# Ning Lu

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**Research Interests**: Acoustics/Ultrasonics, Instrumentation, Parallel Computing, AI-Powered Algorithms, Distributed Systems, and Wearable Devices for Digital Sensing.

## MISSION STATEMENT

I am an ultrasound scientist specializing in developing integrated systems and computational tools for medical imaging, non-invasive therapy, digital sensing, and wearable devices.

## EDUCATION&TRAINING

**Stanford University, Palo Alto, CA** 08/ 2023 - Present

Postdoctoral Scholar *(PI: Katherine W. Ferrara, member of the National Academy of Engineering)*

**University of Michigan, Ann Arbor, MI** 08/ 2018 – 07/ 2023

Ph.D. in Biomedical Engineering & Scientific Computing *(PI: Zhen Xu)* GPA: 4.0/4.0

**Southeast University, Nanjing, China** 08/ 2014 – 06/ 2018

B.E. in Biomedical Engineering (Highest Honor, Chien-Shiung Wu College*) GPA: 3.6/4.0

* Only the top 30 engineering undergraduates in Southeast University are selected for this college.

## FEATURED PUBLICATIONS

1. **N Lu**, TL Hall, JR Sukovich, SW Choi, J Snell, N McDannold, Z Xu. "Two-step Aberration Correction: Application to Transcranial Histotripsy". *Physics in Medicine & Biology,* 2022; 67 (12). doi: 10.1088/1361-6560/ac72ed.
2. **N Lu,** TL Hall, D Choi, D Gupta, BJ Daou, JR Sukovich, A Fox, TI Gerhardson, AS Pandey, DC Noll, Z Xu. "Transcranial MR-Guided Histotripsy System." *IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control,* 2021; 68 (9). doi: 10.1109/TUFFC.2021.3068113. (**Front cover article**)
3. **N Lu**, F LaRocca, S Talathi. "Accurate and Robust Eye Tracking with Ultrasound: A Computational Study." *IEEE International Ultrasonics Symposium (IUS) Proceedings*, 2023. doi: 10.1109/IUS51837.2023.10306398.

* *For the full publication list, see Pages 3-5.*

## RESEARCH EXPERIENCE

**Real-time 3D+ Ultrasound Imaging for Early Cancer Detection and Interventional Guidance**

Stanford University, Palo Alto, CA 08/ 2023 – Present

- Developed real-time 3D spine imaging techniques using a large-aperture array, which significantly improved image quality for diagnosis and interventional guidance. The performance of this system has been validated in human volunteers and reviewed by a board-certified radiologist at Stanford Medicine.
- Developed a 1024-channel ultrasound tomography scanner with high resolution for breast cancer screening (with ongoing preclinical study in human volunteers).
- Developing imaging sequences and GPU-based real-time beamformers using a highly parallelized distributed computing architecture.
- Developing aberration correction algorithms to improve image quality in 3D+ anatomical and functional ultrasound imaging.

**Transcranial MR-guided Histotripsy (TcMRgHt) for Brain Tumor Treatment**

University of Michigan, Ann Arbor, MI 08/ 2018 – 07/ 2023

*Dissertation committee: Drs. Zhen Xu (IEEE fellow, NAI fellow), Douglas C. Noll (former BME Department Chair and fMRI Center Director), Jeffrey A. Fessler (ECE Department Chair), Aditya Pandey (Neurosurgery Department Chair), Timothy L. Hall, Jonathan R. Sukovich*

- Histotripsy is a non-invasive, non-thermal, non-ionized ultrasound therapy technique that mechanically fractionates target tissue using acoustic cavitation generated by short, high-intensity ultrasound pulses.
- Designed and constructed the first human-scale TcMRgHt system in the world, including the transducer array, the transmit-and-receive capable electronic driver, and peripheral mechanical structures.
- Developed a two-step aberration correction method to improve treatment efficacy and precision, which uses CT-based raytracing as the first step, followed by a cavitation-based time-reversal approach.
- Developed imaging algorithms for focused ultrasound treatment monitoring, with a spatial-temporal resolution that allows imaging for every cavitation event including the skull surface cavitation.
- Evaluated the feasibility, safety, and outcome of TcMRgHt treatment *ex vivo* and *in vivo*.

