[\mathcal{D}\mathbf{x}^{(k-1)} + \mathcal{B}\,\mathrm{vec}(\mathbf{\Sigma}) - \boldsymbol{\tau}\right]$	✓	211

2. DeepWave Network Architecture

$$\mathbf{x}_f^{(k)} = \mathrm{ReLu}\left[P_\theta(\mathbf{L})\mathbf{x}^{(k-1)} + \left(\overline{\mathbf{B}} \circ \mathbf{B}\right)^H \mathrm{vec}(\mathbf{\Sigma}) - \boldsymbol{\tau}\right] \quad ✓ \quad 6$$

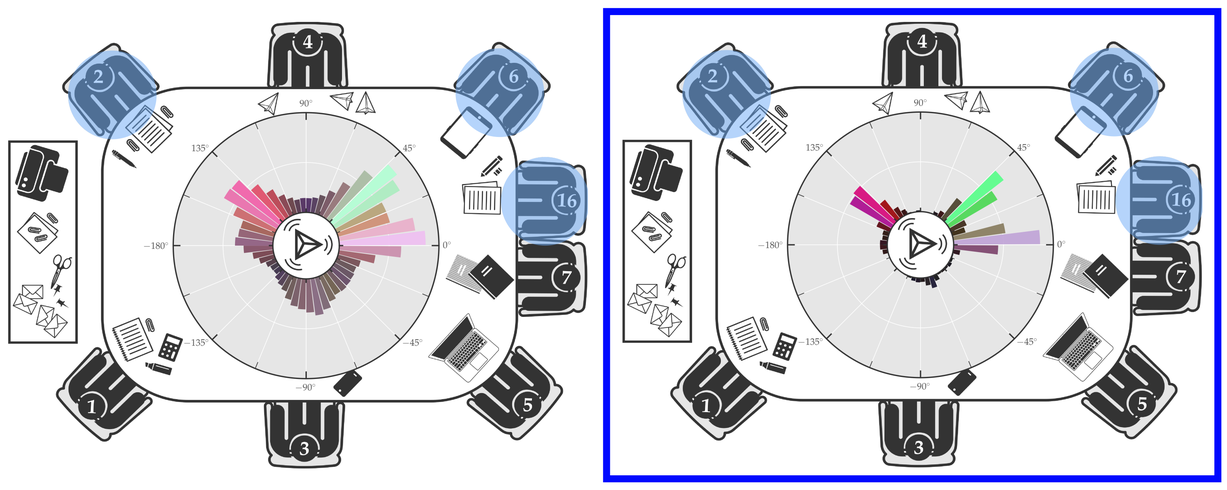
Intuition: learn shortcuts to PGD solution space. Smart parameterization using domain knowledge.



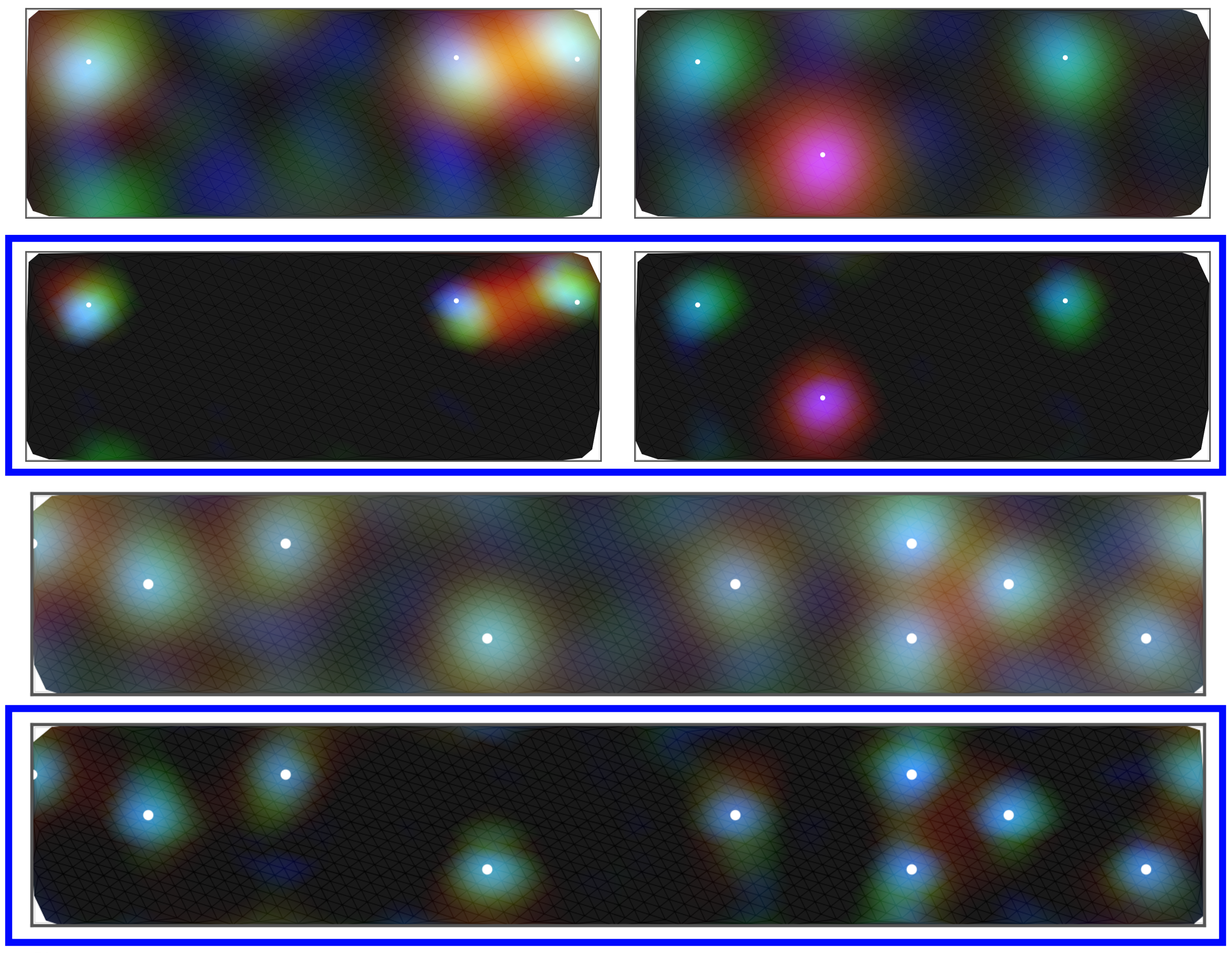
3. Experimental Results

Conference Room Dataset

DAS | **DeepWave**



Pyramic Dataset



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