Fatemeh Pourahmadian

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Education

2016 Postdoc., Civil Engineering/Geomechanics, University of Minnesota, Twin Cities

2016 Ph.D., Civil Engineering/Geomechanics, University of Minnesota, Twin Cities

2015 M.S., Geo-Engineering, University of Minnesota, Twin Cities

2010 M.S., Mechanical Engineering, Iran University of Science and Technology, Tehran

Research and Professional Experience

Department of Civil, Environmental & Architectural Engineering, University of Colorado Boulder

2017– Assistant Professor

keywords: multiscale and multiphysics remote sensing, laser-enabled in-situ diagnostics, dynamics of material interfaces, multifunctional metamaterials for wave guiding, deep learning approaches to inverse scattering and systematic material design

Department of Applied Mathematics, University of Colorado Boulder

2019– Affiliated Faculty

keywords: physics-based data analytics germane to uncertain or unknown environments, dynamic multiscale homogenization, inverse problems, asymptotic analysis, deep learning

Department of Civil, Environmental & Geo- Engineering, University of Minnesota, Twin Cities

2016–2017 Postdoctoral Research Associate

2011–2016 Research Assistant

keywords: holistic approaches to waveform tomography and characterization of fractures, high-frequency inverse scattering, 3D acoustic and elastic wave propagation in fractured media

Department of Mechanical Engineering, Iran University of Science and Technology, Tehran
Experimental Modal Analysis Laboratory

2010–2011 Research Associate

2008–2010 Research Assistant

keywords: inverse problems in nonlinear dynamics, mechanics of frictional contacts, nonlinear normal modes and their application to signal processing and system identification

Journal Publications

⋆ highlights students advised and † highlights postdocs advised

J18. Xu Y⋆, Pourahmadian F, Song J⋆, Wang C⋆ (2023). "Deep learning for full-field ultrasonic characterization", *Journal of Mechanical Systems and Signal Processing*, under review.

J17. Narumanchi V V*, Pourahmadian F, Lum J, Townsend A, Tringe J W, Stobbe D M, Murray T W (2023). "Laser ultrasonic imaging of subsurface defects with the linear sampling method", *Optics Express*, under review.

J16. Liu X, Song J*, Pourahmadian F, Haddar H (2023). "Time- vs. frequency- domain inverse elastic scattering: Theory and experiment", *SIAM Journal on Applied Mathematics*, accepted for publication (02/01/23).

J15. Pourahmadian F, Haddar H (2023). "Ultrasonic imaging in highly heterogeneous backgrounds", *Proceedings of the Royal Society A*, accepted for publication (01/27/23).

J14. Pourahmadian F, Napal K† (2022). "Poroelastic near-field inverse scattering", *Journal of Computational Physics*, **455**, 111005.

J13. Pourahmadian F, Yue H* (2021). "Laboratory application of sampling approaches to inverse scattering", *Inverse Problems*, **37**, 055012.

J12. Pourahmadian F (2021). "Experimental validation of differential evolution indicators for ultrasonic imaging in unknown backgrounds", *Journal of Mechanical Systems and Signal Processing*, **161**, 108029.

J11. Pourahmadian F, Haddar H (2020). "Differential tomography of micromechanical evolution in elastic materials of unknown micro/macrostructure", *SIAM Journal on Imaging Sciences*, **13**(3), 1302−1330.

J10. De Teresa I, Pourahmadian F (2018). "Real-time imaging of interfacial damage in heterogeneous composites", *SIAM Journal on Applied Mathematics*, **78**(5), 763−2790.

J9. Pourahmadian F, Guzina BB (2018). "On the elastic anatomy of fractures in rock', *International Journal of Rock Mechanics and Mining Sciences*, **106**, 259−268.

J8. Pourahmadian F, Guzina BB, Haddar, H (2017). "A synoptic approach to the seismic sensing of heterogeneous fractures: from geometric reconstruction to interfacial characterization", *Computer Methods in Applied Mechanics and Engineering*, **324**, 395−412.

J7. Pourahmadian F, Guzina BB, Haddar, H (2017). "Generalized linear sampling method for elastic-wave sensing of heterogeneous fractures", *Inverse Problems*, **33**, 055007 (33pp).

J6. Pourahmadian F, Guzina BB (2015). "On the elastic-wave imaging and characterization of fractures with specific stiffness", *International Journal of Solids and Structures*, **71**, 126−140.

J5. Guzina BB, Pourahmadian F (2015). "Why the high-frequency inverse scattering by topological sensitivity may work", *Proceedings of the Royal Society A*, **471**, 20150187 (28pp).

