Shima Jalalian

Computational Brain Biomechanics | Multiphysics Modeling | Patient-Specific Simulation | Soft Tissue Mechanics
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Education

Ph.D. Mechanical Engineering (Biomechanics) - *Stevens Institute of Technology* 2019 - 2025
Dissertation: Multiphysics Modeling of Alzheimer's Disease

M.Sc. Biomedical Engineering (Biomechanics) - *University of Tehran* 2015 - 2018
Thesis: Computational Modeling of the Cervix to Understand Mechanical Causes of Preterm Birth

B.Sc. Mechanical Engineering - *Ferdowsi University* 2010 - 2015

Skills

Programming & Data Analysis:	Python (SciPy, Pandas, Seaborn, Matplotlib), MATLAB, R, Shell scripting
Computational Modeling:	Abaqus (Python scripting, UMAT, CEL), FEBio, COMSOL, ANSYS
Numerical Methods & Mechanics:	Nonlinear continuum mechanics, Constitutive material modeling, Large deformation analysis, Damage and failure modeling, Multiphysics coupling
Image Analysis & Meshing:	MRI/DTI processing, image registration, image-based mesh generation FreeSurfer, MRtrix, Mimics, Simpleware, HyperMesh, Gmsh, ParaView

Research Experience

Postdoctoral Research Fellow, *Thomas Jefferson University, Dept. of Neurosurgery* 2025-present
Visiting Scholar, *Villanova University, Dept. of Mechanical Engineering*

- Developed a **coupled Eulerian–Lagrangian (CEL) framework** in Abaqus to investigate the mechanics of DBS probe insertion (indentation, puncture, and trajectory deviation) in agar brain-tissue phantoms.
- Implemented MRE-informed **hyperelastic** and **viscoelastic** constitutive models of agar gel from experimental data and incorporated a **ductile damage model** to capture tissue puncture and failure during probe insertion.
- Designed and executed **simulation-experiment validation workflows**, comparing reaction force and deformation behavior across multiple insertion speeds and material conditions.
- Collaborated with neurosurgeons in the operating room, assisting with **sensor setup** and intraoperative **data acquisition** during **DBS procedures**, enabling integration of experimental and computational datasets.

Graduate Research Assistant, *Weickenmeier Lab - Stevens Institute of Technology* 2019 - 2025

- Developed a **multiphysics simulation framework** using **Abaqus UMAT** and Python-based ODE solvers to couple toxic protein **diffusion** with a **nonlinear constitutive material model** of **tissue atrophy**, enabling prediction of Alzheimer's disease progression patterns for early diagnosis and intervention.
- Built an **automated analysis pipeline** processing 100+ Human Connectome Project participants and extracted and analyzed **MRI/DTI** data to build an anatomically accurate **discrete model** of the **network-based diffusion.**
- Developed automated Python-based post-processing tools to extract **morphometry** and mechanical markers from large-scale mesh data, enabling reproducible parametric studies across hundreds of simulations and revealing **region**- and **time-specific** degeneration patterns.

Graduate Research Assistant, *University of Tehran* 2015 - 2018

- Developed **finite element models** of **biodegradable stents** under **physiological loading** to assess stress distribution, restenosis risk, and deployment mechanics.
- Created **patient-specific computational models** to explore the **biomechanics of premature birth**, correlating **uterine wall stress** with clinical outcomes.

Teaching and Mentorship Experience

Research Advisor & Teaching Assistant, *Stevens Institute of Technology* 2019 - 2025

- **Trained and mentored 15+ undergraduate and graduate students** in FEA, scripting, and scientific visualization, with mentees achieving two consecutive first-place departmental research awards.
- **Supported 5+ new doctoral students** through structured outreach and individualized guidance.
- **Led weekly problem-solving sessions** as Teaching Assistant for *Advanced Mechanics of Solids*.
- **Designed and delivered Python-based coding workshops** for *Biomechanics of the Brain*.

Research Advisor, *University of Tehran* 2015 - 2018

- **Mentored students** in **biomechanics** and **simulation methods**, focusing on **FEBio** for **soft tissue finite element analysis.**
- Delivered **hands-on training sessions** on **MRI segmentation**, **mesh generation**, and **patient-specific modeling** workflows for research applications.

Journal Publications

- **Jalalian, S.**, et al., "A Coupled Eulerian–Lagrangian Framework for Modeling Deep Brain Stimulation Probe Insertion in MRE-Characterized Brain Tissue Phantoms", in preparation 2026
- **Jalalian, S.** & Weickenmeier, J., "Alzheimer's Disease Accelerates Cerebral Atrophy by Over a Decade Compared to Healthy Aging", *Annals of Biomedical Engineering, Mar 24:1-22* 2026
- Blinkouskaya, Y., Cacoilo, A., Gollamudi, T., **Jalalian, S.**, & Weickenmeier, J. "Brain aging mechanisms with mechanical manifestations" *Mechanisms of Ageing and Development*, *200*, 111575 2021
- **Jalalian, S.** & Vahidi, B. "A Patient-Specific Study to Investigate Mechanical Functions of the Uterus and Cervix on Preterm Birth in a Pregnant Woman" *Studies in Medical Sciences* 2020

Select Conference Presentations

- **Jalalian, S.** & Weickenmeier, J., "Exploring the multiphysics of the brain during aging, and in neurological diseases", Contributed talk, *SIAM-NNP* 2023
- **Jalalian, S.** & Weickenmeier, J., "Network-Based Modeling of Alzheimer's Disease: Assessing Impact of Connectome Measures on Progression Patterns", Podium Presentation, *SB3C* 2022
- **Jalalian, S.** & Weickenmeier, J., "Protein Spreading Patterns in Alzheimer's Disease: Exploring the Difference Between a Connectivity-based and Proximity-based Connectome Model", Podium Presentation, *SB3C* 2021

Professional Activities

Peer Review

- Manuscript Reviewer, *Journal of Biomechanics* 2024
- Manuscript Reviewer, *PeerJ* 2023
- Abstract Reviewer, *ISME 27th Annual Conference* 2019

References

- Dr. Johannes Weickenmeier, Associate Professor, University of Oxford, johannes.weickenmeier@eng.ox.ac.uk
- Dr. Robert Chang, Associate Professor, Stevens Institute of Technology, rchang6@stevens.edu
- Dr. Mehmet Kurt, Associate Professor, University of Washington, mkurt@uw.edu