

Shengzhi Luan

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Research Interests

My research focuses on the mechanics of architected materials bridging engineered metamaterials, human bone, and biomedical scaffolds to advance musculoskeletal health through experimental, computational, and artificial intelligence methods, with specific research interests in:

- Nonlinear mechanics and failure mechanisms of metamaterials
- Machine learning-aided design of mechanically multifunctional metamaterials
- Multiscale biomechanics of bone
- Artificial intelligence-assisted clinical assessment of skeletal fragility
- Mechanics-driven design of bone regenerative scaffolds

Academic Employment

Boston University, Boston, MA, USA

August 2023 – present

Postdoctoral Associate in Mechanical Engineering

Advisor: Elise F. Morgan

Education

Johns Hopkins University, Baltimore, MD, USA

September 2017 – July 2023

Ph.D. in Civil Engineering

Advisor: Stavros Gaitanaros

Dissertation: Nonlinear mechanics of architected metamaterials

Northwestern University, Evanston, IL, USA

September 2015 – March 2017

M.S. in Civil Engineering

Advisor: Wing K. Liu

Thesis: Numerical methods for multidimensional fractional advection-diffusion equations

Zhejiang University, Hangzhou, China

September 2009 – July 2013

B.S. in Civil Engineering

Publications

Manuscripts under review:

1. **Luan, S.**, Barbone, P. E., & Morgan, E. F. Verification and validation of digital image/volume correlation on biomedical imaging. (Submitted to *Experimental Mechanics*)
2. Chen, E., **Luan, S.**, & Gaitanaros, S. Tension-compression asymmetry of brittle 3D lattice metamaterials. (Submitted to *npj Metamaterials*)
3. Ma, C., **Luan, S.**, Dong, E., Gardner, L. M., Gernay, T., & Du, H. From occurrence to consequence: a comprehensive data-driven analysis of building fire risk. (Under review at *Nature Cities*)

4. Auger, J. D., Olowu, B., **Luan, S.**, Gerstenfeld, L. C., & Morgan, E. F. On the use of clinical CT-based FE modeling of the proximal femur to assess sideways fall fracture risk in hip osteoarthritis. (Under revision at *Clinical Biomechanics*)

Peer-reviewed articles:

5. **Luan, S.***, & Morgan, E. F. (2025). A data-driven framework for developing a unified density-modulus relationship for the human lumbar vertebral body. *Journal of the Mechanical Behavior of Biomedical Materials*, 163, 106888.
6. **Luan, S.**, Guest, J. K., & Gaitanaros, S. (2024). The effect of topology on the shock dynamics of two-dimensional architected materials. *International Journal of Impact Engineering*, 190, 104987.
7. **Luan, S.**, Chen, E., John, J., & Gaitanaros, S. (2023). A data-driven framework for structure-property correlation in ordered and disordered cellular metamaterials. *Science Advances*, 9(41), eadi1453.
8. Chen, E., **Luan, S.**, & Gaitanaros, S. (2022). On the compressive strength of brittle lattice metamaterials. *International Journal of Solids and Structures*, 257, 111871.
9. **Luan, S.**, Chen, E., & Gaitanaros, S. (2022). Energy-based fracture mechanics of brittle lattice materials. *Journal of the Mechanics and Physics of Solids*, 169, 105093.
10. Chen, E., **Luan, S.**, & Gaitanaros, S. (2022). On the strength of brittle foams with uniform and gradient densities. *Extreme Mechanics Letters*, 51, 101598.
11. **Luan, S.**, Kraynik, A. M., & Gaitanaros, S. (2022). Microscopic and macroscopic instabilities in elastomeric foams. *Mechanics of Materials*, 164, 104124.
12. Chen, M., **Luan, S.***, & Lian, Y. (2021). Fractional SUPG finite element formulation for multi-dimensional fractional advection diffusion equations. *Computational Mechanics*, 67(2), 601-617.
13. **Luan, S.**, Lian, Y., Ying, Y., Tang, S., Wagner, G. J., & Liu, W. K. (2017). An enriched finite element method to fractional advection-diffusion equation. *Computational Mechanics*, 60(2), 181-201.

