

# Zeliang Liu

## Education

- 2012.8– **PH.D. Northwestern University, Evanston, Illinois, USA.**  
2017.12 Theoretical and Applied Mechanics  
Dissertation: *Reduced-order homogenization of heterogeneous material systems: from viscoelasticity to nonlinear elasto-plastic softening material.*  
Advisor: Wing Kam Liu. GPA: 3.98 out of 4.0
- 2008.9– **B.E. Tsinghua University, Beijing, China.**  
2012.6 Micro-Electro-Mechanical System (MEMS) Engineering (with honors)  
Dissertation: *Single-cell capture and in situ impedance measurement on an integrated microfluidic devices.*  
Advisor: Rong Zhu. GPA: 93 out of 100

## Professional Experience

- 2018.10– **Senior Research Scientist.**  
present Livermore Software Technology and Corporation, Livermore, California, USA
- 2017.10– **Research Scientist.**  
2018.10 Livermore Software Technology and Corporation, Livermore, California, USA

## Research Projects

- 2018–present **Deep material network: machine learning in multiscale continuum mechanics.**
- Proposed a material network structure with mechanistic building block
  - Developed machine learning algorithms based on SGD and novel network compression techniques for efficient training of material networks.
  - Developed a novel format of microstructural database targeted for history-dependent material nonlinearity and large deformations
- 2015–present **Data-driven framework for predictive materials science and failure analysis.**
- Developed self-consistent clustering analysis (SCA), a data-driven homogenization method for structure/property relation based on mean-field theories and data-clustering techniques.
  - Presented a novel stabilized homogenization framework for multiscale failure analysis.
  - Applied kriging and neural network (NN) techniques for reduced-order constitutive modeling of hyperelastic polymer composite.
- 2015–present **Deriving process-structure-property relationships in additive manufacturing.**
- Developed crystal plasticity based self-consistent clustering method for fast performance prediction of 3D-printed metals.
  - Developed a FEM-based thermal model to simulate the deposition process.
  - Prediction of material behavior for LENS manufactured products using GTN model.

- 2016–2018 **ICME development of carbon fiber reinforced composites for lightweight vehicles.**
- Established a multiscale concurrent simulation platform based on SCA method carbon fiber reinforced polymer composite.
  - Implemented user-defined material subroutines to compute mechanical responses "on the fly" from microstructural material database.
  - Developed a parallelized algorithm for nonlocal regularization of material damage models.
- 2012–2015 **Bridgestone and Goodyear projects on polymer viscoelasticity design.**
- Implemented a Fast Fourier Transform-based method for efficient homogenization of polymer nanocomposite from 3D TEM image.
  - Hierarchy modeling of polymer/fill nanocomposite based on coarse grained molecular dynamics and analytical micromechanics method.
  - Proposed a robust inverse modeling procedure of fast extracting local interphase properties from experimental DMA data.
- 2010–2012 **Research on Biological Micro-Electro-Mechanical System (MEMS).**
- Designed a new photolithographic fabrication processes of a MEMS device for single-cell capturing and impedance measurement.
  - Launched a LabVIEW-based platform for single-cell positioning and impedance measuring.
  - Elucidated the physics of positioning mechanism via high-fidelity electromagnetic simulations.

## Teaching Experience

### As Instructor

- June 2020 **Machine Learning Data-Driven Discretization Theories, Modeling and Applications**, Short course to offer at 14th World Congress in Computational Mechancis.
- July 2019 **Machine Learning Data-Driven Discretization Theories, Modeling and Applications**, Short course at 15th U.S. National Congress on Computational Mechanics, with Prof. W.K. Liu, Prof. George Karniadakis and Dr. C.T. Wu.
- July 2018 **Mechanistic Data-driven Multiscale Analysis and Applications**, Short course at 13th World Congress in Computational Mechancis, with Prof. W.K. Liu and Dr. C.T. Wu.