J4. Pourahmadian F, Mogilevskaya SG (2015). "Complex variables-based approach for analytical evaluation of boundary integral representations of three-dimensional acoustic scattering", *Engineering Analysis with Boundary Elements*, **53**, 9−17.

J3. Pourahmadian F, Ahmadian H, Jalali H (2012). "Modeling and identification of frictional forces at a contact interface experiencing vibro-impacts", *Journal of Sound and Vibration*, **331**, 2874−2886.

J2. Jalali H, Ahmadian H, Pourahmadian F (2011). "Identification of micro-vibro-impacts at the boundary condition of a nonlinear beam", *Journal of Mechanical Systems and Signal Processing*, **25**, 1073−1085.

J1. Ahmadian H, Jalali H, Pourahmadian F (2010). "Nonlinear model identification of a frictional contact support", *Journal of Mechanical Systems and Signal Processing*, **24**, 2844−2854.

Journal Publications In Preparation

J23. Xu Y*, Pourahmadian F (2023). “Multiscale poro-elastography via deep learning”.

J22. Schmid A*, Pourahmadian F, Doostan A (2023). “Bayesian data driven modelling”.

J21. Narumanchi V V*, Song J*, Wang C*, Pourahmadian F, Murray T (2023). “Laser ultrasonic imaging via multiplexed excitation”.

J20. Francis N M*, Pourahmadian F, Lebensohn R, Dingreville R (2023). “A fast-Fourier transform solver for micropolar composites”.

J19. Song J*, Xu Y*, Narumanchi V V*, Pourahmadian F, Murray T (2023). “Deep learning for laser ultrasonic imaging”.

Technical Presentations

TP23. Song J*, Liu X, Pourahmadian F, Haddar H (2022). “Time-domain linear sampling method for in-situ ultrasonic imaging”, *Engineering Mechanics Institute Conference*, Johns Hopkins University, Baltimore, MD. **Jian won the best student paper award from the EMI Elasticity Committee.*

TP22. Xu Y, Pourahmadian F (2022). “Deep learning tools for ultrasonic elastography”, *Engineering Mechanics Institute Conference*, Johns Hopkins University, Baltimore, MD.

TP21. Pourahmadian F, Song J, Liu X, Haddar H (2022). “Time- vs. frequency- domain ultrasonic tomography”, *7th Annual Meeting of SIAM-CSS*, Oklahoma State University, OK.

TP20. Pourahmadian F (2021). “Recent progress on inverse scattering in highly heterogeneous solids”, *6th Annual Meeting of SIAM-CSS*, University of Kansas, KS.

TP19. Pourahmadian F, Yue H (2021). “Experimental validation of differential evolution indicators”, *Engineering Mechanics Institute Conference*, Virtual.

TP18. Pourahmadian F (2021). “Data-driven characterization of micromechanical evolution in highly scattering solids”, *14th World Congress on Computational Mechanics (WCCM XIV) and 8th European Congress on Computational Methods in Applied Science and Engineering (ECCOMAS 2020)*, Virtual.

TP17. Napal K, Pourahmadian F (2020). “Detection and quantification of small cracks aggregates using artificial backgrounds”, *Society of Engineering Science Conference*, Virtual.

TP16. Pourahmadian F (2020). “Sampling-based approaches to laser ultrasonics”, *Society of Engineering Science Conference*, Virtual.

TP15. Pourahmadian F (2019). “Imaging in highly scattering composites”, *Review of Progress in Quantitative Nondestructive Evaluation*, Portland, OR.

TP14. Shakeri R, Pourahmadian F (2019). “poroelastic imaging of hydraulic fractures”, poster presentation, *Engineering Mechanics Institute Conference*, Caltech, CA; and *2019 Hilf Lecture*, Boulder, CO.

TP13. Pourahmadian F, Yue H (2019). “Differential imaging of evolution in elastic backgrounds with unknown microstructure”, *Engineering Mechanics Institute Conference*, Caltech, CA.

TP12. Pourahmadian F (2018). “Real-time imaging of microstructural damage in complex composites”, *International Mechanical Engineering Congress & Exposition*, Pittsburgh, PA.

TP11. Pourahmadian F (2018). “Real-time waveform tomography of damage precursors in complex composites”, *Review of Progress in Quantitative Nondestructive Evaluation*, Burlington, VT.

TP10. Pourahmadian F (2018). "3D seismic waveform tomography of subsurface fractures", *GRSG Oil and Gas Remote Sensing Workshop*, Boulder, CO.

