SASNet: Spatially-Adaptive Sinusoidal Networks for INRs

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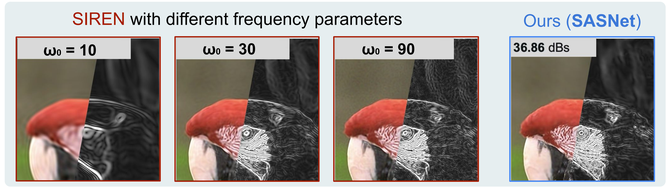
CVPR JUNE 3-7, 2026 DENVER COLORADO

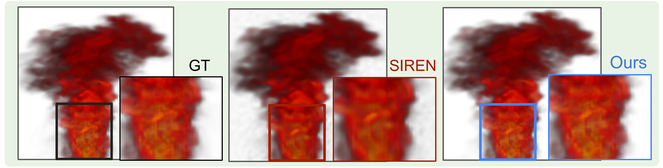
Overview

Frequency Leakage: SIREN neurons activate globally.

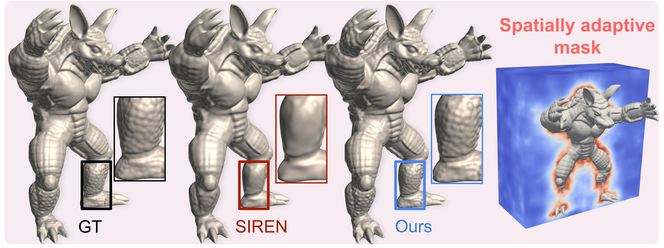
SIREN has a narrow optimal frequency range.



High frequencies improve detail but leak into smooth regions.



SASNet localizes SIREN neurons with spatially adaptive masks.

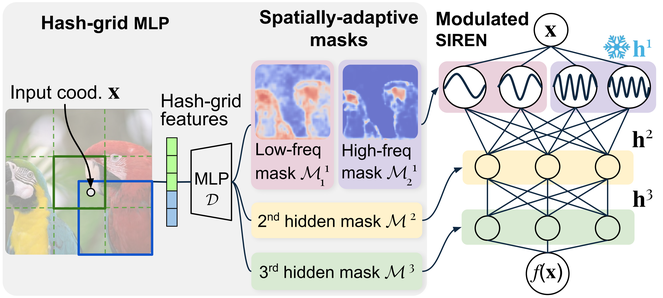


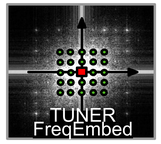
Contributions

- **Frozen frequency embedding:** controls the network spectrum and reduces the need to tune ω_0.
- **Jointly optimized spatial masks:** a hash-grid MLP localizes sinusoidal neuron responses, mitigating frequency leakage.
- **Versatile across INR tasks:** sharper reconstruction, lower frequency leakage, and faster convergence.

Method

SASNet localizes sinusoidal neurons using learned spatial masks.

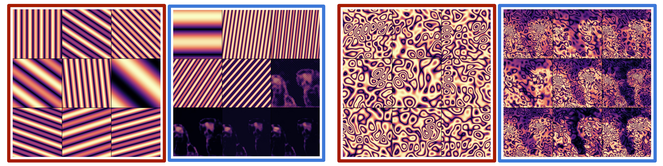




- Frozen frequency embedding layer uses integer frequencies grouped by frequency band.
- Learned masks modulate grouped neuron amplitudes through the Hadamard product:

$$\widetilde{h}_j^i(\mathbf{x}) = \sum_{\mathbf{k}\in\mathbb{Z}^{n_i}} \alpha_{\mathbf{k}}\, \mathcal{M}_j^i(\mathbf{x})\, \sin\Big(\langle \mathbf{k}, \mathbf{y}\rangle + b_j^i\Big).$$

Neuron responses: **SIREN** activates globally, while **SASNet** activates locally.



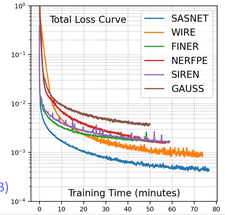
Efficiency Analysis

The mask branch adds only modest overhead.