### As Student Instructor

- Fall 2015 **Multi-scale Modeling and Simulation in Solid Mechanics (ME417)**, Undergraduate level course in Mechanical and Civil Engineering at Northwestern. Taught 2 weeks of the total 10 weeks, supervised by Prof. Wing Kam Liu.
- Spring 2015, **Advanced Finite Elements II (ME426-II)**, Graduate level course in Mechanical and Civil  
2016 Engineering at Northwestern. Taught 2 weeks of the total 10 weeks, supervised by Prof. Wing Kam Liu.

### As Teaching Assistant

- Spring 2016 **Computational Forensics (ME395)**, Undergraduate level course in Mechanical Engineering at Northwestern. Instructor: Prof. Mark Fleming.
- Fall 2013, **Finite Element Methods in Mechanics (ME327)**, Undergraduate level course in Mechanical  
2014 and Civil Engineering at Northwestern. Instructor: Prof. Wing Kam Liu.

## Awards & Honors

- 2017 **Melosh Medal Finalist**, for one of the 6 best student papers in computational mechanics each year, Duke University, Durham, NC.

- 2014 **Predictive Science & Engineering Design fellowship**, awarded on a competitive basis to Ph.D students with interest in the interdisciplinary issues across the boundary of predictive science and engineering design.
- 2013 **NSF Fellowship for NSF Summer Institute on Materials Genome**, Northwestern University, Evanston, IL.
- 2012 **Walter P. Murphy Fellowship**, award attributed to outstanding first-year Ph.D. students of Northwestern University.
- 2012 **Excellent Graduate Award**, award attributed to the top 5% student of Tsinghua University based on overall undergraduate achievement.
- 2011 **National Scholarship**, award attributed to the student with top 2% GPA of Tsinghua University.
- 2008, 2009 **National Encouragement First Class Scholarship**, award attributed to the student with top 5% GPA of Tsinghua University.
- 2009 **First Prize of Beijing Undergraduate Physics Tournament**, Beijing.
- 2007 **First Prize of Chinese Physics Olympiad**, China.

## Associations

- 2018-present **Member**, *Sigma Xi*, the Scientific Research Honor Society.
- 2018-present **Member**, *United States Association for Computational Mechanics (USACM)*.
- 2017-present **Member**, *Society of Automotive Engineers (SAE) International*.
- 2017-present **Member**, *The American Society of Mechanical Engineers (ASME)*.
- 2016-2017 **President**, Northwestern student chapter of the U.S. Association for Computational Mechanics.
- 2015-2016 **Co-founder and vice president**, Northwestern student chapter of the U.S. Association for Computational Mechanics.

## Academic Services

- 2020 **Mini-symposium organizers**, *WCCM/ECCOMAS 2020, Paris, France*.
- 2019 **Mini-symposium organizers**, *Finite Element in Fluid (FEF) 2019, Chicago, IL*.
- 2013-present **Journal reviewers** .  
Computational Mechanics, Computer Methods in Applied Mechanics and Engineering, Computer Modeling in Engineering & Sciences, Journal of Micromechanics and Molecular Physics, Structural Engineering and Mechanics, Steel and Composite Structures, Mathematical Reviews, Current Trends: Medical & Biological Engineering, Mathematical and Computational Applications, Materials, Sensors
- 2019-present **Conference reviewers** .  
International Conference on Computer Science and Application Engineering (CSAE 2019)

## Skills

- Languages C/C++, Python, Fortran, R, Matlab, MPI/OpenMP, CUDA,  $\LaTeX$
- Technologies LS-DYNA, ABAQUS, ANSYS, AutoCAD, LAMMPS, LabVIEW
- ML Packages TensorFlow, Pandas

## Conference Presentations & Invited Talks

- 3/11/2019 **Invited talk**, Deep material network for data-driven structure-property predictions, Workshop on Meshfree Method and Advances in Computational Mechanics, Pleasanton, CA