TP9. Pourahmadian F (2017). "Active monitoring of fracturing in quasi-brittle solids: an experimental study", *Engineering Mechanics Institute Conference*, UC San Diego, CA.

TP8. Pourahmadian F, Guzina B B (2016). "Active Elastic-Wave Imaging of Heterogeneous Fractures: From Geometric Reconstruction to Interfacial Characterization", *Engineering Mechanics Institute Conference*, Vanderbilt University, Nashville.

TP7. Pourahmadian F, Guzina B B (2015). "A hybrid approach to active seismic imaging of fractures: geometric reconstruction & interface characterization", *International Mechanical Engineering Congress and Exposition*, Houston.

TP6. Pourahmadian F, Tokmashev R D, Risch P A, Guzina B B (2015). "Imaging and Characterization of Fracture Interface: An Experimental Study", *Review of Progress in Quantitative Nondestructive Evaluation*, Minneapolis, MN.

TP5. Pourahmadian F, Guzina B B (2015). "Simultaneous recovery of fracture geometry and boundary condition at high frequencies", *Engineering Mechanics Institute Conference*, Stanford University, CA.

TP4. Pourahmadian F, Tokmashev R D, Guzina B B (2015). "On the Elastic-wave Imaging and Interfacial Characterization of Heterogeneous Fractures", *IMA Hot Topics Workshop "hydraulic fracturing: from modeling and simulation to reconstruction and characterization"*, Institute of Mathematics and its Applications (IMA), Minneapolis, MN.

TP3. Guzina B B, Pourahmadian F (2014). "Why the obstacle reconstruction by topological sensitivity may work", *11th World Congress on Computational Mechanics (WCCM XI)*, Barcelona, Spain.

TP2. Pourahmadian F, Guzina B B (2013). "Why the shape reconstruction by topological sensitivity may work", *International Conference on Novel Directions in Inverse Scattering*, University of Delaware, DE.

TP1. Pourahmadian F, Guzina B B (2013). "Qualitative identification of the interfacial condition in cracks via the method of topological sensitivity", *Society of Engineering Science 50th Annual Technical Meeting*, Brown University, RI.

Refereed Conference Papers

CP5. Pourahmadian F, Guzina B B, Haddar H (2017). "Generalized linear sampling method for active imaging of subsurface fractures", *WAVES 2017*, Minneapolis, MN.

CP4. Pourahmadian F (2017). "Real-time monitoring of heterogeneous fractures in rock: an experimental study", *51th US Rock Mechanics/Geomechanics Symposium*, San Francisco, CA.

CP3. Pourahmadian F, Guzina B B (2016). "Active ultrasonic imaging and interfacial characterization of stationary and evolving fractures in rock", *50th US Rock Mechanics/Geomechanics Symposium*, Houston, Texas.

CP2. Pourahmadian F, Ahmadian H, Jalali H (2010). "Identifying slip-slap forces in the contact interface using dual-mode excitation", *International Conference on Noise and Vibration Engineering*, Leuven, Belgium, pp 1235-1244.

CP1. Pourahmadian F, Jalali H, Ahmadian H (2010). "Identifying normal modes of a nonlinear system", *10th International Conference on Recent Advances in Structural Dynamics*, Southampton, UK.

Invited Talks

I8. Pourahmadian F (2019). "Recent advances on imaging in complex media", *Inverse Problems Seminar, Department of Mathematics*, Colorado State University, CO.

I7. Pourahmadian F (2019). "Waveform tomography in uncertain/unknown media", *SIAM annual meeting on recent progress in wave phenomena*, Laramie, WY.

I6. Pourahmadian F (2018). "Differential imaging of evolution in elastic backgrounds with unknown microstructuree", *Colloquium, Applied Mathematics Department*, University of Colorado Boulder, CO.

I5. Pourahmadian F (2017). "High-frequency inverse scattering by Topological Sensitivity", *Nonlinear Waves Seminar, Applied Mathematics Department*, University of Colorado Boulder, CO.

I4. Pourahmadian F (2017). "Sounding of heterogeneous fractures in the subsurface", *Nonlinear Waves Seminar, Applied Mathematics Department*, University of Colorado Boulder, CO.

I3. Pourahmadian F (2016). "Sounding of Heterogeneous Fractures in Geomaterials", *CEE Seminar*, Duke University, Durham, NC.

I2. Pourahmadian F, Guzina B B, Haddar H (2015). "Active seismic imaging & characterization of fractures", *CEGE Seminar*, University of Minnesota, Minneapolis, MN.

I1. Guzina B B, Pourahmadian F (2013). "Why the shape reconstruction by topological derivative may work", *CEGE Seminar*, University of Minnesota, Minneapolis, MN.

