Accurate diffuse acoustic simulation reduces Direction-of-arrival (DOA) estimation angular error by 41%.

Regression and Classification for Direction-of-Arrival Estimation with Convolutional Recurrent Neural Networks

Zhenyu Tang, John D. Kanu, Kevin Hogan, Dinesh Manocha

INTRO

- Conventional methods for training DOA estimation models use the **image method** simulation to create synthetic data
- Diffuse reflections / late reverberations are missing from training samples
- We propose to use more accurate diffuse simulation methods

METHODS

1. Generated synthetic impulse responses (IRs) using **diffuse acoustic simulation**
2. Compared both regression and classification networks
3. Tested with real-world dataset

RESULTS

- Perotin et al. uses image method with classification network. We use the same network structure and training method. Our regression network with **diffuse acoustic simulation** has the best performance

Model	< 5°	Avg. Err	Improv.
Perotin et al.	11.9%	16.9°	-
Classification	**24.4%**	9.96°	41%
Regression	**24.4%**	**9.68°**	**43%**

DISCUSSION

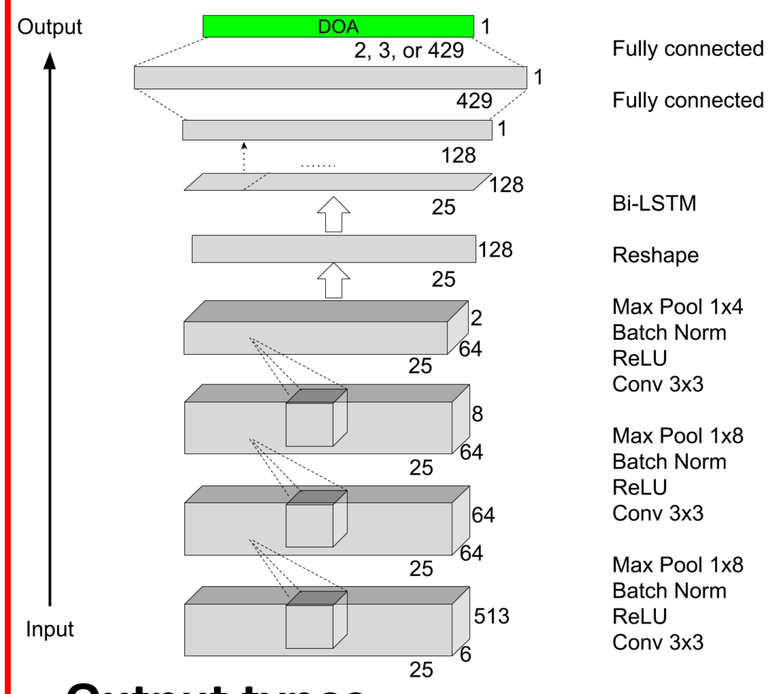
- Diffuse reflection plays a big part for training DOA estimation models
- Regression models seem more natural and effective for this task
- Our synthetic IRs can do more…

Input feature

1st order Ambisonic intensity vectors, dim: (nBatchx25x513x6)

$$\mathbf{I}(t,f) = \begin{bmatrix} W(t,f) * X(t,f) \\ W(t,f) * Y(t,f) \\ W(t,f) * Z(t,f) \end{bmatrix} \begin{matrix} \mathbf{I}_a(t,f) = \mathcal{R}\{\mathbf{I}(t,f)\} \\ \mathbf{I}_r(t,f) = \mathcal{I}\{\mathbf{I}(t,f)\} \end{matrix}$$

Network architecture



Output types

Output Type	Activation	Dimension	Loss Function
Categorical	Sigmoid	$\mathbb{R}^d$	Cross-entropy
Cartesian	Linear	$\mathbb{R}^3$	MSE
Spherical	Linear	$\mathbb{R}^2$	Haversine

# of classes d=429

Training and Test data

126,000 IRs are generated from synthetic rooms for training.
Test data from LOCATA challenge and SOFA spatial IR dataset.
Training uses purely synthetic data, but tested on these 3rd party real data.

UNIVERSITY OF MARYLAND 1856
DEPARTMENT OF COMPUTER SCIENCE

Take a picture to download data and code

GAMMA research group https://gamma.umd.edu/