- 04/28/2017 **Invited talk**, Robert J. Melosh Competition held at Duke University, Raleigh, NC.
- 12/27/2016 **Invited talk**, Livermore Software Technology Corporation (LSTC), Livermore, CA.
- 7/28/2019 Advances in immersed particle method and deep material network for data-driven RVE analysis, 15th U.S. National Congress on Computational Mechanics (USNCCM15), Austin, TX.
- 04/01/2019 Deep material networks for creating microstructural database of polycrystalline materials in additive manufacturing, FEF 2019, Chicago, IL.
- 11/10/2018 Advances in RVE large deformation analysis of heterogeneous structures using an immersed particle modeling method and mechanistic machine learning technology, IMECE 2018, Pittsburgh, PA.
- 07/23/2018 Multiscale microstructural database for concurrent modeling of nonlinear softening material with damage and failure, 13th World Congress on Computational Mechanics (WCCM XIII), New York City, NY.
- 06/10/2018 Multiscale simulations of material with heterogeneous structures based on representative volume element techniques, 15th LS-DYNA International Conference, Detroit, MI.
- 07/26/2017 A consistent concurrent framework for multiscale material failure based on self-consistent clustering analysis, SES 2017, Boston, MA.
- 06/05/2017 Multiscale microstructural database for elastoplastic material with damage based on self-consistent clustering analysis, EMI 2017, San Diego, CA.
- 07/28/2016 Data-driven modeling of heterogeneous materials: self-consistent homogenization for elastoplastic behavior, 12th World Congress on Computational Mechanics (WCCM XII), Seoul, Korea.
- 07/30/2015 Pattern characterization and volume-integral micromechanics model of elastic and elastoplastic heterogeneous material, 13th U.S. National Congress on Computational Mechanics (USNCCM13), San Diego, CA.
- 05/28/2015 A statistical descriptor based volume-integral micromechanics model of heterogeneous material, 4th International Congress on Material Modeling (ICMM4), Berkeley, CA.

## Publications

Google Scholar Citations, \* indicates corresponding author

### Book Chapters

- [18] M. Shakoar, J. Gao, **Z. Liu**, W. K. Liu, "A Data-Driven Multiscale Theory For Modeling Damage and Fracture of Composite Materials," Proceedings of the 9th International Workshop on Meshfree Methods for Partial Differential Equations, 2019.
- [17] **Z. Liu**, O. L. Kafka, C. Yu, and W. K. Liu\*. "Data-driven self-consistent clustering analysis of heterogeneous materials with crystal plasticity," Advances in Computational Plasticity, Springer (2018): 221-242

### Journal Publications

- [15] **Z. Liu\***, "Deep material network with cohesive layers: Multi-stage training and interfacial failure analysis", submitted.
- [14] **Z. Liu\***, C.T. Wu, M. Koishi. "Transfer learning of deep material network for seamless structure-property predictions." Computational Mechanics (2019), 1-15.
- [13] **Z. Liu\***, C.T. Wu. "Exploring the 3D architectures of deep material network in data-driven multiscale mechanics." Journal of Mechanics and Physics of Solids 127 (2019), 20-46.
- [12] **Z. Liu\***, C.T. Wu, M. Koishi. "A deep material network for multiscale topological learning and nonlinear modeling of heterogeneous materials." Computer Methods in Applied Mechanics and Engineering 345 (2019): 1138-1168.