**Ultrasound Eye Tracking for AR/VR Devices**

Meta (formerly Facebook) Reality Labs, Redmond, WA 05/ 2022 – 09/ 2022

- Developed an acoustic simulation platform to synthesize data for ultrasound eye tracking data as a function of transducer/system design, sensor noise, eye/face occlusion, and headset slippage.
- Achieved end-to-end ultrasound eye tracking which outperforms state-of-art camera-based methods using a machine learning algorithm to jointly estimate eye gaze and headset slippage.

**High-Speed Photon Counter for Multi-photon Optical Imaging System**

Johns Hopkins University, Baltimore, MD 06/ 2017 – 09/ 2017

- Designed a fast signal acquisition pipeline using a high-speed amplifier and digitizer to increase the sensitivity and precision of photon detection for multi-photon imaging systems.
- Achieved a data processing rate of up to 7 GB/s using multi-threading and GPU acceleration.

**High-Performance Cluster Building and Parallel Optimization**

National Supercomputer Center, Wuxi, China 01/ 2017 – 04/ 2017

(First Class Award in Asia Student Supercomputer Challenge 2017)

- Implemented parallel optimization for high-resolution surface wave simulations on a supercomputer.
- Designed and built a 6-node server cluster, achieved a LINPACK benchmark score of 4 TFLOPS, and conducted genome assembly simulation and molecular dynamics simulation on the cluster.

**Design, Optimization, and Software Development of 1310 nm SS-OCT System**

Southeast University, Nanjing, China 12/ 2017 – 06/ 2018

- Built a 1310 nm SS-OCT system with an imaging depth of 4.8 mm and axial resolution of 25 μm for ex-vivo tissue imaging.

**Multichannel Micro-electrode for in vivo Neural Signal Recording**

Southeast University, Nanjing, China 04/ 2015 – 01/ 2017

- Designed a lightweight, highly integrated 256-channel 3D micro-electrode for neural signal recording on freely moving rats.

## SKILLS

**Programming**: Python, C/C++, CUDA, shell scripting, Verilog, R.

**Software**: Matlab, Julia, PyTorch, LaTeX, LabVIEW.

**Technical**: Signal and image processing, circuit design (schematic & PCB layout), ultrasound transducer design and fabrication, parallel optimization, 3D printing, mechanical design, MRI, animal experiments.

## SELECTED COURSE PROJECTS

- *Learning-based Optimization for Under-Sampling MRI*
  Image Processing (EECS 556), Winter 2021 (KLA Runner-up Team Prize)
- *VolumeRend for 3D Lung Nodule Segmentation*
  Advanced Topics in Computer Vision (EECS 542), Fall 2020
- *Point-source Separation for Aberration Correction in Ultrasound Therapy using GAN*

Advanced Machine Learning for Bioinformatics (BIOINFO 590), Fall 2019

## PATENT APPLICATIONS

1. **N. Lu**, F. LaRocca, S. Talathi. Provisional patent application under review, 2023.

