



Super Resolution Ultrasound via Model Based Deep Learning for Improved Breast Lesion Characterization

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Goal: reconstruct breast lesion microvasculature via contrast enhanced ultrasound

Inject microbubbles into blood stream → Bubbles act as point emitters → Resolved microvasculature

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Existing methods for microvasculature reconstruction

Averaging frames (naive) → Diffraction limited resolution
Detect bubbles centers by Sparse Recovery (SOTA) → Super resolved vasculature

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Problems with sparse recovery approaches:

- i. *Slow inference* due to the iterative structure of the algorithms
→ Impairs the translation of super-resolution US into the clinic
- ii. *Manual calibration* of the system PSF is required
→ High user dependency

Our approach:
Training a model-based deep neural network with architecture inspired from sparse recovery:

- i. One shot inference
→ Short & known inference time
- ii. No prior knowledge about the system PSF is required
→ Alleviate dependency on user's experience

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Model-based network architecture for microvasculature reconstruction

Block diagram of ISTA for sparse recovery
Deep neural network for sparse recovery

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Results demonstrates our method on clinical data for the first time showing super resolved microvasculature recoveries of breast lesions

	<u>B-mode image used in clinical practice showing tissue!</u>	<u>Super resolved recoveries showing vascular profiles!</u>	
Patient 1: Fibroadenoma (benign)			Oval, well circumscribed mass with homogeneous high vascularization
Patient 2: Cyst (benign)			Round structure with high concentration of blood vessels at the periphery of the mass
Patient 3: Invasive ductal carcinoma (malignant)			Irregular mass with ill-defined margins. High concentration of blood vessels at the periphery. Low concentration of blood vessels at the center

31.25 μm spatial resolution!

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We implemented a **model-based deep learning framework** for super resolution ultrasound on clinical scans using a clinical ultrasound scanner and standard clinical procedure.

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We showed super resolved microvasculature recoveries in human patients with various breast lesions. Our results **demonstrate different morphological features**, which are characteristic of the various lesions, thus **assisting diagnosis**.