In preparation papers:

14. **Luan, S.**, Xiao, Y., & Morgan, E. F. A data-driven multiscale modeling framework for clinical evaluation of vertebral mechanical behavior.
15. **Luan, S.**, Chen, E., & Gaitanaros, S. Evaluation of anisotropic fracture toughness and flaw sensitivities on brittle lattice metamaterials.
16. **Luan, S.**, Guest, J. K., & Gaitanaros, S. Foreseeing shock dynamic properties of architected metamaterials from quasi-static responses.
17. Kang, J., Cui, Y., **Luan, S.**, & Jiao, Q. Fracture of additively manufactured 316L stainless steel micro lattice by laser powder bed fusion.
18. Xiao, Y., Wright, L. G., & **Luan, S.** Inverse design of nonlinear mechanical porous media by deep learning.
19. **Luan, S.**, Xiao, Y., Du, H., & Morgan, E. F. Deep generative reconstruction of bone microarchitecture in computed tomography.
20. **Luan, S.**, & Morgan, E. F. A crisis in the bone fracture risk assessment. (Invited editorial by Journal of Bone and Mineral Research)

(* representing the corresponding authorship)

Talks and Presentations

Invited talks:

1. "Mechanics of architected materials: from engineered metamaterials to natural human bone", *Department of Civil & Environmental Engineering, University of Illinois Urbana-Champaign*, Champaign, IL, May 2024.
2. "Nonlinear mechanics of architected metamaterials", *Department of Mechanical Engineering, Boston University*, Boston, MA, May 2023.

Conference presentations (selected):

3. "A data-driven multiscale modeling for clinical evaluation of vertebral performance", *20th U.S. National Congress on Theoretical and Applied Mechanics*, Pasadena, CA, June 2026. (Upcoming)
4. "Data-driven multiscale modeling for vertebral trabecular elasticity", *Orthopaedic Research Society 2026 Annual Meeting*, Charlotte, NC, March 2026. (Upcoming)
5. "A data-driven framework for modulus-density relationship of human lumbar vertebral body", *Orthopaedic Research Society 2025 Annual Meeting*, Phoenix, AZ, February 2025.
6. "A data-driven framework for modulus-density relationship of lumbar vertebral body", *Engineering Mechanics Institute Conference and Probabilistic Mechanics & Reliability Conference*, Chicago, IL, May 2024.
7. "A data-driven framework for structure-property correlation in ordered and disordered cellular metamaterials", *Mach Conference*, Towson, MD, April 2023.
8. "Data-based techniques for structure-property correlation in periodic and aperiodic metamaterials", *10th International Conference on Multiscale Materials Modeling*, Baltimore, MD, October 2022.
9. "Data-based techniques for structure-property correlation in periodic and aperiodic metamaterials", *19th U.S. National Congress on Theoretical and Applied Mechanics*, Austin, TX, June 2022.
10. "Microscopic and macroscopic instabilities in elastomeric foams", *19th U.S. National Congress on Theoretical and Applied Mechanics*, Austin, TX, June 2022.
11. "Data-based techniques for structure-property correlation in periodic and aperiodic metamaterials", *Engineering Mechanics Institute Conference*, Baltimore, MD, June 2022.
12. "Energy-based fracture mechanics of 2D lattices", *International Mechanical Engineering Congress & Exposition*, Virtual, November 2021.
13. "Strength of additively manufactured foams with uniform and gradient densities", *International Mechanical Engineering Congress & Exposition*, Virtual, November 2021.
14. "Energy-based fracture mechanics of lattice materials", *25th International Congress on Theoretical and Applied Mechanics*, Virtual, August 2021.
15. "Microscopic and macroscopic instabilities in polymeric foams", *International Mechanical Engineering Congress & Exposition*, Virtual, November 2020.