## PUBLICATIONS

1. **N Lu,** J Foiret, B Yoon, KW Ferrara. "Improving Ultrasound Spine Imaging with a Large-Aperture Array". Under review, 2024.
2. **N Lu,** JR Sukovich, TL Hall, Z Xu. "Transcranial Cavitation Imaging Using a Large-Aperture Transcranial Histotripsy Array". In preparation, 2024.
3. **N Lu,** E Yeats, JR Sukovich, TL Hall, Z Xu. "Treatment Envelope of Transcranial Histotripsy: Strategies to Improve the Treatment Efficacy for Targets Near Skull Surface". *Physics in Medicine & Biology*, 2024. doi: 10.1088/1361-6560/ad8d9f.
4. **N Lu**, F LaRocca, S Talathi. "Accurate and Robust Eye Tracking with Ultrasound: A Computational Study." *IEEE International Ultrasonics Symposium (IUS) Proceedings*, 2023. doi: 10.1109/IUS51837.2023.10306398.
5. **N Lu**, TL Hall, JR Sukovich, SW Choi, J Snell, N McDannold, Z Xu. "Two-step Aberration Correction: Application to Transcranial Histotripsy". *Physics in Medicine & Biology,* 2022; 67 (12). doi: 10.1088/1361-6560/ac72ed.
6. **N Lu,** D Gupta, BJ Daou, A Fox, D Choi, JR Sukovich, TL Hall, S Camelo-Piragua, N Chaudhary, J Snell, AS Pandey, DC Noll, Z Xu. "Transcranial MR-guided Histotripsy for Brain Surgery – Pre-clinical Investigation". *Ultrasound in Medicine & Biology,* 2022; 48 (1). doi: 10.1016/j.ultrasmedbio.2021.09.008.
7. **N Lu,** TL Hall, D Choi, D Gupta, BJ Daou, JR Sukovich, A Fox, TI Gerhardson, AS Pandey, DC Noll, Z Xu. "Transcranial MR-Guided Histotripsy System." *IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control,* 2021; 68 (9). doi: 10.1109/TUFFC.2021.3068113.
8. R Wodnicki, J Foiret, B Liu, **N Lu**, X Sun, J Zhang, H Kang, H Bendjador, L Fu, C Notard, M Legros, Q Zhou, KW Ferrara. "Handheld Large 2D Array with Azimuthal Planewave and Row-Multiplexed Elevation Beamforming Enabled by local ASIC Electronics". Under review at *IEEE TUFFC*.
9. E Yeats, G Stocker, **N Lu**, M Komaiha, JR Sukovich, Z Xu, TL Hall. "In Vivo Cavitation-Based Aberration Correction of Histotripsy in Porcine Liver". *IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control,* 2024; 71(8). doi: 10.1109/TUFFC.2024.3409638.

10. SW Choi, M Komaiha, D Choi, **N Lu**, TI Gerhardson, A Fox, N Chaudhary, S Camelo-Piragua, TL Hall, AS Pandey, Z Xu, JR Sukovich. "Neuro-navigation-guided Transcranial Histotripsy (NaviTH) System". *Ultrasound in Medicine & Biology,* 2024. doi:10.1016/j.ultrasmedbio.2024.04.001.
11. S Haskell, **N Lu**, G Stocker, Z Xu, JR Sukovich. "Monitoring Cavitation Dynamics Evolution in Tissue-mimicking Hydrogels for Repeated Exposures via Acoustic Cavitation Emissions". *Journal of the Acoustical Society of America,* 2023; 153 (237). doi:10.1121/10.0016849.
12. E Yeats, **N Lu**, JR Sukovich, Z Xu, TL Hall. "Soft Tissue Aberration Correction for Histotripsy Using Acoustic Emissions from Cavitation Cloud Nucleation and Collapse". *Ultrasound in Medicine & Biology,* 2022; 49 (5). doi:10.1016/j.ultrasmedbio.2023.01.004.
13. D Gupta, D Choi, **N Lu**, SP Allen, TL Hall, DC Noll, Z Xu. "MR-thermometry Targeting for MR-guided histotripsy treatments". *Ultrasound in Medicine & Biology,* 2022; 49 (5). doi: 10.1016/j.ultrasmedbio.2022.12.009.
14. **N Lu**, D Xing, T Sheng, W Lu. The mechanism and function of hippocampal neural oscillation. Acta Physiologica Sinica, 2017, 69(5): 647–656. DOI: 10.13294/j.aps.2017.0052