Funded proposals

As PI:

- Hierarchical design of metamaterials architectures for mechanical barriers via generalized homogenization and physics-informed neural networks, *SNL-CEAS Research Partnership*, CU-Boulder PI: Pourahmadian, SNL-PI: Remi Dingreville, $125,000 (01/10/2022-09/30/2023*) **A one-year extension of the project period is underway*

- Real-time In-situ Characterization of Evolving Rock Systems for Smart-controlled Subsurface Engineering: A Holistic Multiscale & Multiphysics Solution, *NSF CAREER*, PI: Pourahmadian, $500,000 (06/01/2020-05/31/2025)

- Data-driven Engineering Science Seminars, *CEAS Interdisciplinary Seminars* (funds matched by the departments), Co-organizers: Pourahmadian (CEAE/lead), Doostan (AES), Becker (APPM), Brown (CS), Murray (ME), Piestun (ECEE) $11,000 (01/10/2022-)

- Differential Tomography of Evolution in Uncertain/Unknown Environments, *CU-Boulder IS-IRT Seed Grants*, PI: Pourahmadian, Collaborator: Appelo, $20,000 (02/21/2019-12/30/2019)

- Real-Time Imaging and Characterization in Complex Composites, *CU-Boulder IS-IRT Seed Grants*, PI: Pourahmadian, Collaborator: Regueiro, $30,000 (02/21/2018-12/30/2018)

- Imaging Science Seminar Grant, CU-Boulder IS-IRT, PI: Pourahmadian, $5,000 (2018-2020)

As Senior Person:

- Center for micromorphic multiphysics porous and particulate materials simulations within exascale computing workflows, *PSAAP III*, PI: R. Regueiro, Co-PIs: J. Brown, A. Clarke, A. Doostan, H. Tufo, Institutions: University of Colorado Boulder, Colorado School Mines, Columbia University, Stanford University, U of Tennessee, Knoxville, University of Texas Dallas, Pourahmadian's share $337,500 (06/01/20-05/31/25)

This project supports one PhD student (Abby Schmid) in my group to develop a laser-enabled in-situ diagnostic framework for multiscale verification & validation of the proposed exascale computational platform.

- Numerical Methods for Wave Equations in Time and Frequency Domain, *NSF DMS*, PI: Daniel Appelo, $303,373 (06/15/2019-05/31/2022)

Selected declined proposals

As PI:

- A holistic approach to elastic-wave cloaking, *CU-Boulder Seed Grants*, PI: Pourahmadian, $50,000 (02/15/19-12/31/20)
- Real-time Remote Sensing of Treatment-Induced Hydraulic fractures in Unconventional Oil and Gas Reservoirs, *DOE DE-FOA-0001990*, PI: Pourahmadian, Co-PIs: Brice Lecampion, Smaine Zeroug, Rich Regueiro, $1,064,718 (9/1/19-8/31/22)
- General Scientific Infrastructure: 3D Scanning Laser Vibrometer for high-fidelity in-situ characterization and prognosis of irradiated structural materials, *DOE-NEUP*, PI: Pourahmadian, $550,000 (06/01/19-06/01/20)
- Differential imaging of evolution in highly heterogeneous composites with unknown micro/macrostructure, *NSF DCSD*, PI: Fatemeh Pourahmadian, Co-PI: Todd Murray, $355,462 (10/1/19-9/30/22)

As Senior Person:

- NRT: Focusing Waves on Information, Safety, and Health (WISH), *NSF NRT*, PI: Todd Murray, Rafael Piestun, Stephen Becker, Carol Cogswell, $3,000,000 (9/1/2019-8/31/2024)

Scholarships & Fellowships

- Sommerfeld Fellowship (2011-2012)
  Civil, Environmental & Geo- Engineering Department
  University of Minnesota
- Daneshy Fellowship (Fall 2014, Fall 2015)
  Civil, Environmental & Geo- Engineering Department
  University of Minnesota

Teaching

- CVEN 5151: Wave Propagation & Imaging Methods for Design and Characterization of Advanced Materials (Spring 2017, 2019, 2021, 2023)
- CVEN 5111: Structural Dynamics (Fall 2018, 2019, 2020, 2021, 2022)
- CVEN 3111: Analytical Mechanics II: Dynamics (Spring 2022 2023)
- CVEN 3718: Geotechnical Engineering II (Fall 2017, Spring 2019, 2020, 2021)