Teaching Experience

- **ENGBE 500 Introduction to Biological Feedback Control**
 - Boston University – Spring 2025

Instructor: bioinspired robotics, microbial population dynamics, and development patterning.

- **EN.560.255 Dynamical Systems**

- Johns Hopkins University – Spring 2023

Guest Lecturer: numerical techniques for one-dimensional ordinary differential equations.

- Johns Hopkins University – Spring 2022

Guest Lecturer: vibrations, oscillations, and time responses for dynamical systems.

- **EN.560.211 Statics and Mechanics of Materials**

- Johns Hopkins University – Fall 2019

Teaching Assistant: in-class guidance of exercises, office hours, and homework grading.

- **EN.560.604 Introduction to Solid Mechanics**

- Johns Hopkins University – Fall 2019

Teaching Assistant: in-class guidance of exercises, office hours, and homework grading.

- **EN.560.762 Mechanics of Architected Materials**

- Johns Hopkins University – Spring 2019

Guest Lecturer: numerical modeling of instabilities on architected materials.

- **EN.560.202 Dynamics**

- Johns Hopkins University – Spring 2018

Laboratory Instructor: structural dynamic experiments.

Mentoring Experience

- **Veronica Caruso** – Ph.D. Candidate

- Boston University, September 2024 – present

Project: Effect of disc degeneration on vertebral fracture

- **Benjamin Olowu** – Ph.D. Candidate

- Boston University, August 2023 – present

Project: Mechanical testing of cadaveric femurs

- **Yingjiang Tang** – Ph.D. Candidate

- Johns Hopkins University, September 2022 – July 2023

Project: Progression of instabilities in tubular architected materials

- **Sangchu Quan** – M.S. Student

- Johns Hopkins University, September 2020 – May 2022

Project: Brittle failure of 3D-printed polymer

Current Position: Ph.D. candidate at Imperial College London

- **Joel John** – M.S. Student

- Johns Hopkins University, September 2020 – May 2021

Project: Virtual generation of architected metamaterials

- **Enze Chen** – Ph.D. Candidate

- Johns Hopkins University, September 2018 – July 2023

Project: Brittle failure of cellular metamaterials

Current Position: Postdoctoral fellow at University of Wisconsin-Madison

Grants and Proposals

- K99/R00: Real-time, high-fidelity, patient-specific estimation of vertebral fracture. (Under review)
 - Sponsor: National Institutes of Health (NIAMS)
 - Role: Principal Investigator
 - Dates: 2026 – 2030

Awards and Honors

- Joseph Meyerhoff Fellowship, Johns Hopkins University, 2017

Open-Source Software

- Verification and validation of digital image/volume correlation on biomedical imaging. [[GitHub](#)]
- A data-driven framework for structure-property correlation in ordered and disordered cellular metamaterials. [[GitHub](#)]

Media

- Material structure's surprising role in impact protection: less critical than we thought? – *Johns Hopkins University Department of Civil and Systems Engineering Research News*, November 2024.

Professional Services

Leadership:

- Chair, U.S. Association for Computational Mechanics, Boston University Local Student Chapter

Membership:

- Orthopaedic Research Society
- U.S. Association for Computational Mechanics
- American Society of Civil Engineers
- American Society of Mechanical Engineers
- Engineering Mechanics Institute

Review activities:

- Nature Communications
- International Journal of Solids and Structures
- International Journal of Mechanical Sciences
- Theoretical and Applied Fracture Mechanics

Conference services:

- Reviewer, Orthopaedic Research Society 2026 Annual Meeting
- Moderator, Orthopaedic Research Society 2026 Annual Meeting
- Symposium Organizer, 20th U.S. National Congress on Theoretical and Applied Mechanics
- Volunteer, Engineering Mechanics Institute Conference (2022)

Professional Reference

- **Stavros Gaitanaros**
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- **Elise F. Morgan**
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Department of Mechanical Engineering
Department of Biomedical Engineering
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Director, Micro-Computed Tomography Imaging Core Facility
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- **Paul E. Barbone**
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