## ACADEMIC PRESENTATIONS (* = PRESENTER, 1 = TALK, 2 = POSTER)

1. **N Lu*[1] (Invited)** "3D+ Ultrasound: Imaging, Therapy, and Digital Sensing." *BME Seminar 2024,* Southeast University, Nanjing, China.
2. **N Lu*[1] (Invited)** "Transcranial histotripsy for non-invasive brain therapy." *Academic Seminar on Biomedical and Health Engineering 2024,* Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences.
3. **N Lu*[1],** J Foiret, B Yoon, KW Ferrara. "Real-time volumetric spine imaging for interventional guidance with a large-aperture array". *IEEE International Ultrasonics Symposium (IUS) 2024,* Taipei.
4. **N Lu*[1],** J Foiret, EY Park, S Poplack, KW Ferrara. "High-resolution large field-of-view volumetric ultrasound scanner for breast imaging." *IEEE IUS 2024,* Taipei.
5. R Wodnicki**,** J Foiret, B Liu, **N Lu,** et al. "2D arrays: Technologies and challenges, a review of past, present, and future." Invited talk at *IEEE IUS 2024,* Taipei.
6. E Yeats, **N Lu**, G Stocker, M Komaiha, JR Sukovich, Z Xu, TL Hall. "In Vivo Aberration Correction of Histotripsy Using Acoustic Cavitation Emissions". *IEEE IUS 2024,* Taipei.
7. **N Lu*[1] (Invited)** "High-definition 3D ultrasound imaging and therapy." *Biomedical Engineering Research Forum 2024,* Nanjing Medical University, China (remote).
8. **N Lu*[1]**, F LaRocca, S Talathi. "Accurate and robust eye tracking with ultrasound: a computational study." *IEEE IUS 2023,* Montreal, Canada.
9. **N Lu*[2]**, M Komaiha, JR Sukovich, TL Hall, Z Xu. "Passive cavitation mapping for transcranial histotripsy." *IEEE IUS 2023,* Montreal, Canada.
10. **N Lu*[2],** JR Sukovich, S Camelo-Piragua, Z Xu, AS Pandey. "Ablation of human brain tumors using histotripsy". *Congress of Neurological Surgeons (CNS) Annual Meeting 2023,* Washington D.C., USA.
11. **N Lu*[1]**, JR Sukovich, TL Hall, Z Xu. "Treatment envelope of transcranial histotripsy: Strategies to improve the treatment efficacy for targets near skull surface." *International Symposium on Therapeutic Ultrasound (ISTU) 2023,* Lyon, France.
12. **N Lu*[2]**, JR Sukovich, TL Hall, Z Xu. "Electronic steering capabilities of aberration correction for transcranial histotripsy." *IEEE IUS 2022,* Venice, Italy.

13. **N Lu*[1]**, TL Hall, JR Sukovich, et al. "Two-step aberration correction: application to transcranial histotripsy". *ISTU 2022,* Toronto, Canada.
14. **N Lu*[2]**, TL Hall, JR Sukovich, Z Xu. "Aberration Correction for Transcranial Histotripsy". *IEEE IUS 2021,* virtual.
15. **N Lu*[1],** D Gupta, BJ Daou, et al. "Transcranial MR-guided histotripsy for brain surgery - re-clinical investigation". *ISTU 2021,* virtual (selected as Student Speed Talk Finalist) and *7th International Symposium on Focused Ultrasound, 2020,* virtual.
16. **N Lu*[1],** TI Gerhardson, D Choi, et al. "MR-guided histotripsy system for transcranial therapy." *IEEE IUS 2020,* virtual.
17. **N Lu*[2],** JR Sukovich, T Gerhardson, et al. "Ablation of human brain tumors using histotripsy". *IEEE IUS 2019,* Glasgow, UK.
18. J Foiret, EY Park, **N Lu**, KW Ferrara. "Large aperture imaging, from multi-array prototype to imaging device." *SPIE Medical Imaging*, 2024, San Diego, USA.
19. D Gupta, T Kaovasia, D Choi, **N Lu**, SP Allen, TL Hall, Z Xu, and DC Noll, "Evaluating histotripsy treatment dosage in the brain using MRI". *International Society for Magnetic Resonance in Medicine* (*ISMRM) Annual Meeting, 2023*, Toronto, Canada.
20. JR Sukovich, TL Hall, M Komaiha, S Haskell, **N Lu**, et al. "Acoustic cavitation localization during histotripsy using transmit-receive capable arrays". *Acoustical Society of America (ASA) Meeting 2023*, Chicago, USA.
21. JR Sukovich, **N Lu**, SW Choi, et al. "High-rate implicit cavitation localization during histotripsy via backwards transmit-delay acoustic cavitation emission (backTRACE) methods". *IEEE IUS 2022*, Venice, Italy.
22. G Stocker, **N Lu**, Z Xu, JR Sukovich, TL Hall. "Evaluating cavitation mapping during histotripsy with electronic focal steering". *ISTU 2022*, Toronto, Canada.
23. SW Choi, JR Sukovich, D Choi, M Komaiha, **N Lu**, et al. "Neuronavigation-guided transcranial histotripsy on human cadavers: a feasibility study". *ISTU 2022*, Toronto, Canada.
24. D Gupta, D Choi, **N Lu**, et al. "MR-Thermometry based targeting for histotripsy treatments in ex-vivo tissues". *ISMRM Annual Meeting, 2022*, London, UK.
25. D Gupta, **N Lu**, A Fox, D Choi, et al. "Technical feasibility and imaging of transcranial MR-guided in-vivo histotripsy treatment." *ISMRM Annual Meeting, 2021, virtual*.
26. D Gupta, **N Lu**, JR Sukovich, et al. "MRI assessment and monitoring of cavitation-based ultrasound therapy (histotripsy) for transcranial brain treatment in vivo". *ISMRM Annual Meeting, 2020*, virtual.
27. TI Gerhardson, JR Sukovich, J Lundt, **N Lu**, et al. "Design of a histotripsy array for the treatment of intracerebral hemorrhage". *ASA meeting 2019,* Louisville, USA.