Advising

- **PhD Students:**
  - Jian Song (Fall 2020$-$)
  - Yang Xu (Spring 2021$-$)
  - Vyjayanthi Narumanchi (Fall 2021$-$); with primary advisor Todd Murray of ME
  - Noah Francis (Fall 2021$-$); co-advised with Remi Dingreville of SNL
  - Abby Schmid (Fall 2021$-$); co-advised with Alireza Doostan of AES

- **MSc Students:**
  - Aaron Hoekstra (Spring 2023–)
- **Undergraduate Researchers:**
  - Conglin Wang (Fall 2021–)
- **Past postdocs:**
  - Kevish Napal (2019–2021), now in the Mechanical Engineering Dept at the University of Sheffield, UK
  - Peter Kirkwood (2017–2018), next at Tonkin and Taylor, New Zealand
  - David Stobbe (Feb 2018–Dec 2018), now at Lawrence Livermore National Laboratory
- **Past MSc students:**
  - Hao Yue (2019–2020), now in the Biomedical Engineering Dept at the City University of Hong Kong
  - Greg Maris (2017–2018), now at at Knight Piesold, CO
- **Past undergraduate Researchers:**
  - Emily Szabo (Fall 2021–Fall 2022)
  - Jian Song (Fall 2019–Fall 2020)
  - Hao Yue (Fall 2017–Fall 2019)

Service

- Vice-chair of the *Elasticity Committee* in the Engineering Mechanics Institute (EMI), Fall 2019-
- Member of the *EMI Machine Learning In Mechanics Committee*, Fall 2021-
- Member of the *EMI Dynamics Committee*, Fall 2021-
- Member of the *EMI Properties of Materials Committee*, Fall 2021-
- Co-organizer of the *Data-driven Engineering Science Seminars*, College of Engineering & Applied Science, University of Colorado Boulder, 2021-
- Organizer of the *Imaging Science Seminar Series*, College of Engineering & Applied Science, University of Colorado Boulder, 2018-20
- Coordinator of the CEAE *Engineering Science Program*, University of Colorado Boulder, Fall 2021-
- Member of:
  – CEAE Department Undergraduate Pathways Committee, Spring 2022-
  – CEAE Department Graduate R&A Committee, AY 2021-
  – CEAE Department Computer Committee, AY 2018-
  – CEAE Department Curriculum Committee, AY 2017-18
  – CEAS Imaging Science Search Committee, AY 2018-19
- Mentor in the NSF S-STEM Program, advising:
  – Claudia Acosta-Pina
  – Michelle Amankwah
  – Erika Antunez
- Thesis committee member:
  – Rosa Morales (ME)
  – Enrique Chon (Geophysics)
  – John Nardini (APPM)
  – Clemence Bacquet (AES)
  – Jackson Bell (Geophysics)

- Reviewer for:
  - NSF ECI
  - NSF MOMS
  - CU Boulder's Innovative Seed Grant
  - CU Boulder's AB Nexus
  - CU Boulder's UROP Grant

- Co-chair of mini-symposium on:
  - digital twins, *45th Annual Review of Progress in Quantitative Nondestructive Evaluation*, Burlington, VT, July 2018 (with Steve Holland, Iowa State University)
  - novel methods in imaging and multiscale characterization of damage in complex materials, *Engineering Mechanics Institute Conference*, Caltech, CA, June 2019 (with Dianne Ezell, Oak Ridge National Laboratory)
  - physics-based data analytics for characterization of natural and architected systems, *Society of Engineering Science Conference*, Minneapolis, MN, October 2021 (with Bojan Guzina, University of Minnesota); postponed due to COVID
  - data-driven approaches to engineering mechanics, *Engineering Mechanics Institute Conference*, Johns Hopkins University, MD, June 2022 (with Jeong-Hoon Song)

- Referee for:
  - Proceedings of the Royal Society A
  - SIAM Journal on Applied Mathematics
  - Geophysics
  - Materials Evaluation
  - IMA Volumes in Mathematics and its Applications
  - Journal of Applied Physics & Nanotechnology
  - Journal of Mechanical Systems & Signal Processing
  - Journal of Inverse Problems in Science & Engineering
  - Ultrasonics
  - Journal of Engineering Mechanics
  - ASME Journal of Computing and Information Science in Engineering
  - ASME Journal of Vibration and Acoustics
  - International Journal of Mechanics and Materials in Design
  - International Journal of Rock Mechanics and Mining Sciences

- Member of:
  - Society of Engineering Science (SES)
  - Society for Industrial and Applied Mathematics (SIAM)
  - American Mathematical Society (AMS)
  - Engineering Mechanics Institute (EMI)
  - American Society of Mechanical Engineers (ASME)
  - American Rock Mechanics Association (ARMA)