- [11] W. Yan, Y. Lian, C. Yu, O. L. Kafka, **Z. Liu**, W. K. Liu, G. J. Wagner\*, "An integrated process-structure-property modeling framework for additive manufacturing." *Computer Methods in Applied Mechanics and Engineering* (2018): 184-204.
- [10] C.T. Wu\*, Y. Wu, **Z. Liu**, D. Wang, "A stable and convergent Lagrangian particle method with multiple stress points for large strain and material failure analyses in manufacturing processes." *Finite Elements in Analysis and Design* (2018): 96-106.
- [9] **Z. Liu**, M. Fleming, W. K. Liu\*, "Multiscale microstructural database for nonlinear elastoplastic material with damage based on self-consistent clustering analysis." *Computer Methods in Applied Mechanics and Engineering* 306 (2018): 319-341.
- [8] O. L. Kafka, C. Yu, M. Shakoor, **Z. Liu**, G. J. Wagner, and W. K. Liu\*, "Data-driven mechanistic modeling of microstructural influence on the high cycle fatigue life of Nickel Titanium," *JOM* (2018): 1-5.
- [7] W. Yan, S. Lin, O. L. Kafka, C. Yu, **Z. Liu**, Y. Lian, S. Wolff, G. J. Wagner, and W. K. Liu\*. " Modeling process-structure-property relationships for additive manufacturing," *Frontiers of Mechanical Engineering* (2018): 1-11.
- [6] W. Yan, S. Lin, O. L. Kafka, Y. Lian, C. Yu, **Z. Liu**, J. Yan, S. Wolff, H. Wu, K. Ehmann, J. Cao, G. J. Wagner, and W. K. Liu\*. " Deriving process-structure-property relationships for additive manufacturing with data-driven multi-scale multi-physics material models ," *Computational Mechanics* (2018): 1-21.
- [5] M.A. Bessa, R. Bostanabad,**Z. Liu**, A. Hu, C. Brinson, W. Chen, and W.K. Liu\*. "A framework for data-driven analysis of materials under uncertainty: Countering the curse of dimensionality," *Computer Methods in Applied Mechanics and Engineering* (2017): 633-667.
- [4] **Z. Liu**, M. A. Bessa, and W. K. Liu\*, "Self-consistent clustering analysis: An efficient multi-scale scheme for inelastic heterogeneous materials," *Computer Methods in Applied Mechanics and Engineering* 306 (2016): 319-341.
- [3] **Z. Liu**, J. A. Moore, and W. K. Liu\*, "An extended micromechanics method for probing interphase properties in polymer nanocomposites," *Journal of Mechanics and Physics of Solids* 95 (2016): 663-680.
- [2] Y. Li, **Z. Liu**, Z. Jia, S. M. Aldousari, H. S. Hedia, S. A. Asiri, and W. K. Liu\*, "Modular-based Multiscale Modeling on Viscoelasticity of Polymer Nanocomposite," *Computational Mechanics* (2016): 1-15.
- [1] **Z. Liu**, J. A. Moore, S. M. Aldousari, H. S. Hedia, S. A. Asiri, and W. K. Liu\*, "A statistical descriptor based volume-integral micromechanics model of heterogeneous material with arbitrary inclusion shape," *Computational Mechanics* (2015): 1-19.

#### Conference Proceedings

- [4] **Z. Liu**, C.T. Wu, Bo Ren, W.K. Liu, R. Grimes, "Multiscale Simulations of Material with Heterogeneous Structures Based on Representative Volume Element Techniques," 15th International LS-DYNA Users Conference, 2018.
- [3] J. Gao, B. Liang, W. Zhang, **Z. Liu**, et al. , "Multiscale Modeling of Carbon Fiber Reinforced Polymer (CFRP) for Integrated Computational Materials Engineering Process," *Proceedings of American Society for Composites*, 2017.
- [2] W. K. Liu, Cheng, P., Kafka, O. L., Xiong, W., **Z. Liu**, Wentao, Y., Smith, J, "Linking Process, Structure, and Property in Additive Manufacturing Applications through Advanced Materials Modelling," *Proceedings of the XIII International Conference on Computational Plasticity: fundamentals and applications, CIMNE*, pp. 23- 39, 2015.

- [1] L. Cheng., Z. Liu, M. Li, H. Li, Y. Li, and W.K. Liu. "Subharmonic Resonance of Geometrical Nonlinear Structure in 2-D Periodic Elastic System for Mechanical Wave Filtering," Proceedings of the 10th International Workshop on Structural Health Monitoring, IWSHM 2015.

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