## HONORS & AWARDS

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|---|---|
| IEEE IUS Student Travel Award ($300) | 06/ 2023 |
| ISTU Student Registration Award ($300) | 06/ 2021 |
| Rackham Conference Travel Grant at the University of Michigan (up to $1,400 annually) | 2019 - 2022 |
| Rackham International Student Fellowship (Top 1%, $10k) | 12/ 2019 |
| BME Departmental Fellowship (~ $40k) | 09/ 2018 |
| Best Undergraduate Thesis Award, Southeast University (Top 1%) | 06/ 2018 |

## GRANT EXPERIENCE

1. Pathway to Independence Award for Outstanding Early-Stage Postdoctoral Researchers (K99/R00)
   - *Funding Sources*: National Institutes of Health (NIH)

- *My Role*: Principal Investigator - Application in Progress.

2. Quantitative Volumetric Ultrasound and Photoacoustic Tomography (PI: Katherine Ferrara)
   - *Funding Sources*: National Institutes of Health (NCI R01CA258807)
   - *My Role*: Helped the PI draft progress reports.
3. Transcranial Magnetic Resonance-guided Histotripsy (PI: Zhen Xu)
   - *Funding Sources*: National Institutes of Health (NIBIB R01EB028309); Focused Ultrasound Foundation
   - *My Role*: Helped the PI draft grant proposals, progress reports, and grant renewal proposals.

## PROFESSIONAL SERVICES

Technical Reviewer:

- IEEE Transactions on Biomedical Engineering (TBME), IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control (TUFFC), IEEE International Symposium on Biomedical Imaging (ISBI), Ultrasound in Medicine & Biology, Physics in Medicine & Biology, Journal of Neural Engineering, Medical Engineering & Physics.

Conference Session Chair:

- Brain session at Histotripsy Symposium 2022, Madison, Wisconsin, USA.

Volunteer:

- Deputy Chair of the IEEE UFFC-S Publicity Committee, 2024 – Present.
- Leadership Committee for Women in Molecular Imaging Network (WIMIN), 2024 – 2026.
- President of IEEE UFFC Student Chapter at the University of Michigan, 2020 - 2023.
- Peer mentor for Graduate Rackham International (GRIN), University of Michigan, 2019 – 2021.
- Peer mentor for BME Mentorship Program, University of Michigan, 2019 and 2022.
- Mentor for BME Graduate Application Assistance Program (GAAP), University of Michigan, 2022.

## TEACHING TRAINING & EXPERIENCE

Guest Lecturer: 3D+ Imaging Sensors (EE 119/219) Spring 2024
*Stanford University*

Mentoring Skills Workshops Winter 2024
*Teaching & Mentoring Academy, Stanford Medicine*

Guest Lecturer for Ultrasound Lab: Medical Imaging System (BME/EECS 516) Fall 2019 & 2022
*University of Michigan*

## PROFESSIONAL MEMBERSHIPS

- IEEE UFFC
- IEEE Signal Processing Society (SPS)
- IEEE Young Professionals
- Society for Industrial and Applied Mathematics (SIAM)
- ACM Special Interest Group on High-Performance Computing (SIGHPC)
- Women in Molecular Imaging Network (WIMIN)