Model	AST↓	PMem↓
SIREN	29,224	2075.50
MSIREN	95,438	6077.07
INCODE	59,907	3642.59
SASNET	43,107	3031.60

AST: average step time (μs)
PMem: peak GPU memory (MB)

Faster convergence



Scales favorably

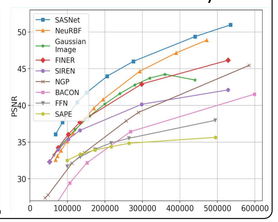
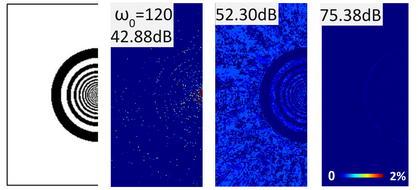


Image Fitting

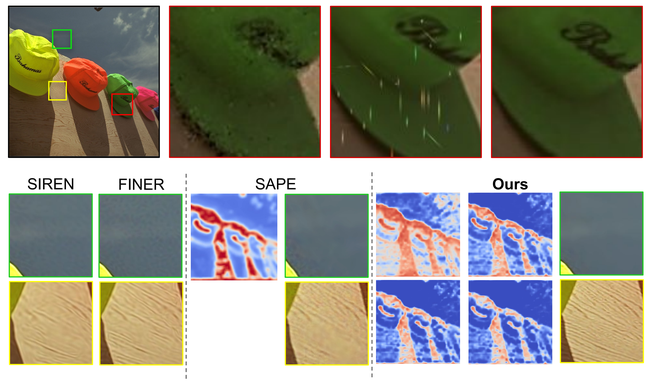
Toy example



Kodak dataset

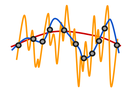
Methods	PSNR ↑	SSIM ↑	Noisiness ↓
SIREN [12]	36.60	0.951	4.079
SAPE [5]	33.37	0.872	5.373
WIRE [11]	29.34	0.804	15.375
FINER [8]	37.72	0.973	5.174
NeuRBF [4]	37.51	0.971	6.258
SASNet	40.43	0.986	3.993

Sub-pixel fitting reveals frequency-leakage artifacts.



Frequency-leakage metric

$$\textbf{Noisiness} = \frac{1}{Z}\sum_{i=1}^{N} \mathbb{1}_{\text{smooth}}(\mathbf{x}_i)\, \Big|\, \|\nabla f(\mathbf{x}_i)\|_2 - \|\nabla f(\mathbf{x}_i)\|_2 \Big|$$



Volumetric and SDF Fitting

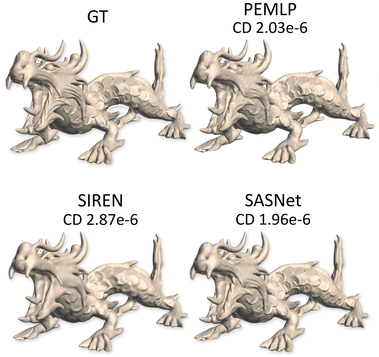
ScalarFlow smoke-density fitting

	PEMLP	Gauss	SIREN	FINER	WIRE	SASNet
PSNR↑	40.42	47.11	47.67	49.77	53.06	55.92
SSIM↑	0.9434	0.9920	0.9948	0.9959	0.9963	0.9973

SDF fitting

	Methods	Armadillo	Dragon	Lucy	Thai Statue	Avg.
Chamfer↓	PEMLP	3.465e-06	2.039e-06	2.387e-06	4.460e-06	3.088e-06
	Gauss	7.283e-06	1.304e-05	1.178e-05	1.162e-05	1.093e-05
	SIREN	3.599e-06	2.871e-06	2.405e-06	4.381e-06	3.314e-06
	WIRE	3.274e-06	2.172e-06	2.419e-06	3.296e-06	2.790e-06
	FINER	4.040e-06	2.477e-06	2.536e-06	4.201e-06	3.313e-06
	SASNet	3.368e-06	1.964e-06	1.927e-06	3.090e-06	2.587e-06
IOU↑	PEMLP	0.9878	0.9803	0.9677	0.9561	0.9730
	Gauss	0.9806	0.9561	0.9581	0.9418	0.9592
	SIREN	0.9872	0.9694	0.9716	0.9561	0.9711
	WIRE	0.9910	0.9747	0.9693	0.9635	0.9746
	FINER	0.9837	0.9728	0.9671	0.9518	0.9689
	SASNet	0.9891	0.9809	0.9813	0.9654	0.9792

3D Shape SDF fitting



SDF error map: w/o mask **vs** w/ mask